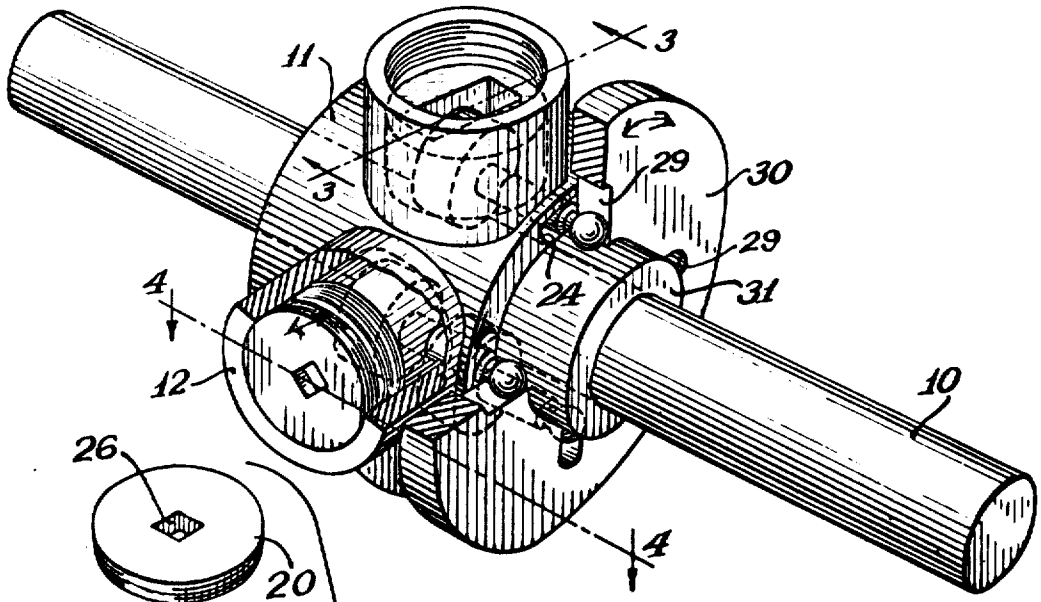
July 31, 1973 J. P. STEIBEL Re. 27,711

CONTROLLABLE MOTION AND FORCE CONVERTER

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FIG. 1.



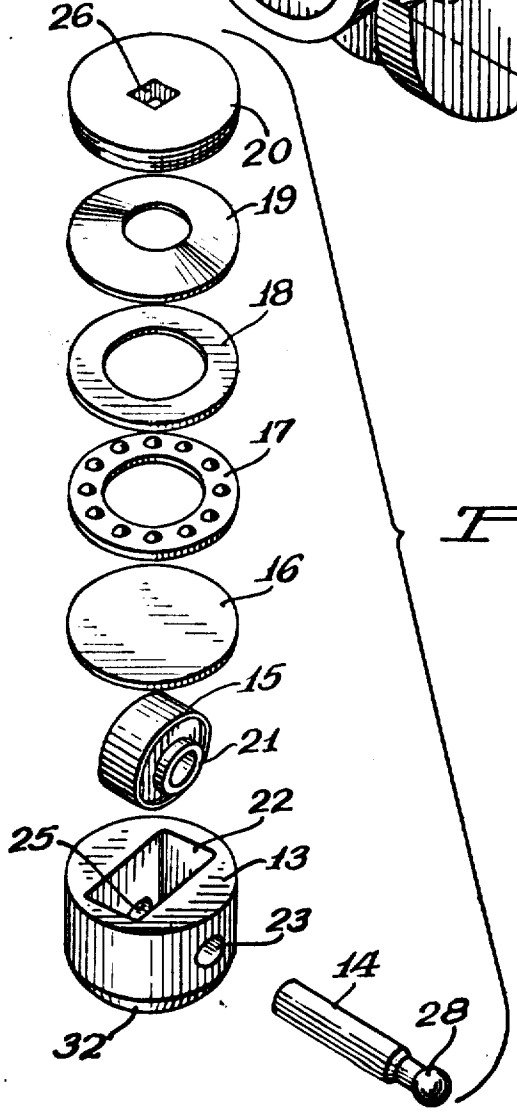


FIG. 2.

FIG. 3.

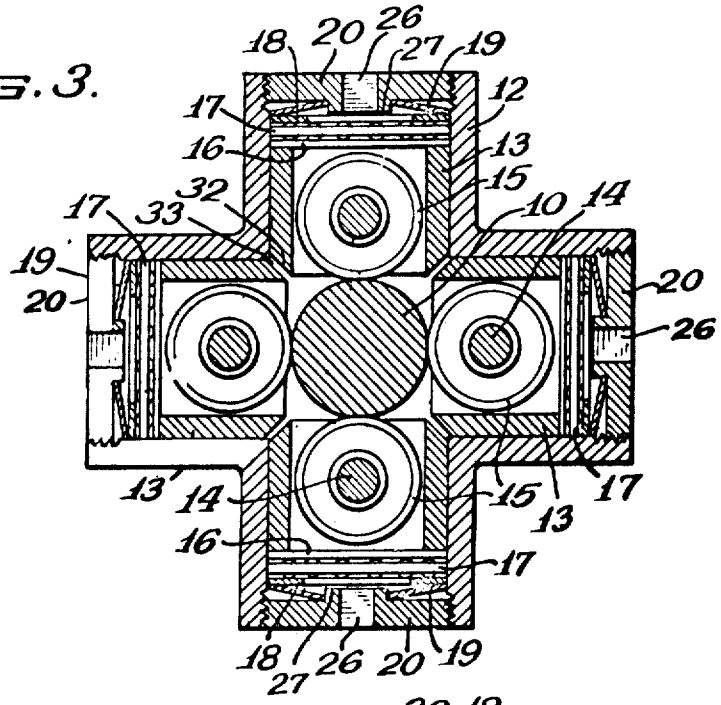


FIG. 4.

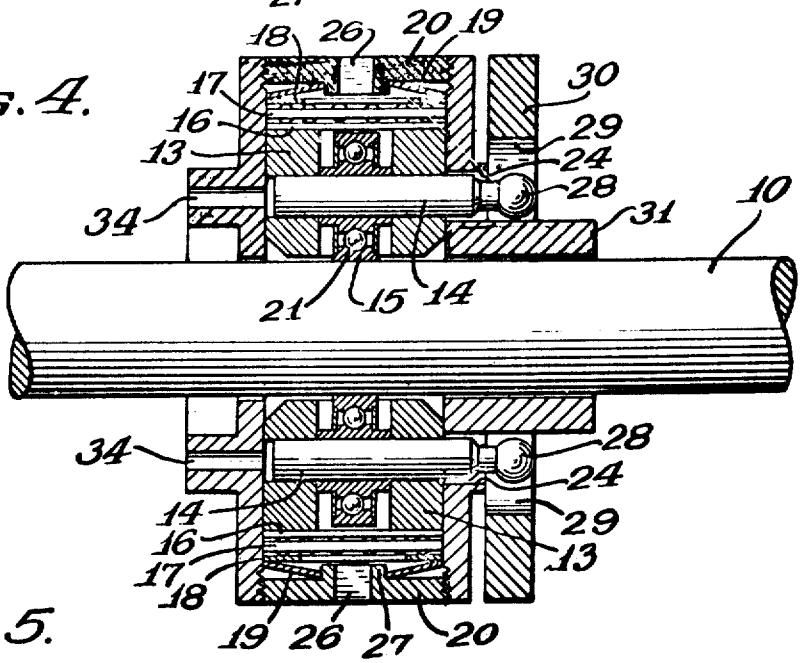


FIG. 5.



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Fig. 6a.

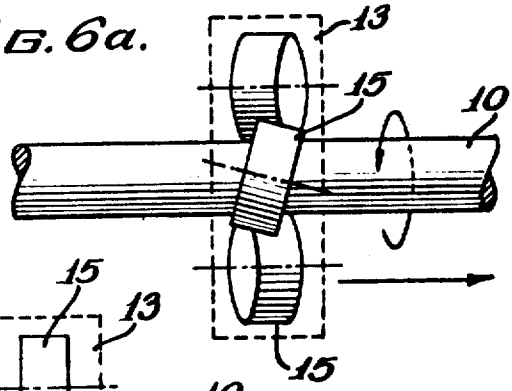


Fig. 6b.

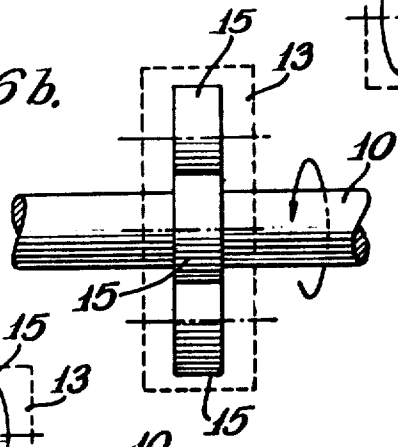


Fig. 6c.

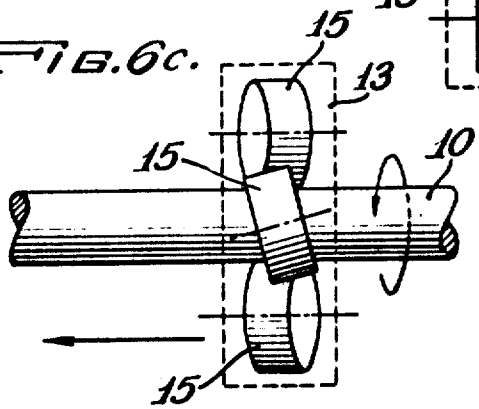
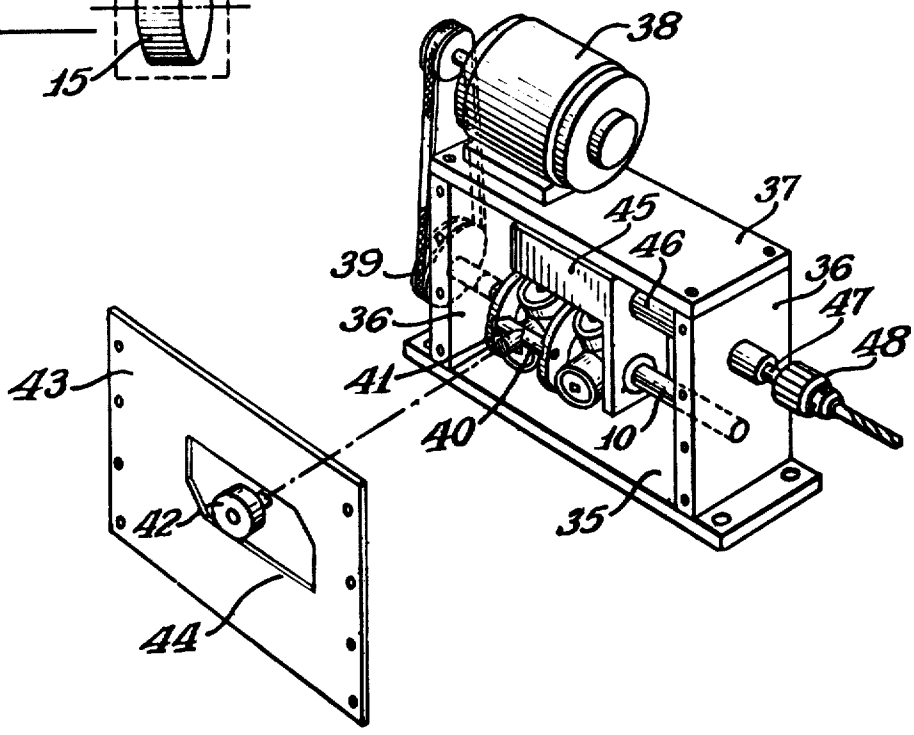


Fig. 7.



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Fig. 8.

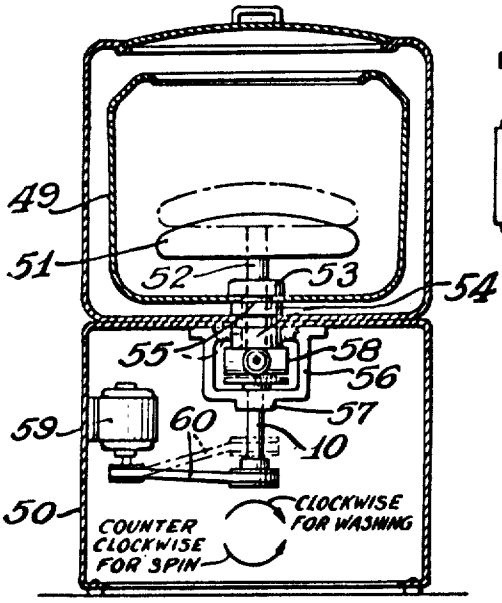


Fig. 9.

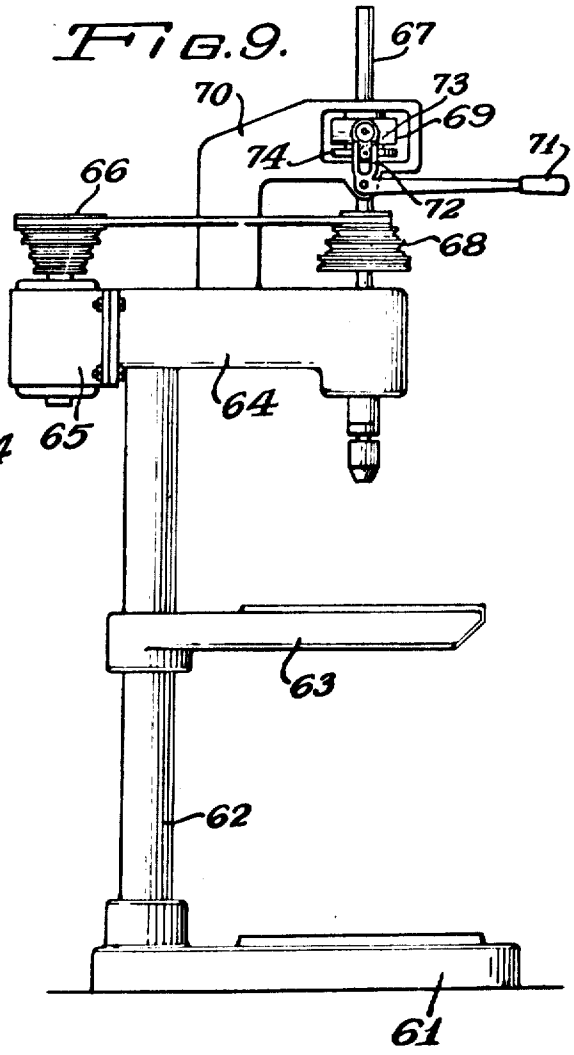
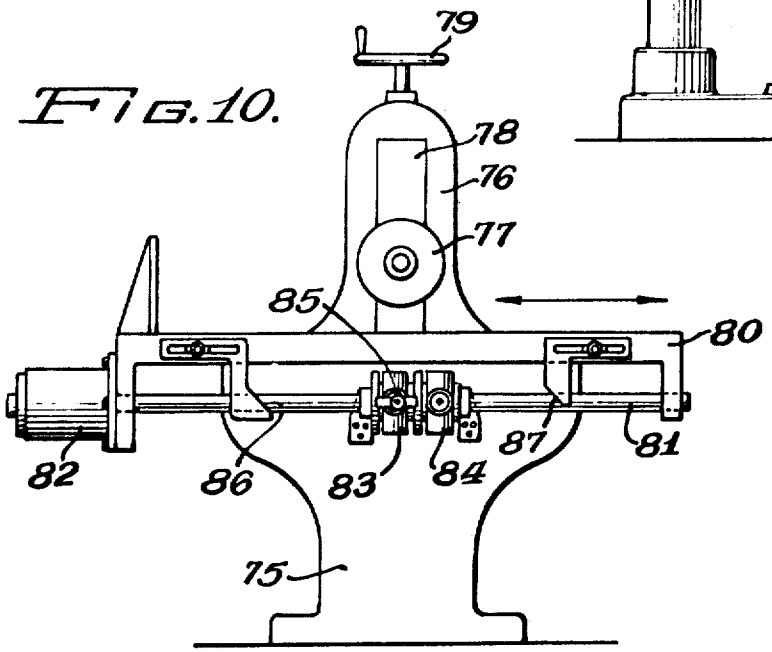


Fig. 10.



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FIG. 11.

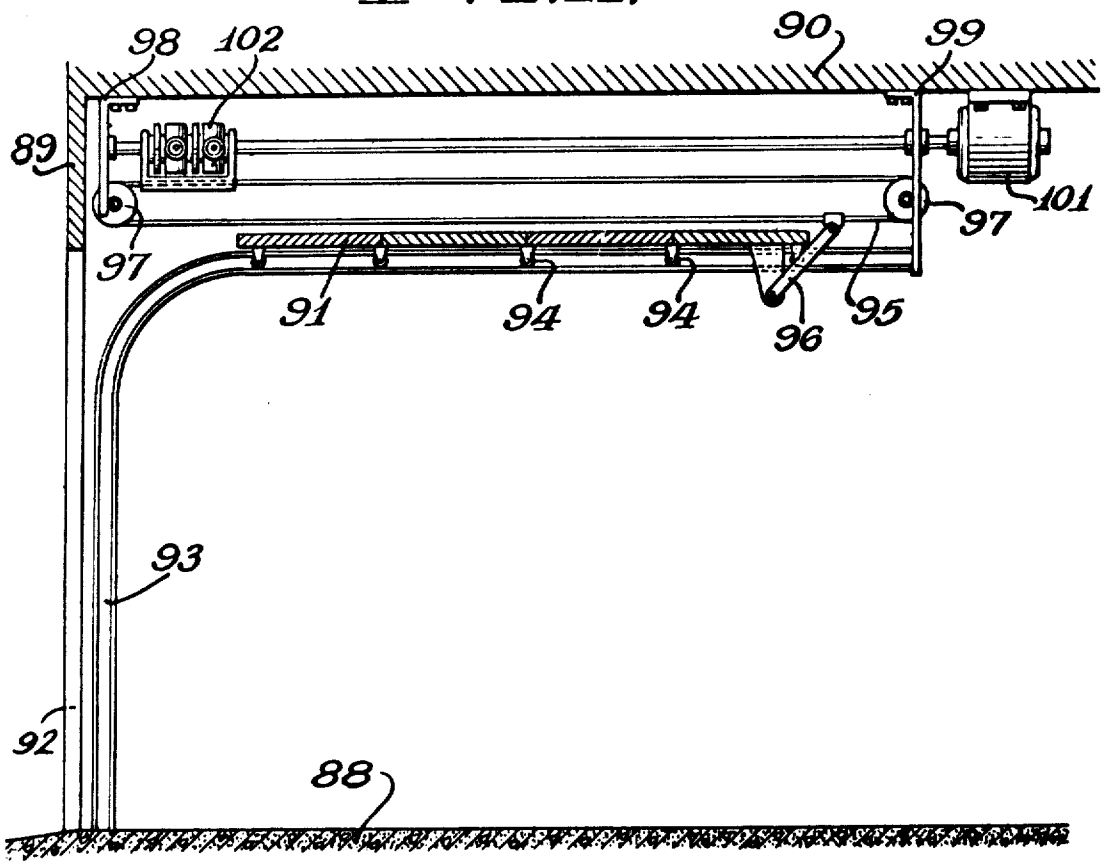
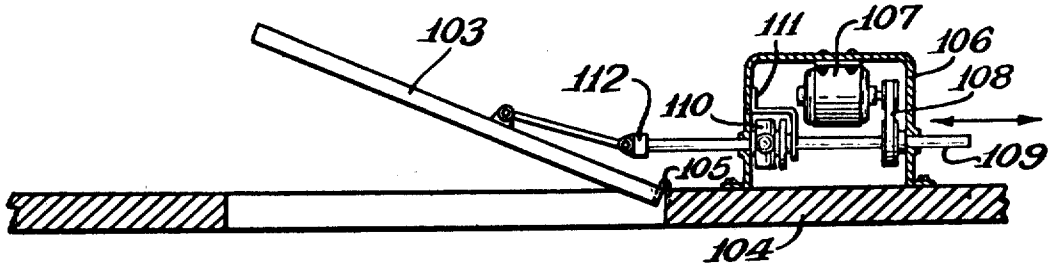


FIG. 12.



United States Patent Office

Re. 27,711
Reissued July 31, 1973

27,711

CONTROLLABLE MOTION AND FORCE CONVERTER

James P. Steibel, Sturtevant, Wis., assignor to The Dumore Company, Racine, Wis.

Original No. 3,475,972, dated Nov. 4, 1969, Ser. No. 809,462, Mar. 7, 1969, which is a continuation of Ser. No. 706,063, Feb. 16, 1968, which in turn is a continuation-in-part of Ser. No. 628,678, Apr. 5, 1967, both now abandoned. Application for reissue Apr. 6, 1970, Ser. No. 26,180

Int. Cl. F16h *21/16*

U.S. Cl. 74—25 13 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

A device for converting a torque force into a linear force directed parallel to the axis of the torque force comprising a rotatable shaft onto which a torque force is applied, a housing surrounding the shaft, the housing including a plurality of bearings each having its outer race peripherally engaging the periphery of the shaft, to be rotatably driven by said shaft about their own axes but being movable axially of the shaft, bearing pivot means for pivoting each bearing about an axis that is perpendicular to both the axis of the bearing and the axis of the shaft, so that a force component is transmitted from the shaft to the bearing which is manifested by development of a force parallel to the axis of the shaft which tends to effect relative movement between the shaft and frame in directions axially of the shaft, and a controller means for selectively effecting substantially identical pivoting of all bearings simultaneously.

This application is a *reissue of U.S. Pat. No. 3,475,972 which was* a continuation of [my copending] application Ser. No. 706,063, filed Feb. 16, 1968, now abandoned for "Controllable Motion and Force Converter," which *was* [is] a continuation-in-part of [my copending] application, Ser. No. 628,678, filed Apr. 5, 1967 now abandoned, for "Threadless Screw Device." The disclosure of said Ser. No. 628,678 is incorporated herein by reference in its entirety.

This invention relates to a device for converting a torque force or rotary motion into a linear force or linear motion having a component parallel to the axis about which the torque force is applied.

Rotary devices, such as electric motors, are the most popular source of work force in use today. The force derivable from the shafts of such rotary devices is a torque force. In many situations it is desirable to convert such a torque force into a linear force, and others have heretofore attempted to devise many different apparatus for such conversion.

The use of a helical inclined plane, appearing most commonly in the form of a screw thread, is one basic type of machine for conversion of a torque force into a linear force. Others have attempted to expand on this ancient and basic concept to provide a form of helical arrangement between a rotating drive shaft and a linear movable part so as to provide for prosecution of motion or force axially of the shaft. Such attempts include Wolff 2,152,518; Prinz 2,234,274; Weathers 2,619,346; Preskitt 2,912,868; Uhing 2,940,322; Pravel 3,046,801; Hauptman 3,081,639; and Hug 3,178,949. Such prior attempts have had limited, if any, success and recent disclosures have resorted to complexity of construction without corresponding increase in claimed benefits or capacity of utility. In a number of instances in the prior art desirable results are sought on employment of large diameter roller means which embrace and surround a rotating shaft of smaller diameter at points spaced axially of the shaft, or by use of smaller diameter rollers engaging the inner wall of a hollow shaft along an axially elongated portion of the shaft.

Thus, one object of this invention is to provide a new and improved device for converting a torque force into a linear force, and vice versa, which device includes new multiple means for control, the availability of which affords great flexibility in achieving variable output from the device.

Another object of this invention is to provide, in an improved device for converting torque force into a linear force, and vice versa, a novel first control for simultaneously, simply, and precisely selectively varying the angle of pitch between the rollers and the shaft, and second control means for selectively individually controlling the bearing force between each roller and the shaft.

Another object of this invention is to provide a multiple axes bearing assembly for use in the controllable motion and force converter device which lends itself to use with the pitch control and bearing force control means of the invention.

It is still another important object of the present invention to provide a motion translating device which is capable of producing a substantial amount of linear thrust with variable feed while economizing on cost and space limitations and which is adaptable for easy tandem mounting (thereby multiplying deliverable thrust) without complex controls.

Still further objects of the invention can be gathered by reference to the following descriptions, drawings and claims, it being noted that the invention may be utilized in multiple applications (i.e., work in on shaft-work out on frame or vice versa).

BRIEF DESCRIPTION OF THE DRAWING

The motion translating device of the present invention is illustrated with reference to a specific embodiment, together with a number of specific illustrations showing the practical application of the device, in the following drawings in which:

FIG. 1 is a perspective view, partly in section, of one embodiment of the motion translating device of the invention;

FIG. 2 is an exploded view showing a subassembly of FIG. 1;

FIG. 3 is a sectional view of the device of FIG. 1 along line 3—3;

FIG. 4 is a sectional view of the device of FIG. 1 taken along line 4—4;

FIG. 5 is a sectional view of another embodiment of the pin shown in FIG. 2, as hereinafter described;

FIGS. 6a, 6b and 6c illustrate the physical principles governing movement of the device of the present invention;

FIG. 7 is a schematic view, partly exploded, showing the use of tandem mounted devices of the present invention in an automatic or semi-automatic drill;

FIG. 8 is a schematic view showing the use of the device of the invention in an automatic laundry washer;

FIG. 9 is a schematic view showing the application of the device of the invention in a semi-automatic drill;

FIG. 10 is a schematic view of a surface sander or grinder employing an embodiment of the present invention;

FIG. 11 is a schematic view of a garage door opener using an embodiment of the present invention; and

FIG. 12 is a schematic view of a swinging door opener using an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a central shaft or tube **10** having mounted thereover a frame or housing **11**. On housing **11**, there are four wells or socket-defining portions **12** (only two of which are shown) integrally joined thereto and forming a part thereof. Wells **12** are bores radially extending from the shaft with the axes of the bores perpendicular to the axis of the shaft. Within each of the wells **12** there is mounted a bearing assembly, which in the present embodiment is a ball bearing assembly. The elements of the ball bearing assembly are more clearly shown in FIG. 2, which also shows illustrative additional elements useful, when assembled, in controlling the pressure of the bearing on the shaft. Referring to FIG. 2, there is shown a ball bearing housing or carrier **13**, a pin **14**, a ball ring unit **15**, a bearing plate **16**, a bearing **17**, a bearing washer **18**, a spring washer **19**, and a threaded screw plug **20**. Ball bearing unit **15** has a friction-reducing bearing element **21** for mounting the ball bearing assembly on pin **14**. The ball bearing housing **13** has an opening **22** for receiving the ball bearing assembly and holes **23** and **25** for receiving pin **14**.

When the ball bearing assembly is to be placed in a socket defining portion or well **12**, the ball bearing housing or carrier **13** is first inserted into socket defining portion **12**, then ball bearing unit **15** is dropped into opening **22** of the ball bearing housing, and a pin **14** is introduced into an opening **24** in the main housing unit **11** through the hole **23** and a bore in bearing element **21** to the corresponding hole **25** on the opposite wall of the opening **22**. The inner cylindrical surface of socket defining portion **12** provides a bearing surface for ball bearing housing **13** so that the latter can rotate therein. The seating of pin **14** within the ball bearing housing **13** is more clearly shown in FIG. 4, to be described below. After the pin **14** has been inserted, the bearing plate **16** is placed on top of ball bearing housing **13** and the bearing **17**, bearing washer **18**, spring washer **19** and threaded screw plug **20** are mounted in the order shown in FIG. 2. The threaded screw plug **20** is threaded into the socket defining portion **12**. The plug **20** has a slot **26** for receiving an Allen type wrench to raise or lower plug **20** within well **12**. The lower side of plug **20** has a boss member **27**, shown in FIGS. 3 and 4, which extends into the opening of the spring washer to hold the spring washer in position when the plug **20** is raised or lowered. By adjusting the vertical position of plug **20**, it can be seen that force will be transmitted through the elements of the ball bearing assembly to ball bearing unit **15**. In this manner, the bearing pressure between ball bearing assembly **15** and the central shaft **10** can be adjusted by adjusting the position of plug **20** in well **12**. The housing **11** is not in direct contact with central shaft **10** and only indirectly contacts the shafts through the ball bearing units **15**.

As shown in FIG. 2, pin **14** is of generally cylindrical configuration having one end terminating in a spherical or ball portion **28**, although the specific configuration is not critical. Pin **14** is of sufficient length so that when it is inserted into the ball bearing assembly, the spherical portion **28** extends through slot **24** of housing **11** to rest in a slot **29** on a control plate **30**, as shown in FIG. 1. The holes **23** and **25** on ball bearing housing **13** are of a size to permit a tight fit with pin **14**. When the ball bearing assembly is put together the entire assembly will move with pin **14** as a substantially rigid unit. The slot **24**, as can be seen from FIG. 1, is shaped to permit lateral movement of the spherical portion **28** of pin **14**. Thus the axis of pin **14** may be made to be parallel to the axis of the central shaft **10** or to form an angle therewith. The positioning of the pin **14** controls the amount and the direction of linear motion of the shaft vis-a-vis the frame or housing as more clearly indicated in FIGS. 6a, 6b, and 6c.

Referring to FIG. 6b, the central shaft **10** is driven by a motor or other means (not shown) in a rotary motion. The ball bearing units **15** are shown in a position where the axes of their pins **14** are parallel to the axis of shaft **10**. In this arrangement, the outer races of the ball bearing units **15** will contact and rotate around shaft **10** without imparting axial motion to the frame or housing relative to the shaft **10**. The system is in an idle position. In FIG. 6a, the axes of pins **14** of the ball bearing units **15** form a small angle with the axis of the shaft **10** to cause the outer races of the ball bearing units to travel a helical path on the surface of shaft **10** when the shaft is rotated. When the central shaft is rotated in the direction as indicated in FIG. 6a and the frame is held rotationally motionless, the frame, in contact through the ball bearing assemblies, will travel on the shaft from left to right. In FIG. 6c, the axes of pins **14** of the ball bearing units **15** are inclined in a direction opposite to that shown in FIG. 6a. If the central shaft is rotated in the direction as indicated in FIG. 6c, and the frame is held rotationally motionless, the frame, in contact with the shaft through the ball bearing assemblies, will travel on the shaft from right to left.

Numerous variations in work-in, work-out applications of the device of my invention are possible without material hardware modification. For example, it should be evident that the device may be usefully employed by:

(1) Holding the frame axially and rotationally motionless, imparting a desired pitch angle to the various ball bearing units in pressure contact with the shaft, and rotating the shaft either clockwise or counterclockwise with respect to the frame, resulting in axial movement of the shaft.

(2) Holding the shaft axially and rotationally motionless, imparting a desired pitch angle to the various ball bearing units in pressure contact with the shaft, and rotating the frame either clockwise or counterclockwise with respect to the frame, resulting in axial movement of the frame.

(3) Holding the shaft axially motionless, imparting a desired pitch angle to the various ball bearing units in pressure contact with the shaft, and axially moving the frame while holding the frame rotationally motionless,

(4) Holding the frame axially motionless, imparting a desired pitch angle to the various ball bearing units in pressure contact with the shaft, and axially moving the shaft while holding the shaft rotationally motionless, resulting in rotational movement of the frame.

Referring again to FIG. 1, the housing **11** is shown to have a hub **31**. Over hub **31**, there is provided in sliding engagement a control plate **30** having slots **29** thereon. As indicated above, the spherical portions **28** of pins **14** terminate and rest in slots **29**. It should be evident that the precise configuration of spherical portion **28** is not critical and the contact between the pivot pins **14** and control plate **30** may be made in various ways in keeping with the principles of my invention. Slots **29** are constructed to provide a relatively tight fit for the spherical portions **28** so that the pins **14** will not be able to move laterally when control plate **30** is held stationary. It is clear, therefore, that by revolving control plate **30** slightly in either direction of neutral, the axes of the pins **14** will be shifted or steered to a position non-parallel to the axis of shaft **10**. In this manner, through use of the ball bearing assemblies pivotally operating within the socket defining portions **12** of the frame **11**, movement of control plate **30** will control the direction and the speed of linear movement of shaft **10** relative to the frame **11** when motion is imparted to either the frame or the shaft from an outside source. Various means of positioning control plate **30** are shown in FIGS. 7 et seq. It should be noted that the slots **29** on the control plate **30** should be so located as to synchronize the pivoting of the ball bearing assem-

blies so that each ball bearing unit **15** cooperates with every other one to produce the maximum amount of linear thrust, and to minimize vibration and wear of the component parts.

In FIG. 3, a sectional view of the device of FIG. 1 along line **3—3** is shown. In this drawing, the central shaft **10** is shown to be surrounded by four ball bearing units **15** although it is clear that more or less than four units can be used. I have found, however, that the use of four ball bearing units optimizes the advantages of my invention and that tandem mounting of four-ball-bearing-unit devices is preferable to increasing the number of ball bearing units thereby apparently decreasing the area of contact with the shaft resulting from the use of smaller diameter ball bearing units. The outer races of the ball bearing units are the only elements in direct contact with shaft **10** and all remaining structure is supported on the shaft through the ball bearing units. Referring to one of the ball bearing units and its associated elements in FIG. 3, it is seen that in socket defining portion **12** there is placed a roller housing or cage **13** in snug fit but not such as to prevent a sliding action between socket defining portion **12** and ball bearing housing **13**. Ball bearing housing **13** is shown to have a bevelled bottom portion **32**, as also is shown in FIG. 2, to provide a clearance **33** between neighboring ball bearing housing or cages **13**. The clearance **33** separates the neighboring ball bearing housings but the bevelled bottom portions **32** cooperate to prevent the ball bearing units **15** and their housings **13** from dropping into the center of the overall housing **11** when the shaft is removed. The plug **20** is threaded into the top threaded portion of socket defining portion **12** and presses the assembly in a downwardly direction to force the ball bearing unit into frictional contact with shaft **10**. Through boss member **27**, plug **20** maintains the spring washer **19** in position and exerts a force thereon. In its turn, spring washer **19** presses on a force-distributing washer **18** which rides on bearing **17**. Bearing **17** presses on the bearing plate **16** which transmits the force onto the top of ball bearing housing **13**. The outer surface of the ball bearing unit and the surface of the shaft or tube **10** are preferably heat treated to provide case hardened steel wearing surfaces to minimize wear and damage, thus increasing their useful life. I have found that I can optimize the high thrust characteristics of the device by use of various types of oil which possess unusual properties. The use of these oils apparently causes increased friction at points of high pressure. Thus, at the points of contact between the ball bearing units and the shaft, friction is apparently increased because of the use of the special oil.

FIG. 4 is another sectional view of the device of FIG. 1, taken along line **4—4**. In this figure the pin **14** is more clearly shown in position within the assembly. Thus, pin **14** is relatively tightly held in place by the ball bearing unit housing **13**. For ease in removing pin **14** when disassembling the unit, a hole **34** is provided on ball bearing unit housing **13** for insertion of an instrument to knock out the pin **14** through slots **24** and **29**. It should be noted that both slots **24** and **29** have sufficient vertical clearance for pin **14** to allow movement of the pin due to the action of the control plate **30** or the spring washer **19** on the pin.

FIG. 5 shows a cross section of a modified pin **14**. The pin in FIG. 5 has a hollow central portion and a longitudinal open slot on its surface substantially along the entire length of the body portion of the pin. This embodiment of pin **14** permits less precise machining of the pin and still obtain the desired tight fit as herein described.

FIG. 7 shows schematically an application of the device of the present invention in an automatic drill mechanism. In this drawing, there is shown a base **35** having two substantially parallel side walls **36** thereon which support a top wall **37**. A shaft **10** is mounted on vertical walls **36** to permit rotation of the shaft. A motor **38** and pulley means **39** are provided for rotating shaft **10**. On the shaft, there are provided two tandemly mounted units on the device shown in FIG. 1. As is clear from the present description, more than one unit of the device of the invention may be used to produce the desired amount of linear thrust. When two or more units are employed as shown in FIG. 7, they should be synchronized in that the control plate of each unit is rigidly attached to all other control plates so that they move in unison and in the same manner. This is accomplished in the embodiment of FIG. 7 by means of a rigid bar **40** securely attached to both of the control plates of the two units. More than one such structural bar may be necessary to maintain the control plates in synchronization, depending on the particular situation. Also rigidly attached to the bar member **40** is a shaft member **41** which serves as the axle for roller **42**. A template **43** is mounted on base **35**, vertical walls **36** and top wall **37**. In FIG. 7, the template **43** is shown away from the base and wall members for clarity. Roller **42** rides on a cutout portion **44** on the template **43**. When motor **38** and pulley means **39** activate shaft **10** to cause the shaft to rotate, and when the control plates of the two devices are initially in a non-neutral position, the ball bearing units within the devices will travel on shaft **10** in a helical pattern either to the left or to the right, depending on the initial positioning of the control plates as explained above in connection with FIGS. 6a, 6b and 6c. When linear motion with respect to the shaft **10** is thus produced the roller **42** will travel along the edges of the cutout portion **44**. It will be recognized that the cutout portion **44** defines a time-motion cam control for roller **42**. Variations of this type of cam control are well known to those skilled in the art. The roller **42** may be firmly held against the periphery of the cutout portion **44** by the use of well-known pneumatic, solenoid or other devices (not shown) which will prevent the roller from damping out, i.e., seeking a neutral position during operation. The rotation of the two control plates will thus cause the ball bearing units to reposition themselves according to the predetermined path dictated by the pattern of the cutout portion **44** in cam template **43**. Mounted on the two units of the device of the invention, and made integral thereto, is a housing **45**. Secured to housing **45** is a cylindrical bushing or bearing member **46** for holding a shaft or spindle **47** of a drill **48**. By the linear motion of the two units of the motion translating device of the invention, drill **48** is caused to move in parallel direction. The drill may be independently powered in any conventional manner, for example, the drill may be operated by compressed air or it may be driven directly through V-belt connection with motor **38**. It is clear that the device described and shown in FIG. 7 may be used for automatically drilling or otherwise working on a large number of production units in an assembly line where one or more holes are to be repeatedly drilled into the product.

An automatic drill mechanism similar to that shown in FIG. 7 was made and operated for more than one million drill cycles, at about 50 drill cycles per minute. The drill mechanism was found to operate entirely satisfactorily and substantially as described above. Although two units of the device of the invention were used in that drill mechanism, it should be understood that the number of units used is governed by space and thrust requirements and may be readily varied.

FIG. 8 shows a schematic view of a washing machine partly in section. It is well known that a tumbling action or reciprocating vertical motion within the washing tub is sometimes desirable. Such a vertical motion is easily obtainable by use of a form of the device of the present invention. Referring to FIG. 8, **49** designates a washing tub or the portion of a washing machine in which the soiled garments are washed, and **50** represents the lower housing of the washing machine wherein the mechanisms for operating the washing machine are located. Within the washing tub **49**, there is an agitating or tumbling element **51** which is mounted on a shaft **52** extending upwardly through a one-way clutch **54** to permit the shaft to both

rotate and to have a vertical motion. The one-way clutch is of the type that prevents rotational motion of a sleeve **55** in one direction but permits its rotational motion in the opposite direction. The washing tub **49** is mounted on a flange **53** of the sleeve **55**. Tumbler shaft **52** extends slidably and rotationally through the sleeve **55**. The one-way clutch **54** guides shaft **10** into operative engagement with the sleeve **55** and thereby with washing tub **49**. A supporting bracket element **56** is mounted on the inside ceiling of housing **50** to support and guide shaft **10** by means of a bearing member **57** attached to the bottom surface of bracket **56**. A unit **58** of the device of the invention as illustrated in FIG. 1 is mounted on shaft **10** within bracket **56**. Shaft **10** is caused to rotate by motor **59** and belt and pulley means **60**. When the motor **59** is rotating in one direction the unit **58** causes a tumbling action through shaft **10** communicating with tumbler shaft **52**. The one-way clutch **54** avoids any rotational movement of shaft **10** or tumbler **51** during the washing cycle. The unit **58** is held stationary within bracket means **56**. The belt and pulley means **60** and the tumbling element **51** thus move in a vertical direction as illustrated by the dash-lines in FIG. 8 during the washing cycle. Reversal of the motor **59** causes the unit **58** to assume a neutral position hence high speed spin drying may be accomplished without any tumbling action. The one-way clutch **54** provides operative engagement between shaft **10**, sleeve **55** during the high speed drying cycle. It is to be noted that the vertical displacement of the shaft is only of the order of magnitude of a couple of inches, which is relatively small as compared to the diameter of the washing machine so that the belt and pulley means **60** can withstand the slight twisting action caused by the vertical motion during the washing cycle.

FIG. 9 shows an embodiment of the invention being used in a semi-automatic drill press. The drill press is shown generally as having a base **61**, a vertical supporting column **62** extending upwardly from the base, a work supporting platform **63** attached horizontally to column **62** at a point above the base. A bracket **64** is mounted near the top of the column **62** for supporting the working elements of the drill press. A motor **65** is attached to one end of bracket **64** for powering belt and pulley means **66** which rotates a shaft **67** through pulley means **68**. Shaft **67** has the drill tool attached to its lower end and the shaft is caused to travel in a vertical direction by a unit of the device of the invention **69** mounted on a support **70** attached to bracket **64**. A handle **71** is shown operatively connected to a U-shaped level **72** for laterally steering guide roller **73** along a slot **74**. Guide roller **73** corresponds in function to the roller **42** in FIG. 7. Thus, by means of handle **71** the drill press is semi-automatically operated.

Turning to FIG. 10, there is shown a surface sander or grinder employing an embodiment of the present invention. The surface sander of FIG. 10 consists of a base **75** supporting a frame member **76** having mounted thereon a sanding element **77** which may be adjustably raised or lowered along a slot **78** by hand-operated turning means **79**. The sanding element **77** is rotated by a motor not shown. Slideably and horizontally mounted on base **75** is a table **80** having shaft **81** rotatably attached thereto. Shaft **81** is connected to a motor **82** for rotating the shaft. Two units **83** and **84** of the device of the invention are rigidly attached to each other and to the base **75**. Shaft **81** is inserted through the two units **83** and **84** and in engaging connection therewith. When motor **82** is turned on to rotate the shaft **81**, the shaft and the table **80** move back and forth in a horizontal direction while the two units **83** and **84** are held stationary with respect to the base **75**. Guide roller **85** on the two units of the device of the invention is controlled by cams **86** and **87** attached to table **80** for reversing the direction of travel of the shaft and the table. As heretofore discussed, the cam roller is firmly controlled by well-known cam actuator devices (pneumatic, solenoid, etc.) to prevent damping of the cam action toward a neutral position. In this manner, any work piece clamped onto table **80** may be subjected to repeated sanding activity by sanding element **77**.

FIG. 11 shows a garage door opener using an embodiment of the present invention. In FIG. 11, a garage for housing an automobile is shown constructed on a floor **88** and having vertical walls **89** (only a portion of the front wall is shown) and a ceiling **90**. A sectioned door **91** is in entrance **92**, mounted on tracks **93** via bracket and roller means **94**. The upper end of door **91** is attached to an endless cable **95** through bracket and pivoting element **96** so that the door will move along tracks **93** when the cable is moved in a horizontal direction. Cable **95** is supported on two pulleys **97** mounted on bracket means **98** and **99**. The two bracket means are attached to the ceiling of the garage and they also support a rotatable shaft **100**. Shaft **100** is rotatably mounted on the bracket means and rotated by a motor **101**. Two units of the device of the invention **102** are mounted over shaft **100** and fixedly attached to a point on cable **95**. Thus, when the shaft **100** is rotated the motion translating device **102** travels horizontally along the shaft and pulls the cable in the same direction. In this manner, the section door **91** is moved long tracks **93** in accordance with the motion of the device **102**.

Finally, FIG. 12 shows a swinging door opening device using an embodiment of the present invention. In FIG. 12, a door **103** is swingably mounted to a wall **104** through hinges **105**. A housing **106** is attached to the wall and contains a motor **107**, belt and pulley means **108**, a rotatable shaft **109** and a unit of the motion translating device of the invention **110**. Shaft **109** is rotatably and slidably mounted on the housing but the unit **110** is prevented from linear motion by a bracket **111** attached to the housing. Shaft **109** is attached to the door through a bearing element **112** which permits the shaft to both rotate and to move laterally. By this arrangement, it can be seen that the door **103** can be opened and closed by an electric eye and its associated electronic circuitry which would then activate the motor **107**.

The invention has been described in detail with particular reference to specific and preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

What is claimed is:

[1. A device for converting a torque force into a linear force directed parallel to the axis of the torque force comprising, in combination: a rotatable shaft onto which a torque force is applied; a frame closely surrounding the shaft and defining therein a plurality of socket defining portions; each of said socket defining portions containing an elongated pivotable bearing housing; a bearing of smaller exterior diameter than the diameter of said housing mounted in and substantially surrounded by said housing and said socket defining portion; each of said bearings having the periphery of its outer race engaging the periphery of the shaft, to be rotatably driven relative to said shaft about its own axis but being movable axially of the rotatable shaft; said bearing having surfaces in contact with said housing for transmitting forces to said housing; said housing having an exterior surface, at least a part of said surface is no farther from said rotatable shaft than the axis of said bearing and said part being in contact with said socket defining portion, for transmitting forces parallel to the axis of the rotatable shaft to said socket defining portion; pivot means for pivoting each bearing about the axis of the pivotable housing in which it is enclosed, so that a force component is transmitted from the rotatable shaft to the bearing and thence to the frame which is manifested by development of a force parallel to the axis of the shaft which tends to effect relative movement between the shaft and frame in directions axially

of the shaft; and controller means for selectively effecting substantially identical pivoting of all bearings simultaneously.]

[2. A device as in claim 1 wherein the bearing is slidably mounted radially of the rotatable shaft in said socket defining portion and connecting means serving as the pivot axis of the bearing and extending outwardly of the frame and connecting said bearing to said controller means whereby the position of the bearing in said socket defining portion may be controlled by said controller means.]

[3. A device as in claim 1 wherein the pivot means for pivoting each bearing includes an axial pin concentrically associated with said bearings, and projecting generally axially relative to the shaft to a point where it is engaged by the controller means.]

[4. A device as in claim 1 wherein the frame includes a plurality of socket-defining portions disposed radially of the shaft, each socket-defining portion having an inner cylindrical wall whose longitudinal axis is perpendicular to the axis of the shaft, a bearing carrier journalled in said cylindrical wall of the socket and having therein a bore whose axis is perpendicular to the longitudinal axis of the socket and a slot-like recess for slidably receiving a bearing, a pin in said bore having the bearing mounted thereon and serving both to maintain the bearing carrier spaced from the shaft when the bearing engages the shaft and serving as a lever for selectively pivoting the bearing about an axis perpendicular to the shaft.]

[5. A device as in claim 4 including selectively variable force means carried on the socket-defining portion and engaging the bearing carrier.]

[6. A device as in claim 1 wherein the frame includes a plurality of radially movable parts operatively associated with the bearings and having portions arranged to engage each other when the shaft is withdrawn from the frame, so as to maintain the bearings at a position to permit of re-entry and re-assembly of the shaft into the frame and between the bearings, and the bearings when operatively engaging the shaft serving to space said radially movable parts from said shaft and from each other.

[7. In a washing machine of the type having an agitator connected to a vertical shaft, said vertical shaft and said agitator having a vertical reciprocating tumbling action during the washing and a spinning action during the drying cycle of said washing machine, the improvement consisting of the device as in claim 1 wherein said vertical shaft is operatively connected through a one-way clutch to said rotatable shaft, an agitator operatively connected to said vertical shaft, so that when clockwise rotary motion is imparted to said shaft and said frame is held motionless, said vertical shaft and said agitator move vertically reciprocally according to a programmed pattern whereby a tumbling action is obtained and when a counterclockwise rotary motion is imparted to said shaft and said frame is held motionless, said vertical shaft and said agitator rotate at high speed without a tumbling action.]

[8. A device as in claim 2 including selectively variable force means carried on the socket-defining portion and operatively engaging said bearing assembly.]

[9. A device as in claim 1 wherein each of said bearing housing includes a radially movable means having portions arranged to engage each other when the shaft is withdrawn from the frame, so as to maintain the bearings at a position to permit the re-entry and reassembly of the shaft into the frame and between the bearings, and the bearings when operatively engaging the shaft serving to space said radially movable means from said shaft and from each other.]

10. A device for converting a torque force into a linear force directed parallel to the axis of the torque force comprising, in combination: a rotatable shaft onto which a torque force is applied, a frame surrounding the shaft, said frame including a plurality of similar bearings each having its outer race peripherally engaging the periphery of the shaft, to be rotatably driven relative to said shaft about its own axis but being movable axially of the shaft, pivot means for pivoting each bearing about an axis that is perpendicular to both the axis of the bearing and the axis of the shaft, so that a force component is transmitted from the shaft to the bearing which is manifested by development of a force parallel to the axis of the shaft which tends to effect relative movement between the shaft and frame in directions axially of the shaft, and controller means for selectively effecting substantially identical pivoting of all bearings simultaneously, said frame is elongated axially of the shaft to provide first and second frame ends having respectively first and second portions adapted for engagement and cooperation with second and first portions on adjacent similar frames, so as to afford multiplying the number of frames on a shaft for multiplying the linear force derivable from the torque force, and means interconnecting the controllers of each frame to cause said controllers to be moved identically in unison.

[11. A device for converting a torque force into a linear force directed parallel to the axis of the torque force comprising, in combination: a rotatable shaft onto which a torque force is applied, a frame surrounding the shaft, said frame including a plurality of similar bearings each having its outer race peripherally engaging the periphery of the shaft, to be rotatably driven relative to said shaft about its own axis but being movable axially of the shaft, pivot means for pivoting each bearing about an axis that is perpendicular to both the axis of the bearing and the axis of the shaft, so that a force component is transmitted from the shaft to the bearing which is manifested by development of a force parallel to the axis of the shaft which tends to effect relative movement between the shaft and frame in directions axially of the shaft, and controller means for selectively effecting substantially identical pivoting of all bearings simultaneously, and guide means extending parallel to said shaft and spaced therefrom and cooperating with the frame to prevent rotation of the frame relative to the shaft but accommodating movement of the frame axially of the shaft.]

[12. A device as in claim 11 in combination with second control means engaging the controller for selectively moving the controller relative to the frame, and positioning means operatively associated with the second control means for effecting pre-determined positioning of the controller depending upon the location of the frame axially of the shaft.]

[13. In a drilling machine of the type having a controllable reciprocating drill spindle the improvement consisting of the device as in claim 12 operatively connected to said reciprocating drill spindle so that when said shaft is held axially motionless and rotational motion is imparted to said shaft, said frame moves axially relative to said shaft according to a programmed pattern whereby a drill operatively connected to said drill spindle can perform a drilling function.]

[14. A threadless screw device having a shaft and a roller assembly, said roller assembly including a holder and a plurality of rollers mounted in said holder and engaging said shaft, the improvement comprising a carrier for each roller journaled in said holder, said holder providing a bore for each carrier, and said carrier having cylindrical surface portions engaging the wall of said bore at a position which is no farther from the shaft than the axis of the rollers, each roller being rotatably mounted within a carrier and surrounded by said bore, means extending transversely from each carrier for maintaining the axis of each roller in a predetermined angular relationship to a plane which includes the axis of said shaft, and means urging each roller into engagement with the surface of said shaft.]

[15. A threadless screw device as claimed in claim 14 in which said transversely extending means extends in a direction generally parallel to the axis of said shaft, and

control means rotatably mounted on said holder and engaging said transversely extending means so that in one angular position of said control means, said shaft axis and the axes of all of said rollers will be parallel to each other, whereby angular adjustment of said control means with respect to said holder will cause a uniform inclination of said roller axes with respect to said shaft axis.]

[16. A threadless screw device as claimed in claim 15 which includes a pin mounted in each carrier, each roller being journaled on a pin, said transversely extending means constituting an extended portion of each pin, the extended portion of each pin, terminating in a spherical portion, and said control means including a plurality of slotted portions, each one receiving one of said spherical portions.]

[17. A threadless screw device as claimed in claim 14 in which said holder is provided with an opening receiving said shaft, said bores being oriented perpendicular to the axis of said shaft and intersecting same, said bores being of a length greater than the axial length of said carriers, confining means located in each bore outwardly of said carrier, said roller urging means comprising a spring confined between each confining means and the carrier located in said bore.]

[18. A threadless screw device as claimed in claim 17 in which said carrier is a cylindrical member having a chamfered inner edge, said chamfered edges being normally spaced from each other, but engaging each other in abutting contact.]

[19. A threadless screw device as claimed in claim 17 in which said confining means comprises a screw threaded plug threaded into the outer end of each bore, a disc overlying said carrier, a ball bearing unit overlying said disc, and said spring means comprising a spring washer having its peripheral face portion engaging said ball bearing unit, and its central portion engaging said plug, said plug constituting means for adjusting the compression of said spring washer.]

[20. A threadless screw device as claimed in claim 14 in which said holder is provided at one end with a hub, and a sleeve at the other end of said holder having an inner surface of a diameter equal to the diameter of the outer surface of said hub.]

[21. A threadless screw device as claimed in claim 15 in which said holder is provided at one end with a hub, said control member comprising a slotted disc mounted on said hub for angular adjustment, and a collar at the other end of said holder having an inner surface of a diameter equal to the diameter of the outer surface of said hub.]

22. A threadless screw device comprising a roller assembly, said roller assembly comprising a holder having an opening for receiving a shaft and a plurality of radially extending bores oriented perpendicular to the axis of said shaft opening and intersecting same, a carrier journaled in each bore for angular adjustment about an axis perpendicular to said shaft opening axis, each carrier having an axial opening, a roller located in said opening and having a portion extending beyond the inner end of said carrier, a pin extending transversely through said carrier and said roller and providing a mounting for said roller, a slot in the wall of each bore, each pin having an extended portion extending through one of said slots, said slots extending in a direction substantially parallel to said shaft opening axis and being larger than the diameter of said pin to permit axial and angular displacement of said pin and carrier with respect to the axis of said bore, said holder including a hub, and control means rotatably mounted on said hub and including means engaging said pins so that in one angular position of said control means said shaft opening axis and the axis of said pins will all be parallel to each other, whereby angular adjustment of said control means with respect to said hub will cause a uniform inclination of said roller axes with respect to said shaft axis, confining means located in the outer end of each bore, and spring means confined between each confining means and its associated carrier to urge each carrier inwardly in said bore.

23. A threadless screw device as claimed in claim 22 in which the engagement of said pin with one wall of the slot limits inward displacement of said carrier by said spring means.

24. A device for converting a torque force into a linear force directed parallel to the axis of the torque force comprising, in combination: a rotatable shaft onto which a torque force is applied, a frame closely surrounding the shaft and defining therein a plurality of socket defining portions, each of said socket defining portions containing an elongated pivotable bearing housing, a bearing of smaller exterior diameter than the diameter of said housing mounted in and substantially surrounded by said housing and said socket defining portion, each of said bearings having the periphery of its outer race engaging the periphery of the shaft, to be rotatably driven relative to said shaft about its own axis but being movable axially of the rotatable shaft, said bearing having surfaces in contact with said housing for transmitting forces to said housing, said housing having an exterior surface, at least a part of said surface being no farther from said rotatable shaft than the axis of said bearing and said part being in contact with said socket defining portion, for transmitting forces parallel to the axis of the rotatable shaft to said socket defining portion, pivot means for pivoting each bearing about the axis of the pivotable housing in which it is enclosed, so that a force component is transmitted from the rotatable shaft to the bearing and thereafter to the frame which is manifested by development of a force parallel to the axis of the shaft which tends to effect relative movement between the shaft and frame in directions axially of the shaft, controller means for selectively effecting substantially identical pivoting of all bearings simultaneously, said pivot means for pivoting each bearing including an axial pin concentrically associated with each of said bearings and being connected to each of said housings on opposite sides of said bearing, said housings supporting said pins to substantially avoid moment forces which could break said pins, and each pin projecting generally axially relative to the shaft and being engaged by said controller means.

25. The device of claim 24 wherein said frame includes a plurality of socket defining portions disposed radially of the shaft, each socket defining portion having an inner cylindrical wall whose longitudinal axis is perpendicular to the axis of said shaft, said bearing housing being held in said cylindrical wall of said socket and having therein a bore whose axis is perpendicular to the longitudinal axis of said socket and a slot-like recess for slidably receiving a bearing, and said pin being in said bore and having the bearing mounted thereon and serving both to maintain the bearing housing spaced from said shaft when the bearing engages the shaft and serving as a lever for selectively pivoting the bearing about an axis perpendicuar to said shaft.

26. The device of claim 25 including a selectively variable force means carried on the socket-defining portion and engaging the bearing carrier.

27. The device of claim 24 wherein the frame includes a plurality of radially movable parts operatively associated with the said bearings and having portions arranged to engage each other when the shaft is withdrawn from said frame so as to maintain said bearings at such a position as to permit re-entry and re-assembly into said frame and between said bearings, and said bearings when operatively engaging the shaft serving to space said radially movable parts from said shaft and from each other.

28. In a washing machine of the type having an agitator connected to a vertical shaft, said vertical shaft and said agitator having a vertical reciprocating tumbling action during the washing and a spinning action during the drying cycle of said washing machine, the improvement con-

sisting of a device for converting a torque force into a linear force directed parallel to the axis of the torque force comprising, in combination, a rotatable shaft on which force is applied, a frame closely surrounding the shaft and defining therein a plurality of socket defining portions, each of said socket defining portions containing an elongated pivotable bearing housing, a bearing of smaller exterior diameter than the diameter of said housing mounted in and substantially surrounded by said housing and said socket defining portion, each of said bearings having the periphery of its outer race engaging the periphery of said shaft, to be rotatably driven relative to said shaft about its own axis but being movable axially of the rotatable shaft, said bearing having surfaces in contact with said housing for transmitting forces to said housing, said housing having an exterior surface, at least a part of said surface being no farther from said rotatable shaft than the axis of said bearing and said part being in contact with said socket defining portion, for transmitting forces parallel to the axis of the rotatable shaft to said socket defining portion, pivot means for pivoting each bearing about the axis of the pivotable housing in which it is enclosed, so that a force component is transmitted from the rotatable shaft to the bearing and then to the frame which is manifested by development of a force parallel to the axis of the shaft which tends to effect relative movement between the shaft and the frame in a direction axially of the shaft, and controller means for selectively effecting substantially identical pivoting of all bearings simultaneously, said vertical shaft being operatively connected through a one-way clutch to said rotatable shaft, an agitator operatively connected to said vertical shaft, so that when clockwise rotary motion is imparted to said shaft and said frame is held motionless, said vertical shaft and said agitator move vertically reciprocally according to a programmed pattern whereby a tumbling action is obtained and when a counterclockwise rotary motion is imparted to said shaft and said frame is held motionless, said vertical shaft and said agitator rotate at high speed without a tumbling action.

29. The device of claim 24 wherein two pairs of opposed socket-defining portions containing said bea ing housings and said bearings are provided.

30. The device of claim 24 wherein each bearing housing is a cylindrical member having a chamfered inner edge, said chamfered edges being normally spaced from each other, but engaging each other in abutting contact.

31. The device of claim 24 including a screw th eaded plug threaded into the outer end of each socket defining portion, a disc overlying said bearing housing, said bearing overlying said disc, and a spring washer having its peripheral face engaging said ball bearing unit, and its central portion engaging said plug, said plug constituting means for adjusting the compression of said spring washer.

32. The device of claim 24 wherein said frame is provided at one end with a hub, and a sleeve at the other end of said frame having an inner surface of diameter equal to the diameter of the outer surface of said hub.

33. The device of claim 24 wherein said frame is provided at one end with a hub, said controller means comprising a slotted disc mounted on said hub for angular adjustment, and a sleeve at the other end of said holder having an inner surface of a diameter equal to the diameter of the outer surface of said hub.

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