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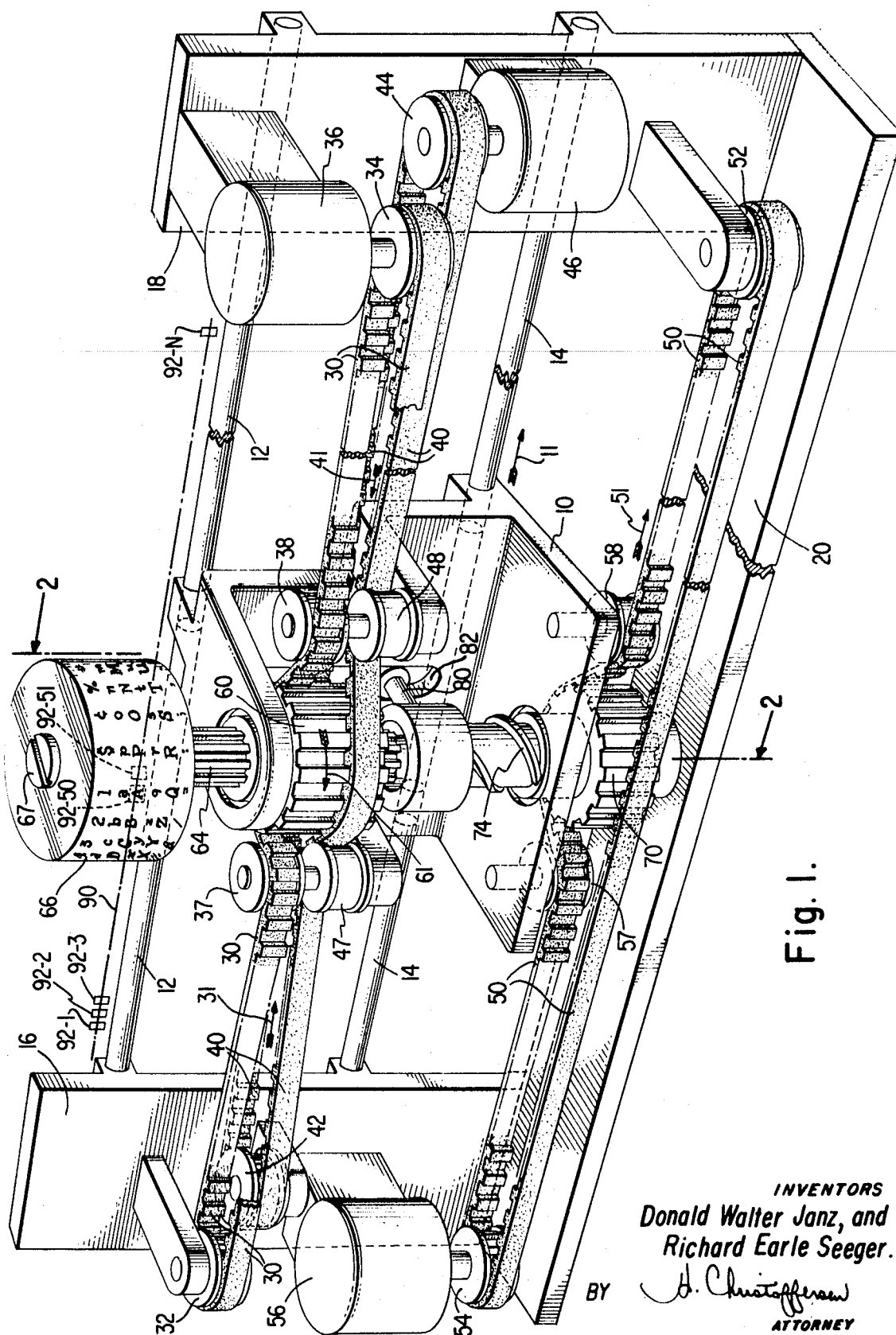
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THREE-AXIS DRIVE SYSTEM

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2 Sheets-Sheet 1



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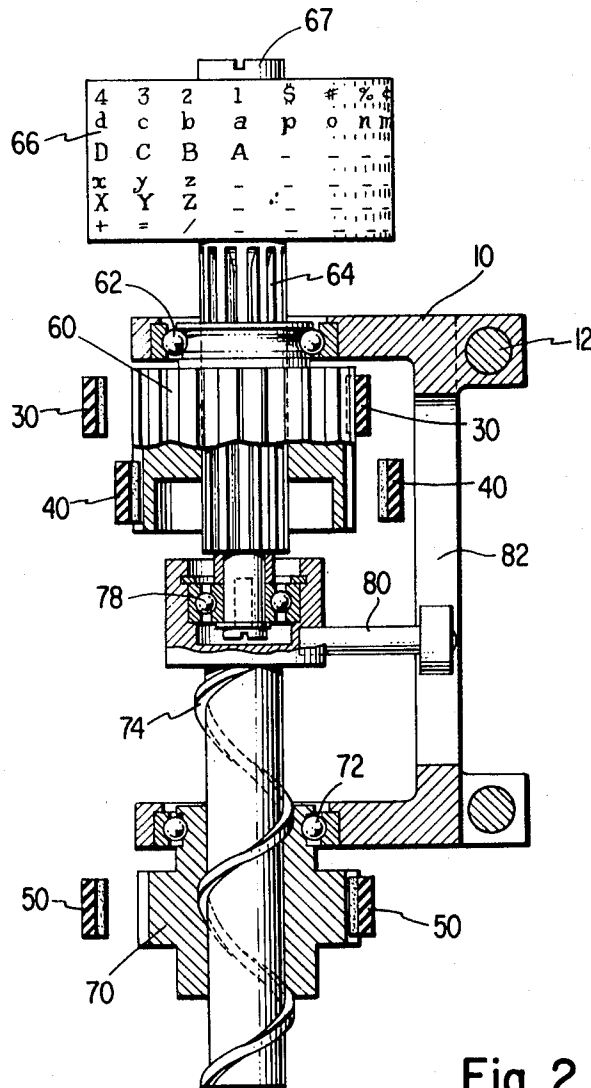


Fig. 2.

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THREE-AXIS DRIVE SYSTEM

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8 Claims

ABSTRACT OF THE DISCLOSURE

Three belt drive assemblies cooperate to selectively position a cylindrical character font carrier in a serial printer angularly about its axis of rotation, linearly along said axis, and linearly in a direction perpendicular to said axis. These movements may occur concurrently to move any desired character on the font carrier into printing position.

BACKGROUND OF THE INVENTION

In the data communications field, a need exists for an inexpensive reliable serial, that is, character-at-a-time printer capable of printing speed of about 15 to 60 characters a second. Previous serial printers include the ordinary office typewriter modified to accept external electrical signals to operate its mechanical type bar mechanism. Newer serial printers employ a rectangular or cylindrical character font manipulated into print position by a complex mechanical arrangement using many stamped metal parts and intricate machined parts.

The several hundred detailed parts used in previous printers such as those mentioned above are costly to manufacture and assemble and require continued maintenance at the installation site. Further, if it is desired to change to a different character font carrier many mechanical parts used to determine the binary code combination of each character also have to be changed.

The object of the present invention is to meet the need discussed above, that is, to provide a machine suitable for use as a serial printer, which is relatively simple, relatively trouble free, relatively inexpensive and whose font easily can be changed.

BRIEF SUMMARY OF THE INVENTION

A pair of belts are coupled to a rotatable member for causing said member to rotate without moving linearly, to move linearly and rotate, and to move linearly without rotating. A third belt may be added to move the rotatable member in the direction of its axis of rotation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic, perspective showing a portion of a serial printer which includes the three-axis drive system of the present invention; and

FIG. 2 is a cross section through the carriage taken substantially along line 2—2 of FIG. 1, showing the mechanism for raising the character font carrier.

DETAILED DESCRIPTION

FIG. 1 should be referred to first. Carriage 10 is slidably mounted on guides 12 and 14 which are attached to supports 16 and 18 mounted on a suitable base plate 20. A rotatable element, shown as a gear 60, is mounted

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in the carriage and a pair of belts 30 and 40 engage the gear. The belts may be timing belts with a tooth-like gripping surface, as shown, or may have any other shape capable of providing a friction surface. For example, they may be of trapezoidal or cylindrical cross section. The belts may be made of any suitable material such as rubber, nylon, or metal.

The belts 30 and 40 are guided at one end by freely rotatable pulleys 32 and 42, respectively, which are attached to support 16. The belts are supported at their opposite end by drive pulleys 34 and 44, respectively, which are driven by motors 36 and 46 respectively. The pulleys 34 and 44 may be any shape necessary to drive the belts without slippage, such as gear-like timing pulleys. The motors 36 and 46 attached to support 18 are, in the preferred embodiment, stepping motors with 15° rotation per step and with a detent mechanism to hold pulleys 34 and 44. Thus the belts 30 and 40 are rigidly held in one of a plurality of positions when not rotating. Alternately, the motors may be of the continuous type.

A third belt 50, similar to belts 30 and 40, is supported at one end by freely rotating guide pulley 52 and at its other end by drive pulley 54. The latter is driven by a motor 56 which may be similar to the motors previously described.

Guide pulleys 37, 38 and 47, 48 over which the respective belts 30 and 40 pass, urge relatively large surfaces of these belts into contact with gear 60, to insure slip free contact between belts and gear. Guide pulleys 57 and 58 perform a similar function for belt 50 and gear 70. The latter is also rotatably attached to carriage 10. Elements 60 and 70, while illustrated with gear-like teeth, can be of any shape that will provide slip free contact with belts 30, 40, and 50 respectively.

The method of mounting gears 60 and 70 and other elements to carriage 10 is best seen in the carriage cross section of FIG. 2 where parts corresponding to those of FIG. 1 are identified by the same reference numbers. Gears 60 and 70 are coupled to carriage 10 via ball bearing assemblies 62 and 72 respectively in such a way that the gears are free to rotate but are restrained from vertical movement. A rotatable member illustrated as a splined shaft 64 is slidably mounted in gear 60. The splines on the shaft engage corresponding grooves on the inner surface of the gear and this prevents rotation of shaft 64 within gear 60. Thus, when gear 60 is rotated, the splined shaft 64 and the cylindrical font carrier 66 which is fixed to the shaft, rotate with it. Fastener 67 which secures carrier 66 to shaft 64 permits easy removal and replacement of the carriers.

The cylindrical character font carrier 66 is formed with raised characters on its surface. These are located in a multiplicity of regularly spaced columns and rows. The rows are circumferentially positioned on the cylinder surface and may be horizontal and the columns are parallel to the cylinder axis and may be vertical. In one embodiment there are six circumferential rows on one-eighth inch centers and sixteen vertical columns, adjacent columns being angularly spaced 22.5°. The diameter of the character font carrier is dictated only by the distance between the axis of the font carrier and the recording medium. Its diameter, as will be seen later, does not affect character spacing on a printed line.

Shaft 64 is coupled at its opposite end, via ball bearing assembly 78, to threaded shaft 74 in such a way that

shaft 64 is free to rotate relative to shaft 74. The latter, however, is restrained from rotation by guide pin 80 attached to shaft 74 and riding in guide slot 82 in carriage 10. However, the coupling is such that any up or down motion of shaft 74 results in an equal up or down motion of shaft 64.

Shaft 74 whose outer surface is formed with male threads as clearly shown in FIG. 1 is positioned in gear 70 which has matching female threads. The combination of elements 70 and 74 form a conversion means for converting rotational motion of gear 70 into linear motion of shaft 64. In other words, when the gear 70 is rotated by belt 50, the shaft 74 and along with it the shaft 64 move up (or down). In one embodiment, the thread pitch is one inch. This means that the shaft 74 will move one inch for each full rotation of gear 70 or one-eighth inch (the spacing between adjacent rows of characters on the character font carrier 66) for each 45° of rotation of gear 70.

Operation of the system may best be understood by referring to FIG. 1, ignoring belt 50 for the present. If belt 30 is caused by the drive motor 36 to move in the direction of arrow 31 while belt 40 is held stationary, gear 60 and thus shaft 64 and carrier 66 rotate clockwise, as shown by arrow 61, and the entire carriage moves in the direction shown by arrow 11. In describing belt movement it will be assumed that the surface of the belt illustrated nearest the arrow specified is moving in the specified direction. Similarly, movement of belt 40 by motor 46, in the direction of arrow 31 with belt 30 held stationary results in movement of carriage 10 in direction 11 but rotation of gear 60 in the counter-clockwise direction, that is, in the direction opposite that shown by arrow 61.

Once movement in the directions shown is understood, it should be apparent that movement of either belt in the opposite direction while the other is stationary results in carriage and gear movements in directions opposite those described above. Thus, for example, with belt 40 stationary, movement of belt 30 in the direction of arrow 41 causes movement of carriage 10 in the direction opposite arrow 11 and causes rotation of gear 60 in a direction opposite arrow 61.

Having described in detail reaction of carriage 10 and gear 60 to single belt movement an examination will now be made of double belt movement. For example, if belts 30 and 40 move equal amounts in the direction of arrow 31, carriage 10 moves the same amount in direction 11 with no rotation of gear 60. However, if the belts move different amounts in the same direction, again say the direction of arrow 31, there will be both linear movement of the carriage in direction 11 and rotation of gear 60 in one of two possible directions, depending upon which belt moves the greater distance.

Rotation of gear 60 with no translation of carriage 10 may be accomplished by causing belts 30 and 40 to move equal distances but in opposite directions. Additionally, any unequal movement of the belts in opposite directions will result in both rotation of gear 60 and translation of carriage 10.

From the explanation thus far presented it can be seen that carriage 10 can be made to move, either direction along guides 12 and 14, and gear 60 and thus shaft 64 and carrier 66 can be made to rotate in either direction by selected amounts and direction of movement of belts 30 and 40.

Thus far, movement in two of the possible three degrees of freedom of shaft 64 have been described. The third degree of freedom is vertical movement of shaft 64 and attached character font carrier 66. This is accomplished by belt 50. Motion of belt 50 with carriage 10 stationary causes rotation of gear 70 in a direction dependent upon the direction of movement of belt 50. As gear 70 rotates, its internal threads cooperate with external threads on

shaft 74. As shaft 74 is prevented from rotating by guide pin 80 in slot 82, the rotation of gear 70 results in linear movement of shaft 74 and corresponding linear movement of shaft 64 and carrier 66.

Because of the ball bearing assembly 78 coupling between shafts 64 and 74, vertical motion of the shafts may well be occurring concurrently with the rotation of shaft 64 under control of belts 30 and 40. Further, if belt 50 remains stationary while carriage 10 is caused to move, gear 70 is caused to rotate because of contact with stationary belt 50 and vertical motion of shaft 64 results. It therefore follows that if translation of carriage 10 is desired and if vertical translation of shaft 64 is not desired, belt 50 must be moved the same distance as carriage 10 to prevent rotary motion of gear 70.

Although many combinations of motor types, pulley, and gear sizes, and screw pitches may be used to practice the present invention, the following parameters for one practical design of a printer embodiment of the invention are illustrative. Motors 36, 46, and 56 are bidirectional stepping motors with 15° rotation per step. Pulleys 34, 44, and 54 are 24 teeth timing pulleys with 0.1 inch pitch. Pulleys of the type just described have adjacent teeth angularly spaced 15° apart ($360^\circ \div 24 \text{ teeth} = 15^\circ / \text{tooth}$). Since each step of the stepping motor is 15°, one step represents the movement of one tooth or 0.1 inch, resulting in a belt movement of 0.1 inch per step. Belts 30, 40, and 50 are 0.1 inch pitch timing belts which is also chosen as the horizontal spacing of printed characters. Character font carrier 66 has 6 rows of characters on one-eighth inch vertical centers and 16 columns of characters angularly spaced at 22.5°. The thread pitch of shaft 74 and gear 70 is 1 inch so 45° rotation of gear 70 results in one-eighth inch travel of shaft 74, the vertical distance between rows of characters on the character font carrier.

It is desired to rotate gears 60 and 70 22.5° per motor step i.e., one step of motor 56 should result in 22.5° of rotation of gear 70 and one step of motors 36 and 46 should result in 22.5° rotation of gear 60. Gears with 16 teeth and 0.1 inch pitch will give the desired rotation ($16 \text{ teeth} \cdot 22.5^\circ / \text{tooth} = 360^\circ$). Note that 22.5° is the angular spacing between characters on the character font carrier.

Having developed one of the many possible sets of parameters and having developed the general interaction between belt movement and carriage and character font movement explanation will conclude with the steps necessary to bring any given character on the character font carrier into print position.

It will be assumed that printing is to occur along a center line 90 shown in FIG. 1 in positions shown by blocks 92-1 through 92-N which are spaced at 0.1 inch centers.

Printing of any one character in several succeeding printed positions requires translation of the carriage in 0.1 inch steps with no rotational motion or vertical translation of the character font carrier 66. This is accomplished by advancing all motors 36, 46, 56 one step which will advance belts 0.1 inch but cause no rotation of either gears 60 or 70 and thus only pure translation of the carriage.

It should be noted here that a one step movement of either belt 30 or belt 40 with the other remaining stationary will move the carriage only 0.05 inch, the average of 0.1 inch movement of the side of gear 60 nearest the moving belt and zero movement of the side of gear 60 nearest the stationary belt. Because a one step move of one belt results in only 0.05 inch of carriage movement, belt 50 must move one step for each combined movement of belts 30 and 40 of two steps to insure zero relative motion between belt 50 and gear 70 thus preventing vertical motion of carrier 66.

As an example of a possible printing situation, assume the character "A" has just been printed in phantom block 92-50 shown in FIG. 1 and it is desired to print the lower

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case letter "c" in phantom block 92-51. From the general discussion of how the drive system works it should be reasonably apparent that the following steps will accomplish the desired objective.

(1) The belts 30 and 40 are moved in the direction of arrow 31 one step (i.e., 15° of the stepping motor or 0.1 inch of belt movement). This moves the carriage 0.1 inch to the right and, in effect, places character "A" in print position 92-51.

(2) The belt 50 is moved one step in the direction of arrow 51. This prevents any relative motion between belt 50 and gear 70 and thus prevents any motion of character font carrier 66 in the vertical direction.

(3) Belt 30 is moved in direction 41 two steps while belt 40 concurrently is moved two steps in direction 31. This causes pure rotation of gear 60 in the direction opposite arrow 61 and through an angle of 45° (2 steps·22.5°/step=45°). Since columns of characters are angularly positioned 22.5° apart, the letter "C" which is 45° from the column containing "A," is now in print position 92-51.

(4) Finally, the belt 50 is moved two steps in the direction opposite arrow 51. Since two steps represent 45° of angular movement of gear 70, which represents one-eighth inch movement of shaft 74, which represents the spacing between rows of characters on the character font carrier 66, the lower case letter "c" is lowered into print position and printing may take place.

In a practical application, all belts may be in motion concurrently, moving in whatever direction necessary to move the desired character into print position. For example, the following three steps carried out concurrently produce the motion described above.

(1) Belt 30 moves one step in the direction of arrow 41.

(2) Belt 40 moves three steps in the direction of arrow 31.

(3) Belt 50 moves one step in the direction opposite arrow 51.

As stated previously, the set of parameters chosen for purposes of illustration is only one of a large number of possible parameter values for belts, gears, and character font layout. Additionally, the layout of the various elements may vary considerably from the layout illustrated in FIG. 1, which is intended to be schematic in nature, and still be encompassed within the scope of the invention.

What is claimed is:

1. In a serial printer, in combination:

a first gear means having an axis of rotation;

a splined shaft having an axis of rotation in its longitudinal direction slidably mounted in said gear means;

a generally cylindrically shaped character font carrier secured to one end of said splined shaft, said carrier having a plurality of rows and columns of raised characters;

a pair of belts substantially parallel over a portion of their length engaging said gear means for moving said gear means in a direction perpendicular to the axis of rotation of said gear means, both with and without concurrent rotation of said gear means, and for rotating said gear means without linearly moving said gear means;

a threaded shaft restrained from rotation coupled to the opposite end of said splined shaft, with the longitudinal axes of the said shafts aligned, for linearly moving said splined shaft in the direction of its axis of rotation;

a second rotatable gear means with internal threads coupled to said threaded shaft, said second gear means and threaded shaft cooperating to convert rotation of said second gear means into linear movement of said threaded shaft in the direction of the axis of rotation of said splined shaft; and

a third belt coupled to said second gear means for causing rotation of same.

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2. The combination as claimed in claim 1 wherein the said character font carrier includes means permitting easy removal and replacement of said carrier.

3. An arrangement for rotating and for moving linearly in different directions a rotatable member comprising, in combination:

gear means having an axis of rotation and coupled to said member;

a pair of belts substantially parallel to one another over an extended portion of their length, one belt coupled to said gear means at a portion of its surface on one side of said axis of rotation and the other belt coupled to said gear means at a portion of its surface on the other side of said axis;

means for rotating the gear means and member comprising means for concurrently moving the belts the same distance in opposite directions relative to one another along the length dimension of the belts; and means for linearly moving the gear means and member in the direction of the length dimension of the belts comprising means for moving one belt a different distance along the length dimension of the belts than the other.

4. An arrangement as set forth in claim 3 wherein said last-named means comprises means for moving one belt in one direction and the other belt in the opposite direction.

5. An arrangement as set forth in claim 3 wherein said last-named means comprises means for moving both belts in the same direction different distances.

6. An arrangement as set forth in claim 3 wherein said last-named means comprises means for moving one belt while the other remains stationary.

7. An arrangement for rotating and for moving linearly in different directions a rotatable member comprising, in combination:

gear means having an axis of rotation and coupled to said member;

a pair of belts substantially parallel to one another over an extended portion of their length, one belt coupled to said gear means at a portion of its surface on one side of said axis of rotation and the other belt coupled to said gear means at a portion of its surface on the other side of said axis;

means for rotating the gear means and member comprising means for concurrently moving the belts the same distance in opposite directions relative to one another along the length dimension of the belts; and means for linearly moving the gear means and member in the direction of the length dimension of the belts comprising means for moving both belts the same distance in the same direction along the length dimension of the belts.

8. An arrangement for rotating and for moving linearly in different directions a rotatable member comprising, in combination:

gear means having an axis of rotation and coupled to said member;

a pair of belts substantially parallel to one another over an extended portion of their length, one belt coupled to said gear means at a portion of its surface on one side of said axis of rotation and the other belt coupled to said gear means at a portion of its surface on the other side of said axis;

means for rotating the gear means and member while linearly moving the same in the direction of the length dimension of said belts comprising means for moving one belt a different distance along the length dimension of the belts than the other; and

means for linearly moving the gear means and member in the direction of the length dimension of said belts comprising means for moving both belts the same distance in the same direction along the length dimension of the belts.

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