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(54) Title: BACKING ASSEMBLY FOR USE IN Z-MILL TYPE ROLLING MILLS

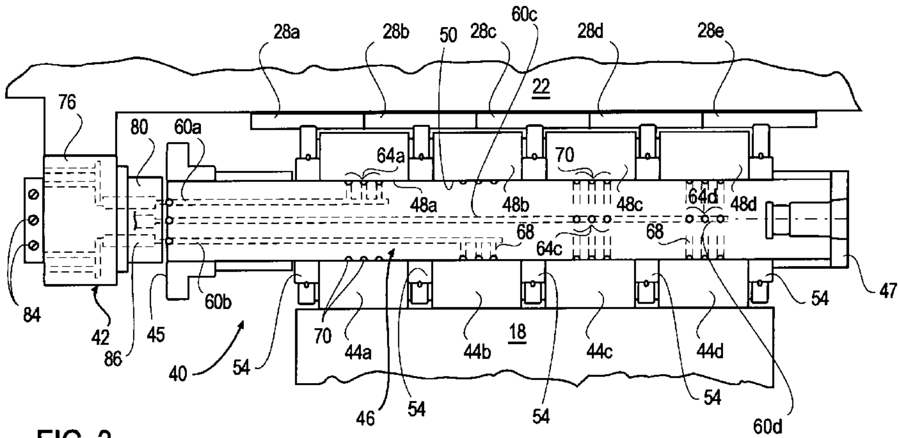

FIG. 3

(57) Abstract: A backing assembly for a Z-mill includes an elongated backing shaft having a number of longitudinally spaced bearing support surfaces configured to rotatably support cylindrical roller bearings thereon. The backing shaft is rotatably secured to a Z-mill housing by saddle assemblies which support the backing shaft in vertical movement along a generally eccentric path. A series of lubricant feed channels are formed along the interior of the shaft, and permit the flow of bearing lubricating fluid to each bearing support surface. The lubricant supply assembly is provided to supply an air/oil lubricating fluid mixture under pressure into the feed channels. The lubricant supply channel includes a supply manifold having internal valving to regulate the volume and timing of gas and oil flow therethrough, and a bearing plate having lubricant outlet ports. The bearing plate is resiliently biased into juxtaposed abutting contact with channel inlets formed in an end of the backing shaft, with the outlet ports and channel inlets having complementary shapes selected to maintain at least partial fluidic contact therebetween, as the end of the backing shaft moves eccentrically.

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BACKING ASSEMBLY FOR USE IN Z-MILL TYPE ROLLING MILLS

SCOPE OF THE INVENTION

The present invention relates to metal working rolling mills, and more particularly a cluster mill or Z-mill, which includes one or more backing assemblies having a lubricant delivery system for supplying high viscosity lubricating fluids to mill roller bearings, independently from rolling fluids.

BACKGROUND OF THE INVENTION

Z-mills, also known as cluster mills, 20 High Mills, or "Sendzimir" mills, are well known for use in metal working applications. Figure 1 shows a conventional Z-mill construction, as for example is described in United States Patent No. 4,289,013 to Hunke, the disclosure of which is incorporated herein by reference, and which is used in the rolling of metal strips 12.

The Z-mill 10 includes a pair of work rolls 14 which engage and work the metal strip 12 as it is moved back and forth therebetween. The work rolls 14 are supported by four first intermediate rolls 16. The first intermediate rolls 16 are in turn, supported by six secondary intermediate rolls, each identified generally as 18, and which include driven rolls 18' and idler rolls 18". The second intermediate rolls 18 are themselves supported by eight backing assemblies 20 which are mounted within a surrounding housing 22 at positions ABCDEFG and H.

Figure 2 shows best a cross-sectional view of a conventional backing assembly 20 as including between four and eight roller bearings 24 which are rotatably mounted on a cylindrical backing shaft 26. The backing shaft 26 is mounted to the housing 22 by a series of longitudinally spaced saddle assemblies 28, which rotatably support the shaft 26 in the housing 22 so as to be rotatable along an eccentric path, allowing the shaft 26 and roller bearings 24 to reciprocally move vertically relative to the metal strip.

As the Z-mill 10 is operated in the rolling of the metal strip 12, rolling fluid is pumped from a reservoir and sprayed via nozzles 29 (Figure 1) onto the upper and lower surfaces of the sheet 12 as it travels between the work rolls 14. Concurrently, rolling fluid is pumped under pressure via a supply line 30 into a hollow bore 32 which extends axially down the centre of the backing shaft 26, flowing outwardly therefrom through a series of holes 34, to provide lubrication to each roller bearing 24.

Typically, rolling fluids are low viscosity oils or emulsions of water and oil. In particular, to achieve proper rolling of the steel sheet 12, rolling fluids are selected from low viscosity fluids having viscosities of about ISO 4 VG (viscosity grade) or less. Conventional Z-mills 10 suffer a disadvantage in that heretofore, large volumes of rolling fluid are required to ensure adequate lubrication of the roller bearings 24. In particular, the use of conventional low viscosity rolling fluids to lubricate the roller bearings 24 necessitates that the lubricating fluid be supplied to the backing shaft 26 in volumes of up to 1000 litres per minute, with up to 35% by volume of the total rolling fluid used in the Z-mill being diverted into the mill roller bearings 24. Although it is known to recirculate rolling fluid in Z-mills for reuse, the loss of rolling fluids associated with prior art constructions results in increased manufacturing costs and inefficiencies.

Prior art Z-mills suffer a further disadvantage in that the flooding of the backing assembly roller bearings 24 with high volumes of rolling fluids tends to increase the amount of heat generated, producing a corresponding loss of power. In addition to increased manufacturing costs associated with higher power consumption rates, the increased temperatures accelerate the degradation of the lubricating properties of the rolling fluid, increasing further overall rolling fluid consumption.

As a result of their lower viscosities and in the case of emulsions, high water content, rolling fluids are therefore poorly suited to lubricate the backing assembly bearings. The applicant has appreciated that preferably, roller bearings should be lubricated with high viscosity lubricants having viscosities of greater than about ISO 150

VG (viscosity grade – average viscosity at 40°C mm^2/S), and more preferably about ISO 100 VG, which are less susceptible to thermal degradation.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a system for lubricating the roller bearings of a Z-mill backing assembly with high viscosity lubricating fluids, and more preferably lubricating fluids containing oils having viscosities of greater than about ISO 50 VG, preferably greater than about ISO 80 VG, and most preferably about ISO 100 VG.

Another object of the invention is to provide a backing assembly for a Z-mill which includes a lubricant supply assembly operable to continuously supply a gas/oil lubricant mixture to each backing assembly roller bearing, while the backing assembly shaft is rotated in eccentric movement.

A further aspect of the invention is to provide a Z-mill which incorporates one or more backing assemblies which include a lubricant supply apparatus which is operable to supply a substantially water-free lubricating fluid to backing rollers, independently from the rolling fluid used in metal rolling operations.

Another object of the invention is to provide a Z-mill which incorporates one or more backing assemblies in which the assembly roller bearings are independently lubricated with a lubricating oil supplied as part of an all-loss system using smaller quantities of oil, and without requiring the recirculation and filtration of lubricating fluids.

To at least partially overcome some of the difficulties associated with prior art devices, the present invention provides for a backing assembly for use in a Z-mill, a cluster mill, 20 High Mill or Sendzimir mill (hereinafter generally referred to as a Z-mill). The backing assembly includes a lubricant supply assembly and an elongated backing shaft which includes a number of longitudinally spaced bearing support surfaces, each configured to rotatably support a cylindrical roller bearing thereon. Preferably, the backing shaft is elongated along a central axis having a longitudinal length selected to support a number, and most preferably between 4 and 8 roller bearings thereon, although fewer or greater numbers of roller bearings may be used. The backing shaft is adapted to be rotatably secured to a Z-mill housing by one or more saddle assemblies. The saddle assemblies may be of a conventional design and include saddle bearings which support the backing shaft so as to be rotatably movable relative to the housing along a generally eccentric path. Most preferably, saddle bearings support the backing shaft so as to be reciprocally movable in a direction relative to said metal strip, selected at between about 0.5 and 5 mm, and preferably about 3 mm.

A series of lubricant feed channels are formed along at least part of the interior of the bearing shaft, and permit the flow of bearing lubricating fluid therealong to outlets adjacent to each bearing support surface. Although not essential, most preferably each lubricant feed channel is formed as a discrete channel which extends from a channel inlet formed in one end of the bearing shaft, axially through the shaft, to an outlet which opens directly into a respective bearing mounting surface to which each roller bearing is secured.

The lubricant supply assembly is provided to supply a lubricating fluid under pressure to the lubricant feed channels as the backing shaft is eccentrically moved. In a simplified construction, the lubricant supply assembly communicates with or includes a pressurized source of a gas such as air, a pressurized oil source and optionally, a supply manifold downstream and in fluid communication with the gas and oil sources. The supply manifold preferably includes internal valving, such as one or more needle valves, which are operable to regulate the volume and timing of gas and oil flow therethrough. In this manner, the supply manifold may be used to regulate and supply a pressurized gas/oil mixture of lubricating fluid into each channel inlet of the lubricant feed channels, in operation of the Z-mill.

In a preferred construction, the supply manifold is provided in fluid communication with a bearing assembly which fluidically couples the lubricant supply assembly to the backing shaft. The bearing assembly is downstream from the supply manifold and includes a bearing plate which is fixed against rotation relative to the housing, in which are provided one or more lubricant outlet ports fed via the manifold. The bearing plate is configured for juxtaposed placement with the channel inlets formed in a selected adjacent end of the backing shaft. Preferably, the outlet ports and channel inlets are formed with complementary shapes selected to maintain at least partial fluidic coupling therebetween, as the adjacent end of the backing shaft eccentrically moves relative to the bearing plate. One or more sealing members, such as a rotary seal, a labyrinthine type seal or a compressible O-ring are preferably also provided to maintain substantially fluid sealing contact between the bearing plate and at least part of the adjacent end of backing shaft 26, to prevent the movement of lubricant fluid therebetween as the backing shaft 26 is rotated.

Although not essential, the bearing plate may be axially movable from a first position spaced towards and in engaging juxtaposition with at least part of the adjacent end of the backing shaft, and a second position moved remote therefrom. One or more biasing members, such as a resiliently compressible or extensible springs, gas struts or pistons or other resiliently compressible member may be provided to resiliently bias the bearing plate to the first position against the shaft end.

Optimally, the applicant has discovered that a lubricant fluid consisting of a gas and oil mixture may be used to lubricate the roller bearings independently of the low viscosity rolling fluids used in rolling operations. More preferably, the bearing lubricant fluid used in the backing assembly to lubricate the roller bearings is supplied as an "all loss" lubricating system, whereby the lubricating fluid is supplied in volumes of less than about 4 litres per hour, so as to be fully consumed in the operation of the Z-mill. Most preferably, the lubricant fluid consists of air/oil droplet lubricant mixtures, with the oil selected from high pressure oils having a viscosity of at least about ISO 50 VG, preferably at least about ISO 75 VG, and most preferably about ISO 100 VG. The high viscosity oil is most preferably selected so as to be compatible with the mill rolling fluid, where excess oil enters the rolling fluid reservoir.

Accordingly, in one aspect the present invention resides in a backing assembly for a Z-mill type rolling mill, the assembly comprising,

a backing shaft being elongated in a longitudinal direction along a shaft axis and extending from a first shaft end to a second shaft end, the backing shaft defining a plurality of longitudinally spaced cylindrical bearing mounting surfaces, and further including a plurality of lubricant feed channels extending axially through said shaft, each of said feed channels providing fluid communication between an associated channel inlet open to said first shaft end and a respective lubricant outlet orifice disposed in an associated one of said bearing mounting surfaces,

a plurality of bearings, each of the bearings including a cylindrical bore having a radial diameter selected marginally greater than a radial diameter of the bearing mounting surfaces, each said bearing being mounted on a respective bearing mounting surface so as to be rotatable thereon relative to said backing shaft,

a saddle assembly for supporting said shaft in rotational movement with said first shaft end being movable along a generally eccentric path, the saddle assembly including at least one saddle bearing surface engaging said backing shaft at a location spaced from said bearing mounting surfaces,

a lubricant supply assembly for supplying a lubricant under pressure to each said channel inlet as said first shaft end moves along said eccentric path, said supply assembly including a fluid flow assembly and a bearing member, the bearing member having an end face configured for juxtaposed contact with at least part of said backing shaft first end, the bearing member being movable in a generally axial direction between a first position where said end face is moved into substantially juxtaposed contact with at least part of said backing shaft first end, and a second position spaced rearwardly therefrom,

a biasing member for resiliently biasing the bearing member to the first position,

the fluid flow assembly providing fluid communication between at least one fluid supply and a lubricant outlet port disposed in said bearing surface, the outlet port being positioned for at least partial fluid communication with at least one feed channel inlet when the bearing member is moved to the first position.

In another aspect, the present invention resides in a backing assembly for a rolling mill comprising,

a backing shaft being elongated in a longitudinal direction along a shaft axis, and extending from a first shaft end to a second shaft end,

the backing shaft defining a plurality of longitudinally spaced cylindrical bearing mounting surfaces, and further including a plurality of lubricant feed channels extending axially along an interior portion of said shaft, each of said lubricant feed channels providing fluid communication between an associated channel inlet open to said first shaft end and a channel outlet disposed in a respective one of said bearing mounting surfaces,

an associated cylindrical roller bearing rotatably mounted on each of said bearing mounting surface,

a saddle assembly rotatably supporting said first shaft end in movement along a generally eccentric path, the saddle assembly including at least one saddle bearing surface engaging said backing shaft intermediate an adjacent pair of said bearing mounting surfaces,

the first shaft end further including a seating surface extending annularly about said channel inlets,

a lubricant supply assembly for supplying a lubricant fluid under pressure to each said channel inlet,

said lubricant supply assembly including a bearing plate having a lubricant fluid outlet port and a fluid flow assembly, the fluid flow assembly providing fluid communication between at least one fluid supply and an outlet port formed in said bearing plate, the bearing plate being movable in a generally axial direction into juxtaposed contact with the first shaft end to provide at least partial fluid communication between the outlet port and the channel inlets,

an annular seal member disposed on said bearing plate and extending radially about said outlet port, the seal member being movable together with the bearing plate into sealing contact with said seating surface to substantially prevent the movement of lubricant fluid therebetween as said backing shaft is rotated.

In a further aspect, the present invention resides in a Z-mill type rolling mill comprising,

a housing,

a plurality of backing shafts mounted in said housing, each of said backing shafts being elongated along a longitudinal axis and extending from a first shaft end to a second shaft end, and defining at least two longitudinally spaced cylindrical bearing mounting surfaces, a plurality of lubricant feed channels extending axially along a portion of said shaft, said feed channels providing fluid communication between an associated inlet open to said first shaft end and a lubricant outlet disposed in a respective one of said bearing mounting surfaces, the first shaft end including a generally flat seating surface extending as an annular surface about said feed channel inlets generally normal to said shaft axis,

an associated cylindrical bearing rotatably mounted on each of said bearing mounting surface,

a plurality of saddle assemblies rotatably supporting said shaft in said housing with said first shaft end being movable along a generally eccentric path, each saddle assembly including at least one saddle bearing surface engaging said backing shaft,

a manifold fixed against rotation relative to said housing and for regulating the supply of a lubricant fluid under pressure to each said associated channel inlet,

a bearing member provided for juxtaposed contact with the first shaft end, the bearing member including a bearing plate having a plurality of outlet feed holes formed therein, the manifold being in fluid communication with a fluid supply and the outlet feed holes disposed in said bearing member,

the bearing member being movable in a generally axial direction between a sealing position wherein the bearing plate is moved into juxtaposed contact with at least part of said first shaft end to fluidically communicate the at least one of the feed holes with a selected feed channel inlet so as to permit the flow of said lubricant therein, and a second position moved a distance therefrom,

an annular seal member disposed on said bearing plate radially about said feed holes, the bearing plate being axially displaceable between a sealing position wherein said annular sealing member is in sealing contact with a biasing member, for resiliently biasing the bearing plate towards the sealing position, and

wherein the lubricant fluid comprises a mixture of air and high viscosity oil.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference may now be had to the following detailed description taken together with the accompanying drawings in which:

Figure 1 illustrates schematically a cross-sectional view of the roller configuration used in a conventional Z-mill;

Figure 2 illustrates a cross-sectional view of a conventional backing assembly used in the Z-mill of Figure 1;

Figure 3 illustrates a partial cross-sectional side view of a backing assembly for use in a Z-mill in accordance with a preferred embodiment of the invention;

Figure 4 illustrates an exploded cross-sectional plan view of the backing assembly shown in Figure 3;

Figure 5 illustrates schematically an exploded partial perspective view of the backing assembly of Figure 3 showing a lubricant supply assembly used to supply high viscosity lubricating fluids to a backing shaft and backing roller bearings in accordance with a preferred embodiment of the invention;

Figure 6 illustrates an enlarged partial cross-sectional view showing the engagement of the lubricant supply assembly shown in Figure 4 in the backing assembly shaft; and

Figures 7 to 12 illustrate schematically the positioning of the outlet feed holes of the lubricant supply assembly relative to the inlet openings of the lubricant feed channels, as the end of the backing shaft is moved eccentrically.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 3 illustrates schematically a backing assembly 40 for use in a Z-mill type rolling mill 10 of the type shown in Figure 1, in accordance with a preferred embodiment of the invention. It is to be appreciated that in assembly, the backing assembly 40 of Figure 3 may be substituted for one or more of the conventional backing assemblies 20 shown in Figure 1, to engage and support the intermediate rolls 18 in the operation of the Z-mill 10. In use of the present invention, rolling of the metal strip 12 is effected in essentially the same manner as prior art devices, with low viscosity rolling fluid sprayed onto the upper and lower strip surfaces by way of spray nozzles 29 (Figure 1), while a high viscosity, high temperature air/oil lubricant fluid mixture being fed to each backing assembly 40, independently from the rolling fluid.

Unlike conventional Z-mills, the air/oil lubricant fluid mixture used to lubricate components of the backing assembly 40 of the present invention consists of a mixture of about 96 to 99% by volume air and 4 to 1% by volume high viscosity oil, and most preferably about 99% by volume air and 1% by volume oil. The oil has a preferred viscosity of about ISO 100 VG. Suitable oils may therefore include gear oils, petroleum based oils and/or oils containing sulphur and/or phosphorous as extreme pressure additives. Most preferably, the oil is present in the air/oil mixture in the form of individual droplets having a mean droplet size selected at between about .005 to .2 mm and more preferably about .01 to .05 mm.

The backing assembly 40 is shown best in Figures 3 and 4 as including a cylindrical backing shaft 46 along which are rotatably mounted a number of cylindrical roller bearings 44, and a lubricant supply assembly 42 which in operation supplies an air/oil droplet mixture as a roller bearing lubricating fluid to the bearing shaft and each of the roller bearings 44.

In the embodiment shown, the backing shaft 46 is longitudinally elongated along a central shaft axis A_S-A_S (Figure 4), extending from a first shaft end 45 which is proximate to the lubricant supply assembly 42 to a second shaft end 47 remote therefrom. The backing shaft 46 is generally cylindrical and defines a number of axially spaced cylindrical bearing mounting surfaces 48a,48b,48c,48d.

Figure 3 shows best each of the roller bearings 44a,44b,44c,44d as having a cylindrical central bore 50 formed therethrough. The cylindrical bores 50 are formed with a diameter which is marginally greater than that of a corresponding mounting surface 48a,48b,48c,48d, allowing the rotational mounting of the bearings 44a,44b,44c,44d in alignment respectively therewith on the shaft 46.

The backing shaft 46 is in turn rotatably mounted in the Z-mill housing 22 by a series of axially spaced saddle assemblies 28a,28b,28c,28d,28e. The saddle assemblies 28a,28b,28c,28d,28e each include at least one saddle bearing 54 which rotatably engages the backing shaft 46 at locations spaced from the roller bearings 44a,44b,44c,44d, so as to effect movement of the shaft 46 along an eccentric path. Most preferably, the saddle bearings 54 support the backing shaft 46 in eccentric movement, so as to be reciprocally displaceable in a direction towards and away from the metal strip 12 (Figure 1). Depending on the mounting location ABCDEFGH (Figure 1), the saddle assemblies 28 typically movably support the backing shaft 46 with the first shaft end 45 so as to be movable in a horizontal plane relative to the feed direction of the metal strip 12 a distance of between about 1 and 6 mm. In particular, the backing shafts 46 mounted at outboard positions ADEH are typically mounted so as to be vertical displaceable by a distance of about 3.3 mm. The backing shafts 46 positioned at inboard locations BCFG are frequently movable in a horizontal plane generally parallel to the feed direction by a distance of between about 1 and 6 mm, and typically with a displacement of about 5.4 mm. In addition, the saddle bearings 54 further define the lateral extent of the bearing mounting surfaces 48a,48b,48c,48d and assist in maintaining the roller bearings 44a,44b,44c,44d in alignment therewith, as the Z-mill 10 is operated.

Figures 3 and 4 shows best four discrete lubricant feed channels 60a,60b,60c,60d as being formed along the interior of the backing shaft 46 which as will be described, communicate the roller bearing lubricant from the lubricant supply assembly 42 to each bearing mounting surface 48a,48b,48c,48d. Each lubricant feed channel 60a,60b,60c,60d has a minimum average diameter of about 0.5 to 7 mm, and preferably about 4 mm, and extends along an interior of the backing shaft 46 generally parallel to axis A_S-A_S. The feed channels 60 extend from a respective inlet opening 62a,62b,62c,62d (Figure 5) open to the first shaft end 45, to a respective outlet orifice 64a,64,64c,64d, permitting fluid flow thereto. The outlet orifices 64a,64b,64c,64d are open respectively into each bearing mounting surface 48a,48b,48c,48d. Although not essential, each outlet orifice 64a,64b,64c,64d is most preferably formed having three axially spaced radially extending aperture passages 68 which each fluidically communicate with a bottom portion of an associated radially extending groove 70 formed about a periphery of the shaft 42.

Figure 5 illustrates best the inlet openings 62a,62b,62c,62d of each lubricant feed channel 60a,60b,60c,60d. The inlet openings 62 are provided as opposing pairs of radially extending recesses 60a,60b and 60c,60d which extend about the shaft axis A_S-A_S. Each of the inlet openings 62a,62b,62c,62d extend about the axis A_S-A_S a radial arc selected at between about 90° and 175° and most preferably between about 140° and 170°. Although not essential, most preferably the pairs of inlet openings 62a,62b and 62c,62d are offset relative to the shaft axis A_S-A_S from each other at approximately 90° for simplified manufacture. The first opposing pair of openings 62a,62b is provided at a first radial distance D_1 (Figure 7) spaced from the shaft axis A_S-A_S, with the second pair of openings 62c,62d spaced radially outwardly from the axis A_S-A_S by a distance D_2 (Figure 7).

As shown best in Figure 5, the portion of shaft end 45 which extends radially about the second pair of inlet openings 62c,62d is preferably formed as a substantially smooth seating surface 65. Most preferably, the seating surface 65 is oriented normal to and extends radially from the axis A_S-A_S by a distance at least equal to, and preferably greater than, the distance between the major and minor axis of the elliptical path along which the shaft end 45 travels.

Figure 5 illustrates best a peripheral edge of the end 45 of backing shaft 46 as having a gear tooth profile 70 which extends about the entirety of the shafts 46 used in positions ADEH (Figure 1). It is to be appreciated that depending on the positioning of the backing assembly 42, the gear tooth 70 could extend only in a partial radial path, where for example the backing assembly 42 is provided in positions BCFG. The gear tooth profile 70 is engageable with a drive gear and/or a rack and hydraulic cylinder (not shown) in all or selected positions in the operation of the Z-mill 10 to drive the shaft 46 in rotation about the shaft axis A_S-A_S.

Figures 4 to 6 show the lubricant supply assembly 42 used to regulate the flow of the air/oil lubricating fluid mixture from a pressurized air source 72 and pressurized oil source 74 into the lubricant feed channels 60a,60b,60c,60d of the backing shaft 46. As shown best in Figure 5, the lubricant supply assembly 42 includes a supply manifold 76, conduit tubing 78 which fluidically couples the air source 72 and oil source 74 to the manifold 76, and a thrust bearing assembly 80. As will be described, the thrust bearing assembly 80 is used to maintain fluid communication with the backing shaft 46 as it eccentrically moves to maintain a steady supply of lubricating fluid thereto.

The supply manifold 76 includes an air/oil injector block housing 82 which is provided immediately downstream from the infeed ends of the conduit tubing 78. A needle valve assembly 84 is housed within the injector block housing 84. The needle valve assembly 84 is provided with valving which is operable to independently regulate the flow of air and oil into and through the lubricant supply manifold 76. In a preferred mode of operation, the needle valve assembly 84 is operable to provide a lubricant fluid mixture which consists of 99 % by volume air and about 1 % by volume high viscosity oil, at an output flow rate being regulated through the manifold 76. Most preferably the needle valve assembly 84 is operable to regulate the air/oil mixture flow, with oil injection into the mixture being provided intermittently, at preferred flow rates as follows:

Backing bearing outside diameter	Oil flow rate Lubrication/Bearing
D	Oil
mm	cm^3/h
120	0.9 to 1.5
160 to 165	1.5 to 2.1
220 to 225	2.1 to 3.6
260	2.4 to 3.9
300 to 300.02	3.6 to 6.0

The applicant has appreciated that the aforementioned construction permits the operation of the Z-mill 10 with bearing lubricating fluids supplied independently of rolling fluids. As such, traditional rolling fluids may be used to effect rolling of the metal strip 12 at conventional rolling rates.

Table: Rolling fluid flow rates for Steel Strip	
Backing bearing outside diameter	Rolling fluid flow rate Per bearing
D	
Mm	litre/minute
120	5 to 7
160 to 165	10 to 15
220 to 225	15 to 25
260	20 to 35
300 to 300,02	30 to 60
from 406	55 to 80

Figures 4 and 5 show the positioning of a series of four axially elongated injector guide tubes 86a,86b,86c,86d downstream from the needle valve assembly 84 within the injector block housing 82.

The four injector guide tubes 86 are each fluidically coupled to the air/oil supply lines 78 by way of the needle valve assembly 84, so as to be independently supplied with the air/oil lubricant under a positive supply pressure. Most preferably, the oil pressure from the source 74 supplies oil to the valve assembly 84 at a supply pressure selected at less than about 700 psi, and most preferably about 400 and 600 psi. The valve assembly 84 includes two injectors (not shown) communicating with each tube 86 for enhanced redundancy in supplying the lubricating oil droplets thereto. Each injector tube 86 is formed as a cylindrical tube having a radial diameter of between about 1 and 4 cm, and an axial length of between about 3 and 10 cm. The relatively larger diameter of the injector tubes 86 assists in the formation of discrete oil droplets within the air/oil lubricant mixture.

The thrust bearing assembly 80 includes a cylindrical bearing plate 90 which extends in an axial direction along a plate axis A_P-A_P (Figure 4). Figure 5 shows the bearing plate 90 as being slidably received within a downstream end of the injector block housing 82 so as to be reciprocally movable relative to the housing 82 in the direction of axis A_P-A_P. A retaining ring 92 is provided to limit the forward movement of the bearing plate 90 outwardly from the injector block housing 82. The bearing plate 90 is formed with four internal chambers 94a,94b,94c,94d (Figures 4 and 6) having a cylindrical profile and alignment which is selected complementary in shape and position of each respective injector tube 82. The chambers 94 have an axial length selected preferably greater than that of the injector tubes 86, so as otherwise not to interfere with the axial sliding movement of the bearing plate 90 in the direction of axis A_P-A_P relative thereto.

Figure 5 illustrates best the injector tubes 86 as being open to and in fluid communication with a respective chamber 94 allowing the substantially unhindered flow of the air/oil lubricant therein.

In the view shown in Figure 5, the thrust bearing assembly 80 is illustrated best as having an axial-most bearing surface 96 which extends normal to the plate axis A_P-A_P. One or more helical compression springs 95 (Figure 6) are provided to resiliently bias the bearing plate 90 axially forward, to move the bearing surface 96 towards juxtaposed engagement with the end 45 of the backing shaft 46.

A lubricant outlet port 98 is formed in the bearing surface 96. The outlet port 98 consists of four separate arrays of feed openings 100a,100b,100c,100d. Each of the arrays 100 consists of three circular openings or feed holes having a diameter selected at between about 1 and 3 mm. The feed holes of each array 100a,100b,100c,100d preferably each communicate directly through the bearing surface 96 with a respective chamber 94. Most preferably, the feed holes of each array 100 are arranged so as to extend at least generally in a radial direction about the plate axis A_P-A_P.

The feed opening arrays 100a,100b are spaced respectively a radial distance d_1 (Figure 8) on opposing sides of the plate axis A_p-A_p, and which generally corresponds to the distance D_1, the radial inlet openings 62a,62b are spaced from the shaft axis A_S-A_S (Figure 7). Similarly, the feed opening arrays 100c,100d are provided at spaced locations about the plate axis A_P-A_P at about a 90° offset from the feed opening arrays 100a,100b. The arrays 100c,100d are spaced from the plate axis A_p-A_p by a radial distance d_2 (Figure 8) generally corresponding to the distance D_2 of the inlet openings 62c,62d spacing from the shaft axis A_S-A_S. In this configuration, the applicant has appreciated that as the first end 45 of the backing shaft 46 moves along its elliptical path, at least two feed holes of at least one or more different outlet arrays 100a,100b,100c,100d, are maintained in fluid communication with each of the inlet openings 62a,62b,62c,62d at all times. As a result, lubricating fluid is supplied along the feed channels 60 and from the outlet orifices with a downstream pressure to the roller bearings 44a,44b,44c,44d selected at less than about 50 psi, and most preferably between about 2 and 30 psi.

The bearing plate 90 of the thrust bearing assembly 80 furthermore includes a resiliently compressible rubber O-ring 110. The O-ring 110 extends radially about the feed opening arrays 100a,100b,100c,100d and plate axis A_P-A_P. The rubber O-ring 110 is sized and positioned for mated engagement with the smooth seating surface 65 formed in the first end 45 of the backing shaft 46. In this manner the bearing plate 90 may be secured against rotation within the mill housing 22 while being rotatably engaged by the backing shaft 46. Because the seating surface 65 of the shaft end 45 extends radially a distance greater than the path of eccentric movement of the shaft 46, the O-ring 110 is maintained in sealing contact thereagainst, even while the shaft end 45 slides vertically relative thereto.

In assembly, the backing shaft 46 and lubricant supply assembly 42, are positioned in the housing 22. The lubricant supply assembly 46 is oriented with the plate axis A_P-A_P parallel to the shaft axis A_S-A_S and generally aligned with the centre of the elliptical path along which the first end 45 of the backing shaft 46 moves. The supply assembly 46 is positioned such that the bearing plate 90 is in juxtaposed contact with the shaft first end 45, and with the biasing springs 95 under partial compression. In this configuration, the springs 95 resiliently urge the bearing plate 90 forwardly towards contact against the shaft end 45, ensuring fluid sealing contact between the O-ring 110 and seating surface 65.

Figures 6 to 11 illustrate the positioning of the inlet openings 62 relative to the feed hole arrays 100 as the backing shaft 46 is eccentrically rotated relative to the bearing plate 90. As the backing shaft 46 moves, each of the radially extending inlet openings 62a,62b,62c,62d are maintained in alignment and fluid communication with at least two feed openings of one or more of the arrays 100a,100b,100c,100c. The applicant has appreciated that this redundancy ensures that bearing lubricant continues to be supplied to each feed channel 60a,60b,60c,60d in the event one of the feed openings may become blocked or inoperable. With the present construction, the air/oil lubricant is therefore continuously fed from the supplies 74,76 via the valve assembly 84, tubes 86 and chambers 94 outwardly from the arrays 100 and into the lubricant feed channels 60 as the Z-mill 10 operates.

Because the present invention uses an air/oil droplet mixture as a bearing lubricant, as contrasted with low viscosity oils or water/oil emulsions used for rolling fluids, the present system allows the operation of a Z-mill 10 with significantly lower volumes of roller bearing lubricants than compared to conventional systems. In normal operations, it is envisioned that the present system would therefore use approximately one gallon of bearing lubricating oil per day on an all or significant loss basis. Although not essential, it is most preferable to select a bearing lubricant oil which is compatible with the rolling fluid, in the event of contamination therewith.

In use of a Z-mill 10 incorporating one or more backing assemblies 40, the rolling of metal strip 12 is performed by work rolls 14 in a conventional manner. During sheet rolling, low viscosity rolling fluid is sprayed via nozzles 29 (Figure 1) onto the surfaces of the sheet 12 as it travels back and forth between the work rolls 14. Concurrently, the air/oil lubricant mixture is fed from the air and oil reservoirs 72,74 via the lubricant supply manifold 76 into the lubricant feed channels 60 via the tubes 86, chambers 94 and arrays 100. Most preferably, the air/oil mixture is fed into each lubricant feed channel 60a,60b,60c,60d under a pressure of about 2 and 6 psi so as to flow outwardly into the radial grooves 70 formed about each bearing mounting surface 48a,48b,48c,48d.

Although the preferred embodiment of the invention illustrates the bearing plate 90 as including arrays 100 of individual feed holes as supplying lubricating fluid to the channel inlet openings 60, the invention is not so limited. It is to be appreciated that the bearing plate 90 could be provided with a lubricant feed port having a variety of different configurations and/or shapes. These would include, without restriction, a single or multiple elongated and/or oval lubricant ports, or alternately as lubricant outlet holes of equal or different sizes in a selected arrangement.

Although the preferred embodiment illustrates the lubricant feed channels 60 as including a three port outlet orifice 64, the applicant has appreciated that while the redundancy of the outlet port construction advantageously minimizes the possibility of blockage, other lubricant outlet constructions may also be used.

While the preferred embodiment describes the preferred roller bearing lubricant as including high viscosity oils having a viscosity of about ISO 100 VG, other low viscosity oils with viscosities of less than about ISO 20 VG may also be used.

In addition, although Figures 7 to 12 illustrate the construction of the manifold bearing plate ports whereby at least two feed holes are provided in continuous connection with each channel inlet for redundancy in the event of blockage, the invention is not so limited. In an alternate simplified construction, the arrays 100 may include outlets formed as elongated grooves or as enlarged diameter circular openings configured, to substantially maintain fluid contact with at least one fluid infeed channel inlet as the backing shaft is rotated.

Although the preferred embodiment of the invention illustrates the backing assembly 40 of Figure 3 as including four roller bearings 44a,44b,44c,44d, it is to be appreciated that the present invention could equally be constructed with either a fewer or greater number of roller bearings 44, with a corresponding decrease or increase in the number of lubricant feed channels 60 being formed through the shaft 42.

Although the detailed description describes and illustrates various preferred embodiments, the invention is not so limited. Many modifications and variations will now occur to persons skilled in the art. For a definition of the invention, reference may be had to the appended claims.

We claim:

1. A backing assembly for a Z-mill type rolling mill, the assembly comprising,

a backing shaft being elongated in a longitudinal direction along a shaft axis and extending from a first shaft end to a second shaft end, the backing shaft defining a plurality of longitudinally spaced cylindrical bearing mounting surfaces, and further including a plurality of lubricant feed channels extending axially through said shaft, each of said feed channels providing fluid communication between an associated channel inlet open to said first shaft end and a respective lubricant outlet orifice disposed in an associated one of said bearing mounting surfaces,

a plurality of bearings, each of the bearings including a cylindrical bore having a radial diameter selected marginally greater than a radial diameter of the bearing mounting surfaces, each said bearing being mounted on a respective bearing mounting surface so as to be rotatable thereon relative to said backing shaft,

a saddle assembly for supporting said shaft in rotational movement with said first shaft end being movable along a generally eccentric path, the saddle assembly including at least one saddle bearing surface engaging said backing shaft at a location spaced from said bearing mounting surfaces,

a lubricant supply assembly for supplying a lubricant under pressure to each said channel inlet as said first shaft end moves along said eccentric path, said supply assembly including a fluid flow assembly and a bearing member, the bearing member having an end face configured for juxtaposed contact with at least part of said backing shaft first end, the bearing member being movable in a generally axial direction between a first position where said end face is moved into substantially juxtaposed contact with said at least part of said backing shaft first end, and a second position spaced rearwardly therefrom,

a biasing member for resiliently biasing the bearing member to the first position,

the fluid flow assembly providing fluid communication between at least one fluid supply and a lubricant outlet port disposed in said bearing surface, the outlet port being positioned for at least partial fluid communication with at least one feed channel inlet when the bearing member is moved to the first position.

2. The backing assembly as claimed in claim 1 wherein said outlet port comprises a plurality of arrays of feed openings disposed in said end face, said arrays being positioned to maintain fluid communication between at least one feed opening and each of the channel inlets as the first shaft end moves along the eccentric path.

3. The backing assembly as claimed in claim 1 wherein the outlet port is selected from the group consisting of an array of a plurality of feed holes and an elongate recess.

4. The backing assembly as claimed in claim 1 wherein said lubricant supply assembly includes a manifold housing having a valve assembly, and at least one injector tube in communication with each of said valve assembly and the outlet ports, the fluid flow assembly further comprising,

a gas supply conduit providing fluid communication between a pressurized gas source and said valve assembly, and

an oil supply conduit providing fluid communication between an oil source and said valve assembly,

and wherein the valve assembly is operable for regulating the flow rate of said gas and said oil into each said injector tube.

5. The backing assembly as claimed in claim 4 wherein said outlet port includes a plurality of feed openings in said end face, the feed openings being in fluid communication with each of the injector tubes.

6. The backing assembly as claimed in claim 5 wherein said bearing member includes an injector chamber, the injector chamber being movable relative to the injector tube and being provided in fluid communication therewith, as the bearing member is moved between the first and second positions.

7. The backing assembly as claimed in claim 2 wherein at least one of the bearing member and the backing shaft first end includes,

a rotary seal extending radially about the outlet port, when the bearing member is moved to the first position, the rotary seal engaging the other of the bearing member and the backing shaft first end to substantially prevent the flow of said lubricant therebetween.

8. The backing assembly as claimed in claim 1 wherein said lubricant comprises a mixture of air and oil droplets having an average droplet size of between about .01 and .05 mm, and said lubricant supply assembly operable to supply said lubricant to each of said lubricant feed channels at a pressure selected at between about 2 and 30 psi.

9. The backing assembly as claimed in claim 1 wherein each of said lubricant feed channels comprise a discrete fluid channel having a radial diameter selected at between about .25 and .75 cm,

wherein the channel inlets of a first pair of said feed channels comprising generally arcuate recesses extending radially a first distance about the shaft axis; and

the channel inlets of a second other pair of said feed channels comprising generally arcuate recesses extending radially a second distance about the shaft axis.

10. A backing assembly for a rolling mill comprising,

a backing shaft being elongated in a longitudinal direction along a shaft axis, and extending from a first shaft end to a second shaft end,

the backing shaft defining a plurality of longitudinally spaced cylindrical bearing mounting surfaces, and further including a plurality of lubricant feed channels extending axially along an interior portion of said shaft, each of said lubricant feed channels providing fluid communication between an associated channel inlet open to said first shaft end and a channel outlet disposed in a respective one of said bearing mounting surfaces,

an associated cylindrical roller bearing rotatably mounted on each of said bearing mounting surface, a saddle assembly rotatably supporting said first shaft end in movement along a generally eccentric path, the saddle assembly including at least one saddle bearing surface engaging said backing shaft intermediate an adjacent pair of said bearing mounting surfaces,

the first shaft end further including a seating surface extending annularly about said channel inlets,

a lubricant supply assembly for supplying a lubricant fluid under pressure to each said channel inlet,

said lubricant supply assembly including a bearing plate having a lubricant fluid outlet port and a fluid flow assembly, the fluid flow assembly providing fluid communication between at least one fluid supply and an outlet port formed in said bearing plate, the bearing plate being movable in a generally axial direction into juxtaposed contact with the first shaft end to provide at least partial fluid communication between the outlet port and the channel inlets,

an annular seal member disposed on said bearing plate and extending radially about said outlet port, the seal member being movable together with the bearing plate into sealing contact with said seating surface to substantially prevent the movement of lubricant fluid therebetween as said backing shaft is rotated.

11. The backing assembly as claimed in claim 10 wherein each associated cylindrical bearing includes a cylindrical through bore having a radial diameter marginally greater than a radial diameter of the bearing mounting surface, the channel outlet of each feed channel including a plurality of longitudinally spaced grooves extending radially about said shaft and which are open to the through bore of the associated bearing.

12. The bearing assembly as claimed in claim 10 including at least four of said lubricant feed channels,

the channel inlets of a first pair of said feed channels comprising first opposed generally arcuate recesses extending radially and being spaced a first distance about the shaft axis; and the channel inlets of a second other pair of said feed channels comprising second opposed generally arcuate recesses extending radially and being spaced a second distance about the shaft axis.

13. The backing assembly as claimed in claim 12 wherein each of the first and second arcuate recesses extend radially about the shaft axis along an arc selected at between about 90 and 175°.

14. The backing assembly as claimed in claim 12 wherein the outlet port comprises two opposing pairs of feed hole arrays, each feed hole array being provided in said bearing plate in a position selected to maintain fluid communication between each of said feed channel inlets and at least two feed holes, as the first shaft end moves along said eccentric path.

15. The backing assembly as claimed in claim 14 wherein said bearing plate is fixed against rotation relative to a rolling mill housing, and the lubricant fluid comprising a gas/oil mixture comprising between about 97 and 99% by volume gas and about 3 and 1% by volume oil droplets.

16. The backing assembly as claimed in claim 15 wherein the annular seating surface comprises a generally flat surface extending normal to said shaft axis, said annular seating surface having a radial width greater than the difference between the major axis and the minor axis of the elliptical path.

17. The backing assembly as claimed in claim 10 wherein the bearing plate is axially displaceable between a sealing position wherein said annular seal member engages and is provided in substantially fluid sealing contact with said seating surface, and a non-sealing position moved axially therefrom, the backing assembly further including a biasing member for resiliently biasing the bearing plate towards the sealing position.

18. The backing assembly as claimed in claim 17 wherein said lubricant fluid comprises a mixture of air and high viscosity oil droplets having an average droplet size of between about .005 and .1 mm, and said lubricant supply assembly is operable to supply said lubricant along each of said fluid feed channels at a pressure selected at between about 2 and 30 psi, at an oil flow rate of less than about 2 cm^3/hour.

19. The backing assembly as claimed in claim 18 wherein each of said lubricant feed channels comprise a discrete fluid channel having a radial diameter selected at between about .4 and .75 cm.

20. A Z-mill type rolling mill comprising,

a housing,

a plurality of backing shafts mounted in said housing, each of said backing shafts being elongated along a longitudinal axis and extending from a first shaft end to a second shaft end, and defining at least two longitudinally spaced cylindrical bearing mounting surfaces, a plurality of lubricant feed channels extending axially along a portion of said shaft, said feed channels providing fluid communication between an associated inlet open to said first shaft end and a lubricant outlet disposed in a respective one of said bearing mounting surfaces, the first shaft end including a generally flat seating surface extending as an annular surface about said feed channel inlets generally normal to said shaft axis,

an associated cylindrical bearing rotatably mounted on each of said bearing mounting surface,

a plurality of saddle assemblies rotatably supporting said shaft in said housing with said first shaft end being movable along a generally eccentric path, each saddle assembly including at least one saddle bearing surface engaging said backing shaft,

a manifold fixed against rotation relative to said housing and for regulating the supply of a lubricant fluid under pressure to each said associated channel inlet,

a bearing member provided for juxtaposed contact with the first shaft end, the bearing member including a bearing plate having a plurality of outlet feed holes formed therein, the manifold being in fluid communication with a fluid supply and the outlet feed holes disposed in said bearing member,

the bearing member being movable in a generally axial direction between a sealing position wherein the bearing plate is moved into juxtaposed contact with at least part of said first shaft end to fluidically communicate the at least one of the feed holes with a selected feed channel inlet so as to permit the flow of said lubricant therein, and a second position moved a distance therefrom,

an annular seal member disposed on said bearing plate radially about said feed holes, the bearing plate being axially displaceable between a sealing position wherein said annular sealing member is in sealing contact with a biasing member, for resiliently biasing the bearing plate towards the sealing position, and

wherein the lubricant fluid comprises a mixture of air and high viscosity oil.

21. The rolling mill as claimed in claim 20 wherein the bearing plate is substantially fixed against rotation relative to said housing with the outlet feed holes provided as a plurality of arrays of at least three discrete feed holes,

wherein each of the channel inlets of a first pair of said feed channels comprising opposed generally arcuate recesses extending radially and being spaced a first distance about the shaft axis; and

each of the channel inlets of a second other pair of said feed channels comprising second opposed generally arcuate recesses extending radially and being spaced a second distance about the shaft axis.

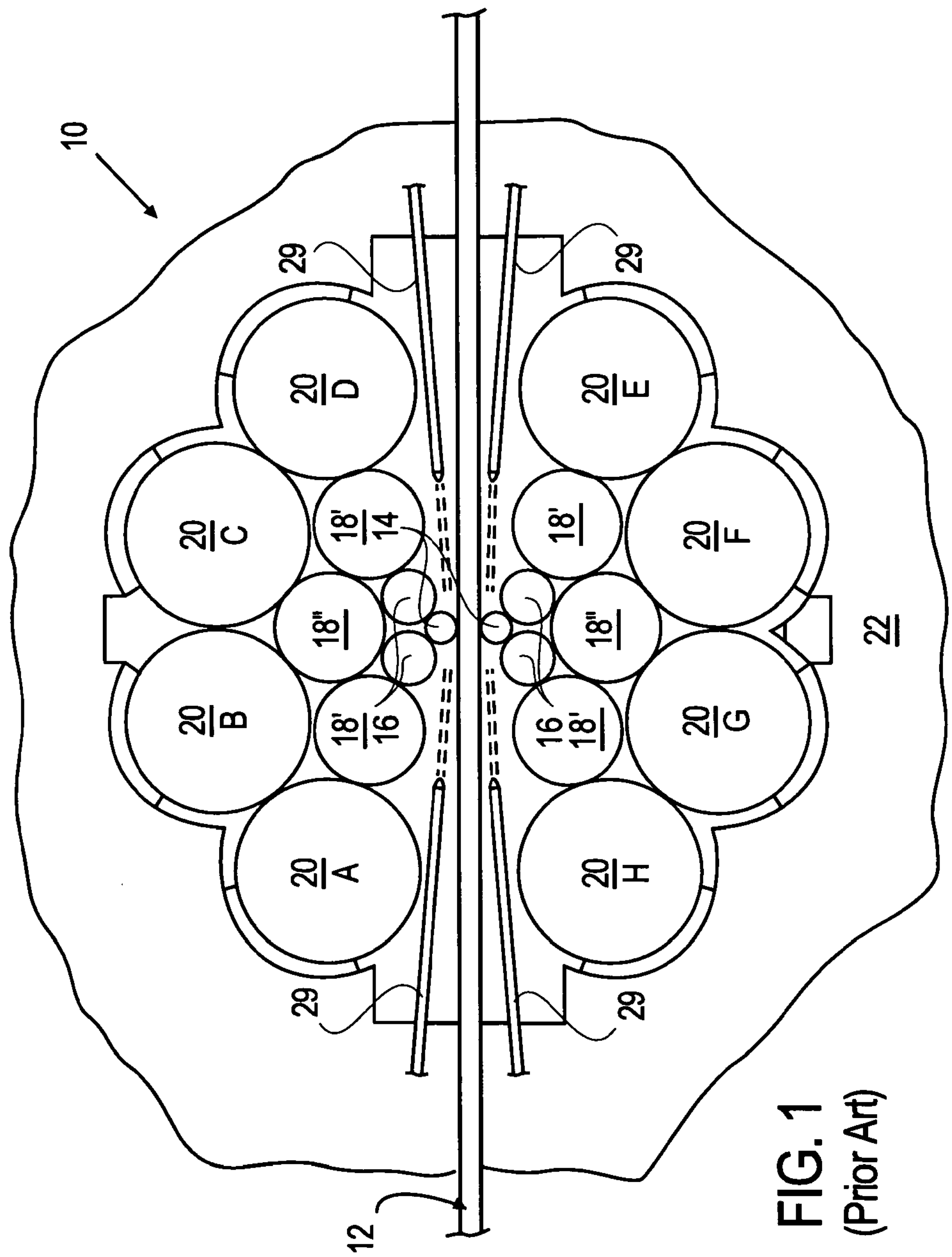


FIG. 1
(Prior Art)

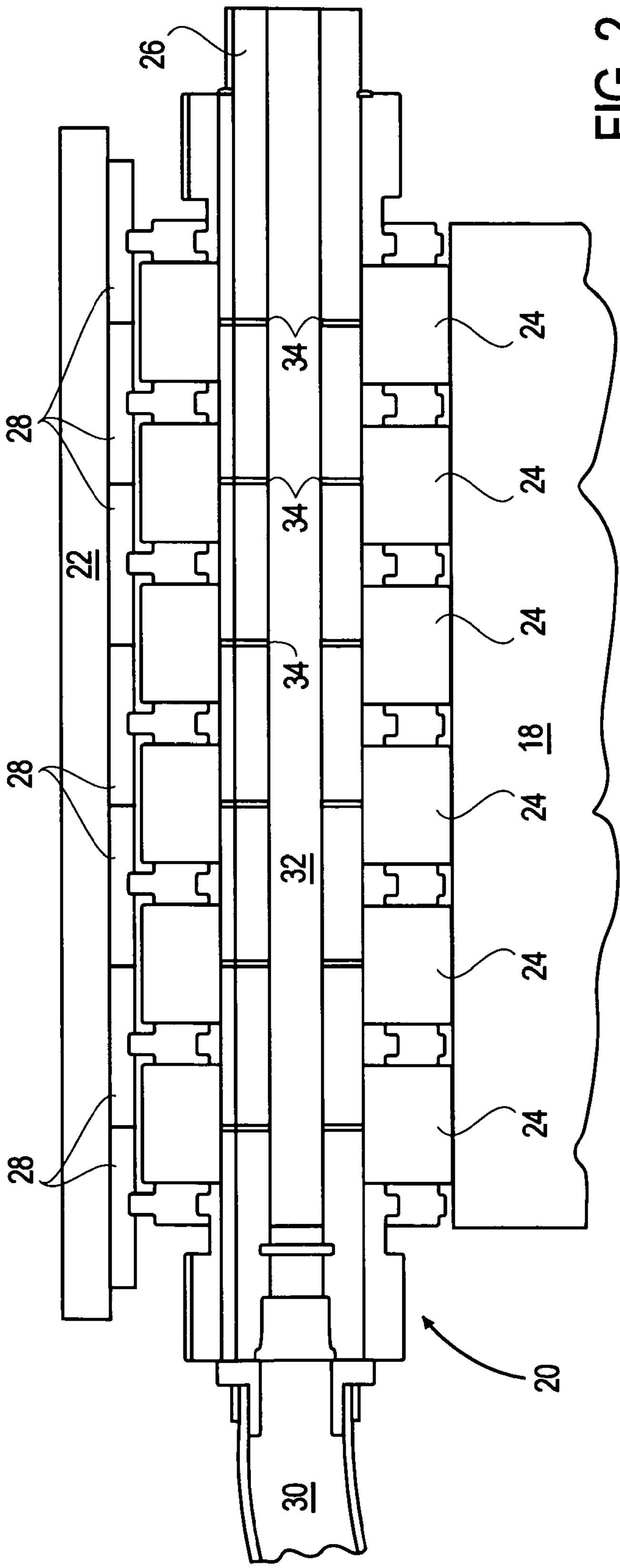
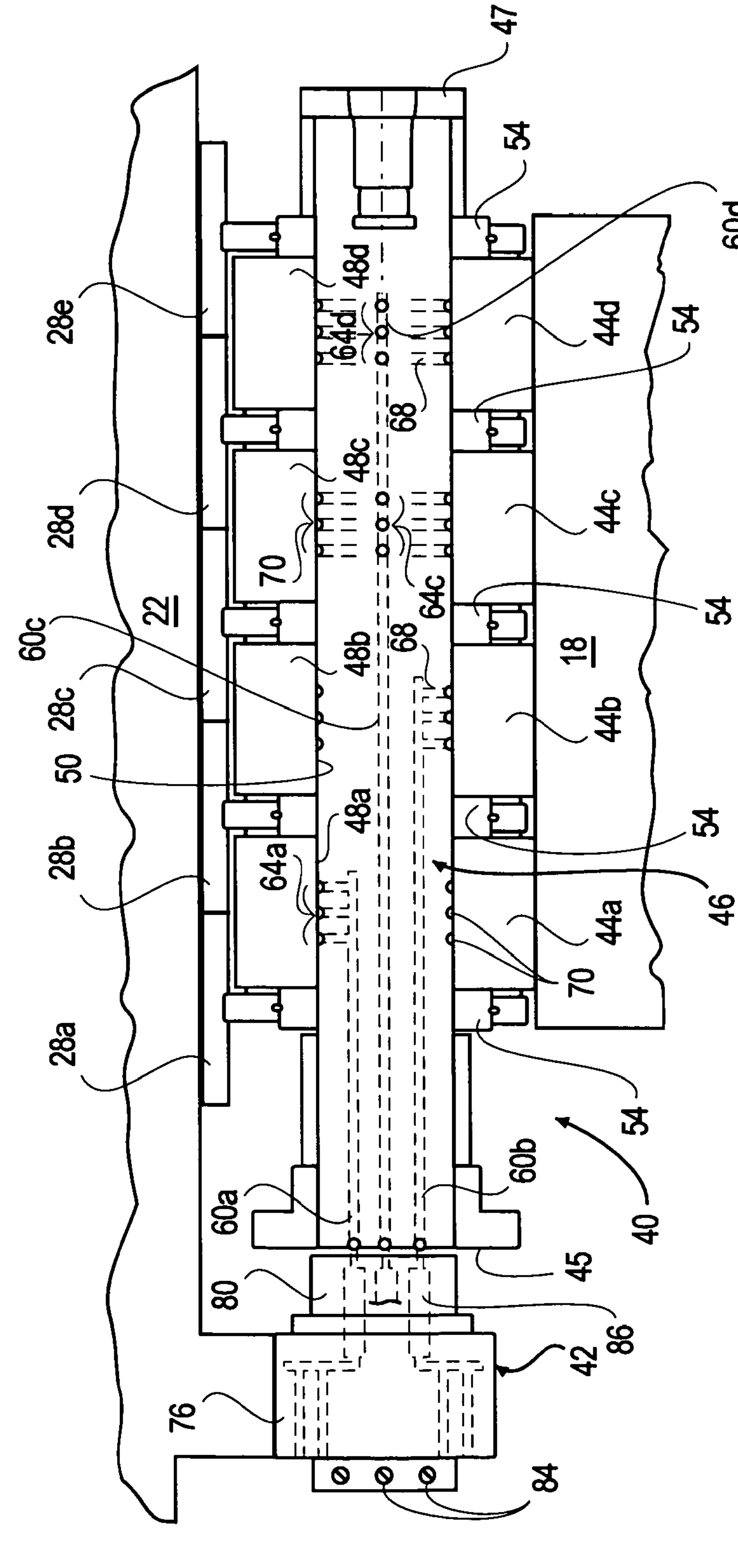


FIG. 2
(Prior Art)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48b
28c
44b
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FIG. 3

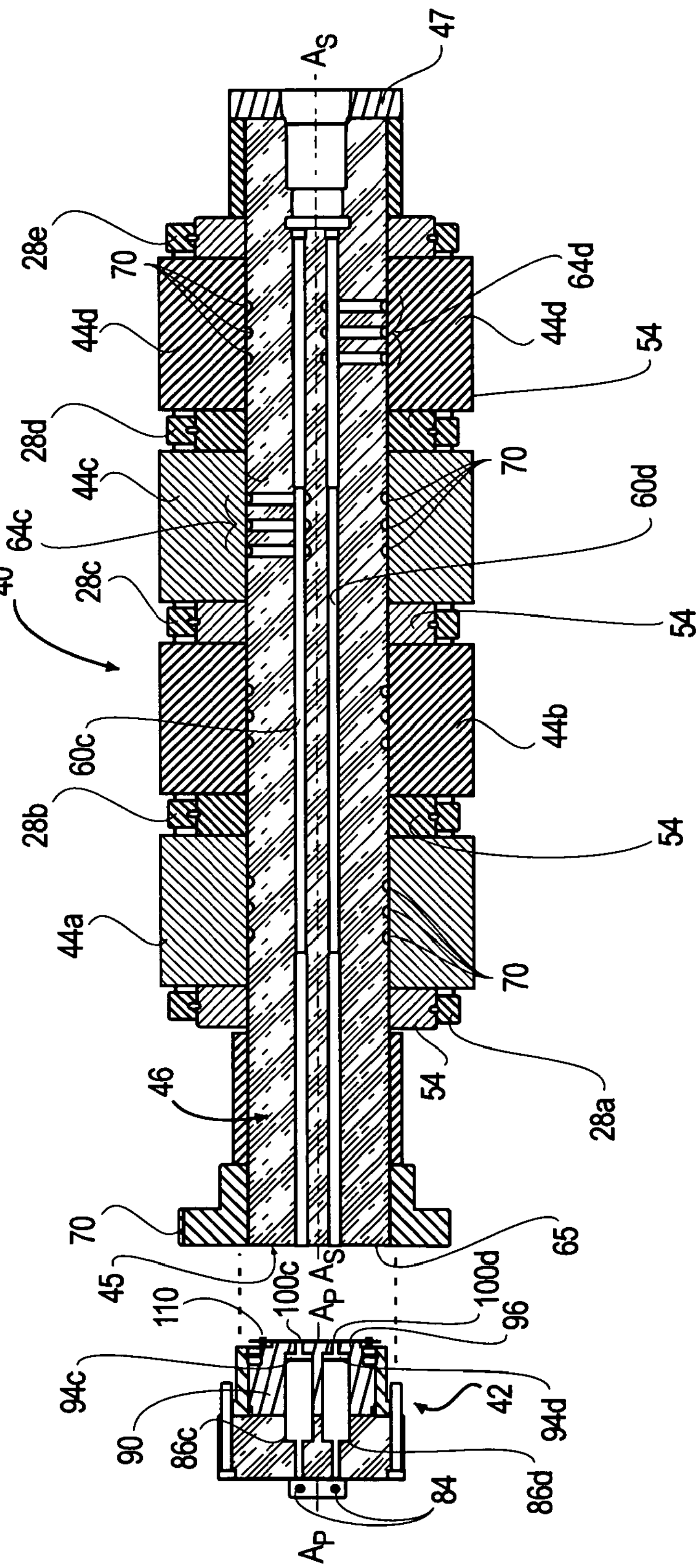
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FIG. 4

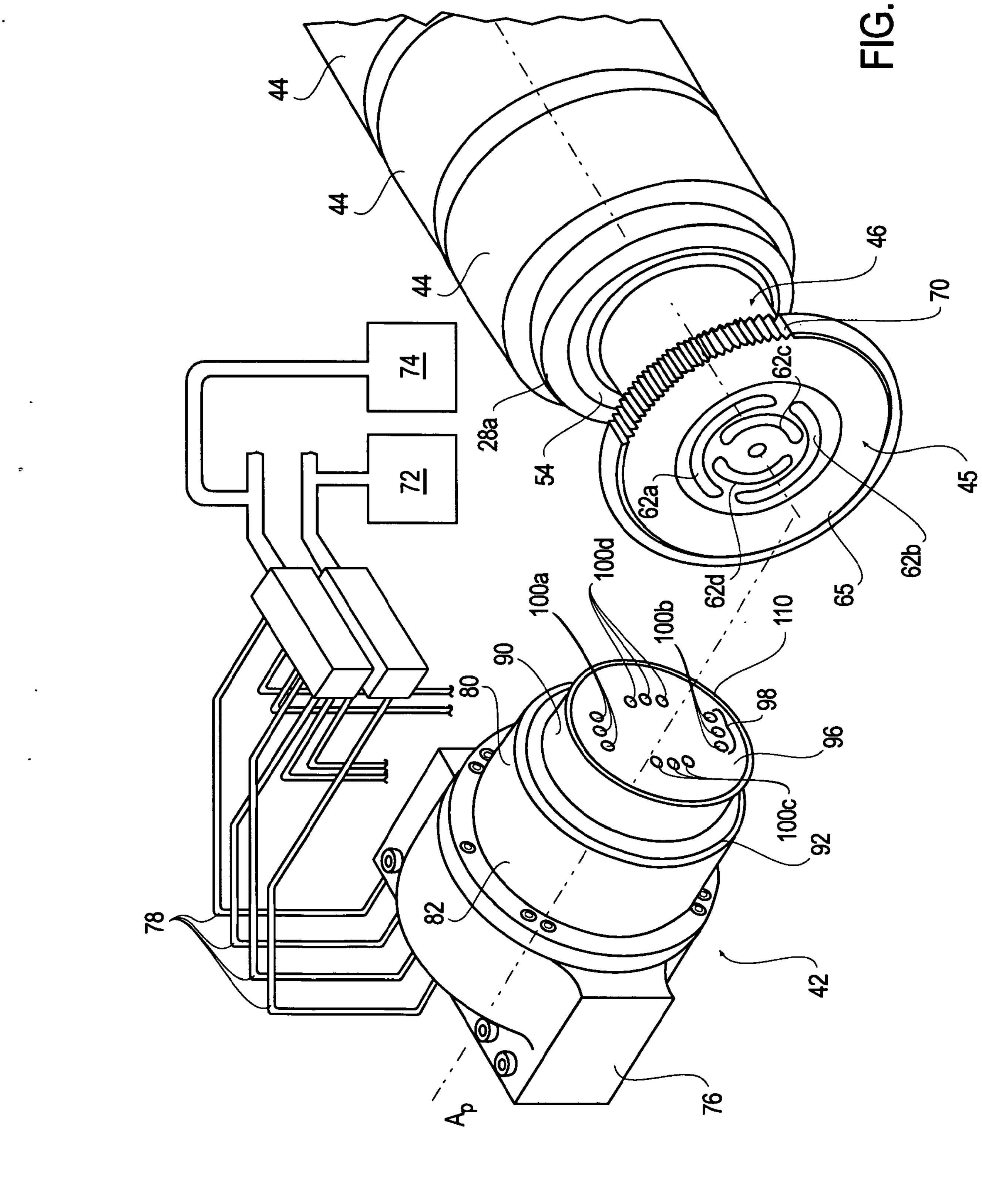
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FIG. 5

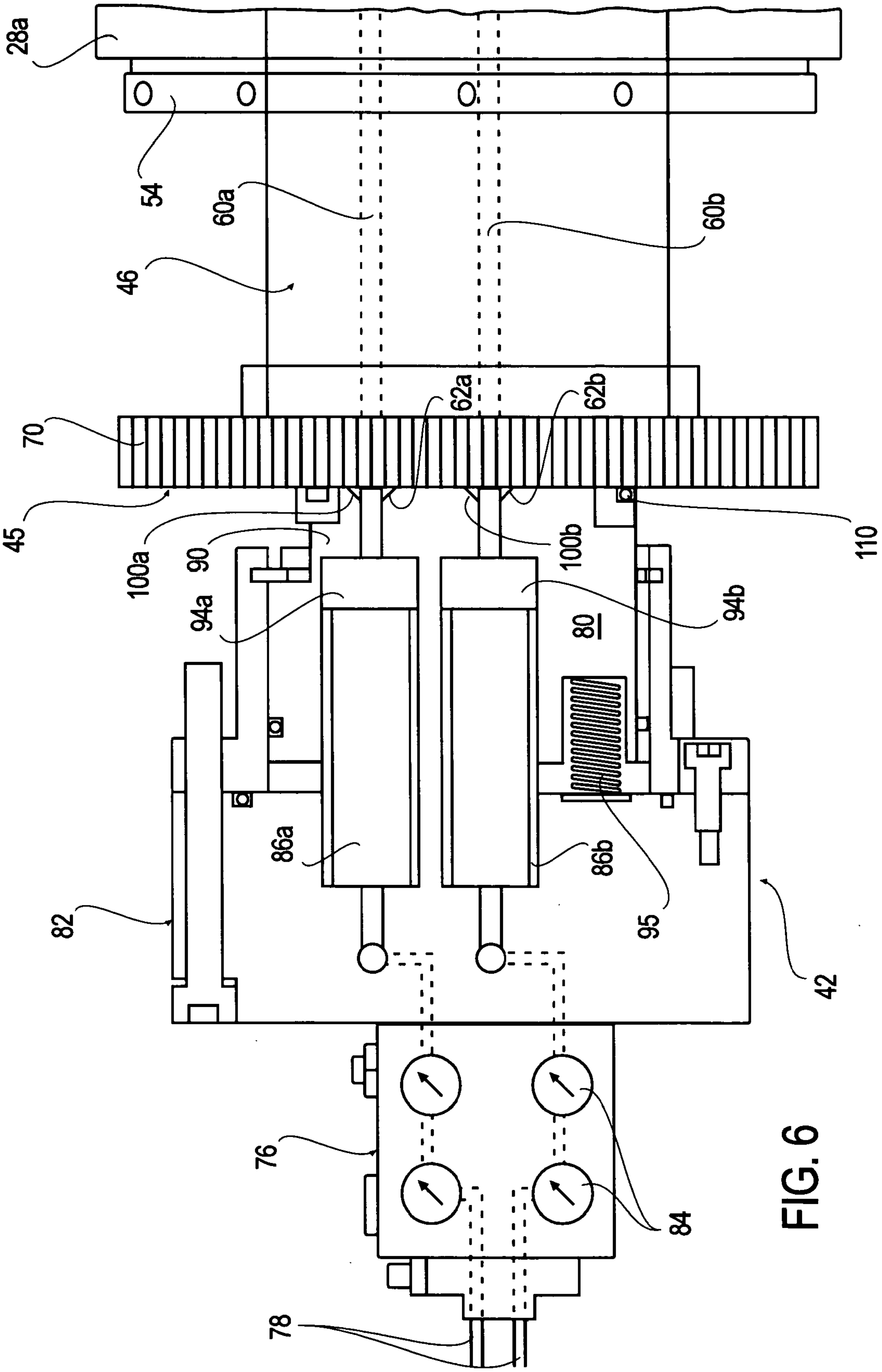
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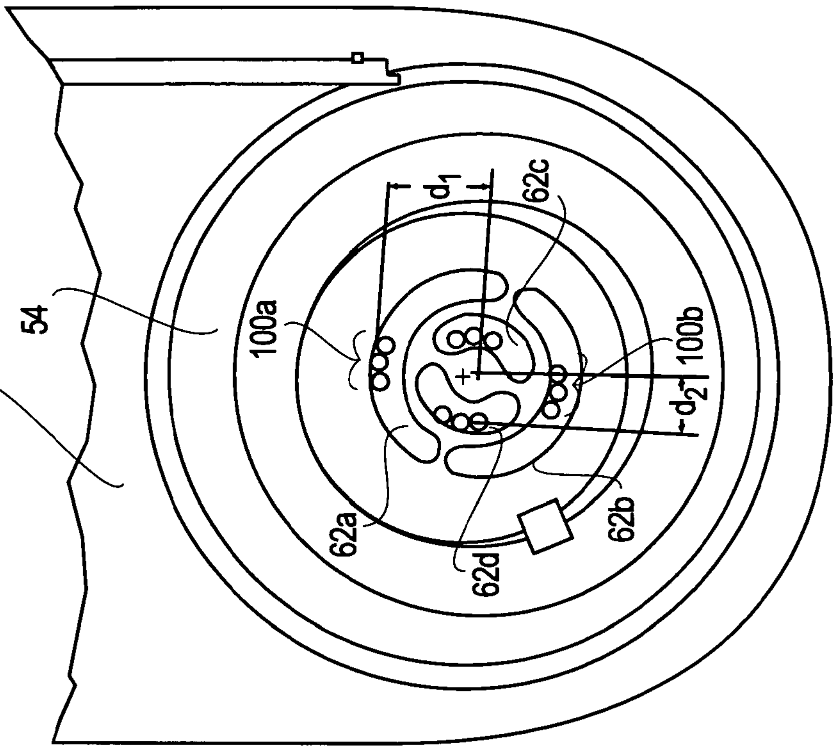
FIG. 6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d2
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62d
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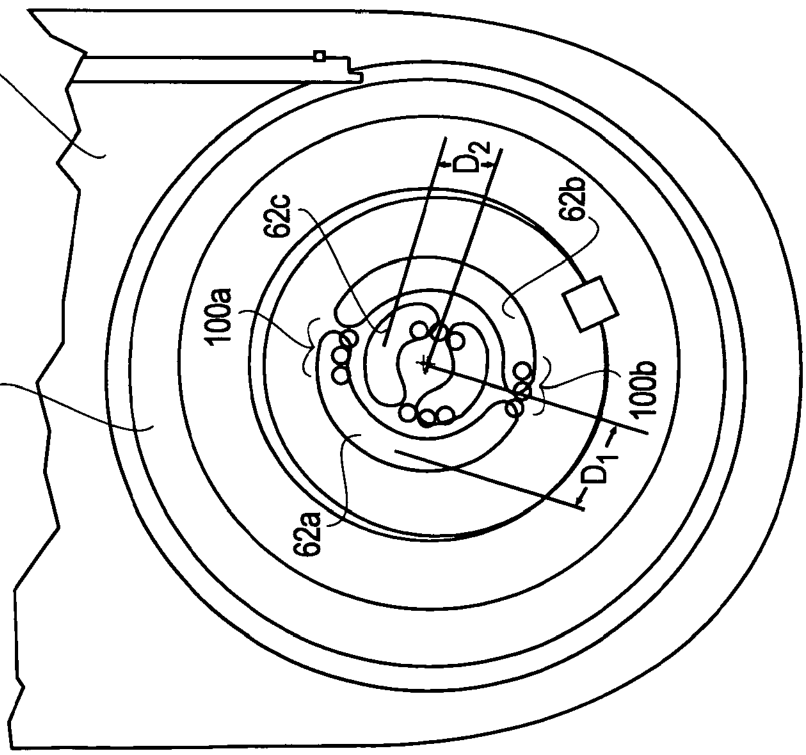
FIG. 8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D2
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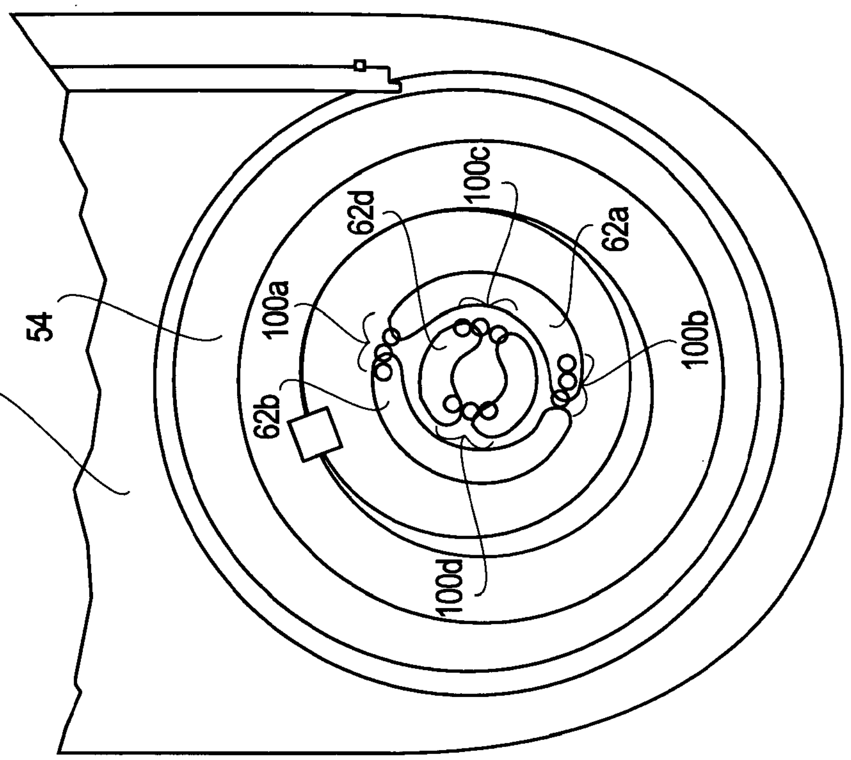
D1
62a

FIG. 7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62d
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FIG. 10

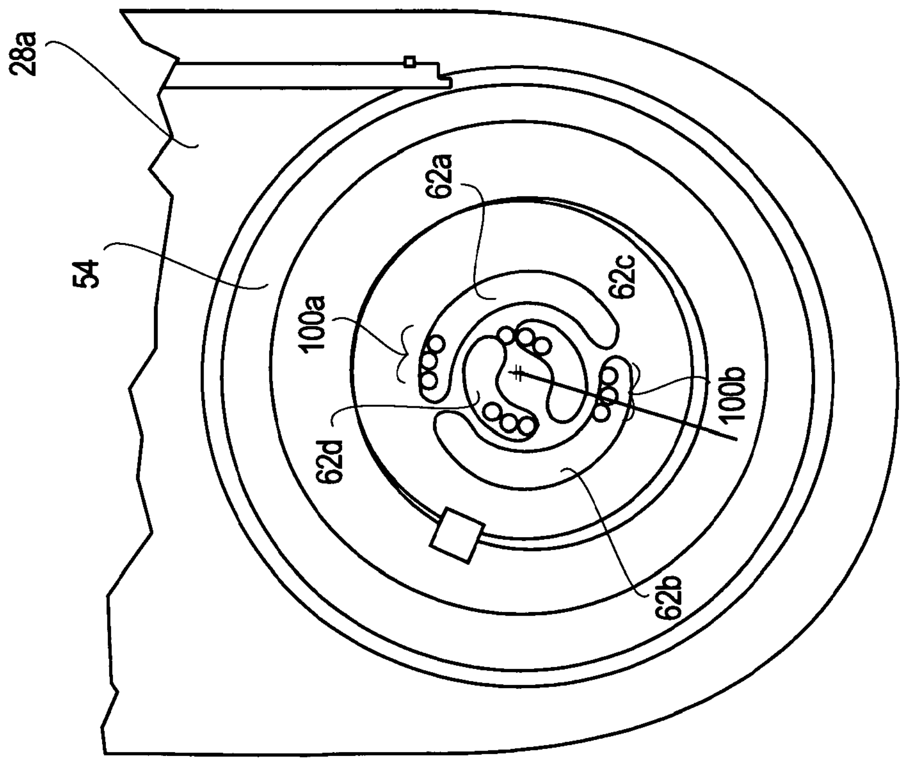
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FIG. 9

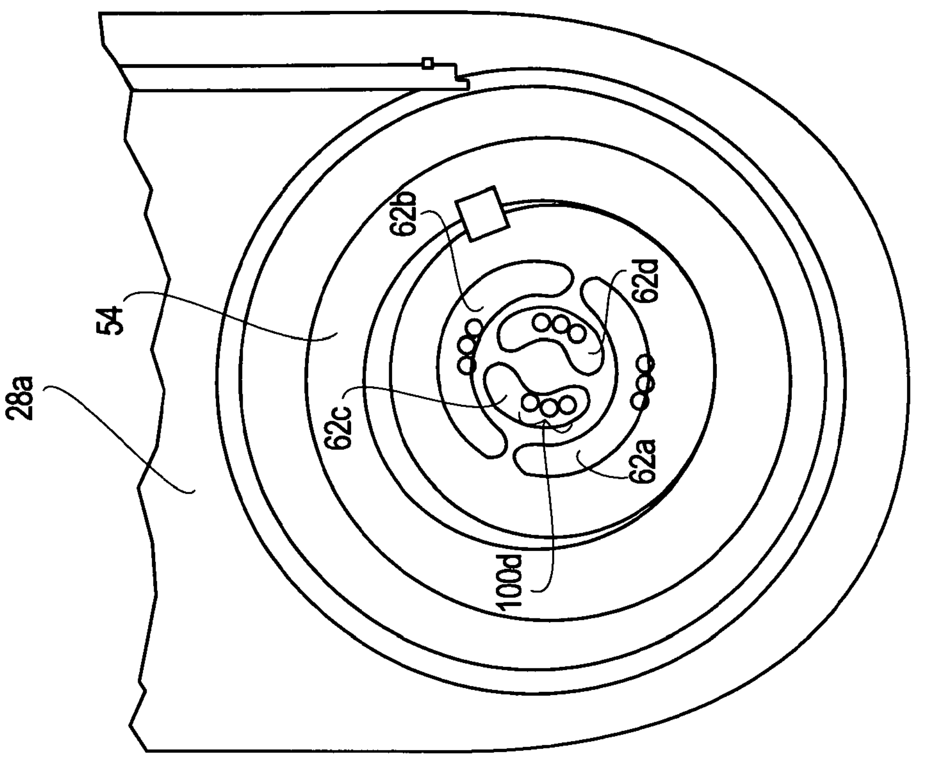
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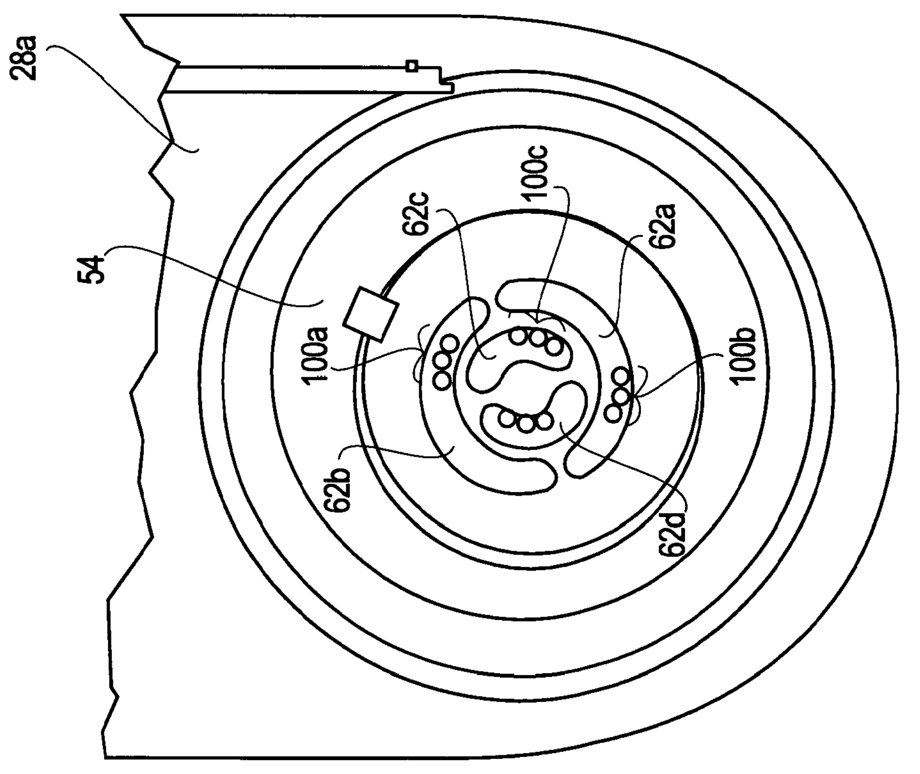
FIG.12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100c
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100b
62b
62d

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US07/20890

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **B21B 27/06**(2006.01),**29/00**(2006.01)

USPC: 72/242.4,43
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 72/242.4, 241.2, 242.2, 41-45, 199-252.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2,776,586 (Sendzimir, T.) 8 Jan. 1957 (08.01.1957), column 8 lines 6-11	1-21
A	US 5,193,377 (Sendzimir et al) 16 March 1993 (16.03.1993), column 8, lines 1-4	1-21
A	US 5,471,859 (Sendzimir et al) 5 Dec. 1995 (05.12.1995), column 9 lines 5-9	1-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
11 August 2008 (11.08.2008)

Date of mailing of the international search report
27 AUG 2008

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