United States Patent [19]

White

[11] **3,864,994**

[45] **Feb. 11, 1975**

[54] **MULTIPLE SPINDLE MACHINE WITH VARIABLE SPEED DRIVE**

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[73] Assignee: **Cone-Blanchard Machine Company,** Windsor, Vermont

[22] Filed: **Feb. 24, 1969**

[21] Appl. No.: **801,497**

[52] **U.S. Cl.** **82/3,** 82/28

[51] **Int. Cl.** **B23b 9/10**

[58] **Field of Search** 82/3, 28

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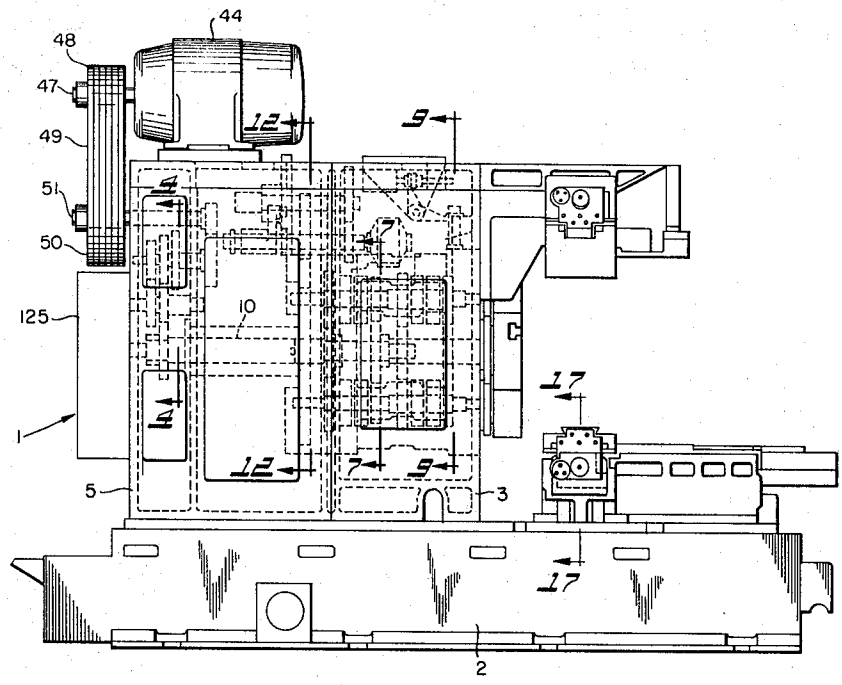
1. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, and additional fluid operated clutch means associated with said spindle shafts and drive shaft for selectively independently driving said spindle shafts in the reverse direction.

14 Claims, 22 Drawing Figures



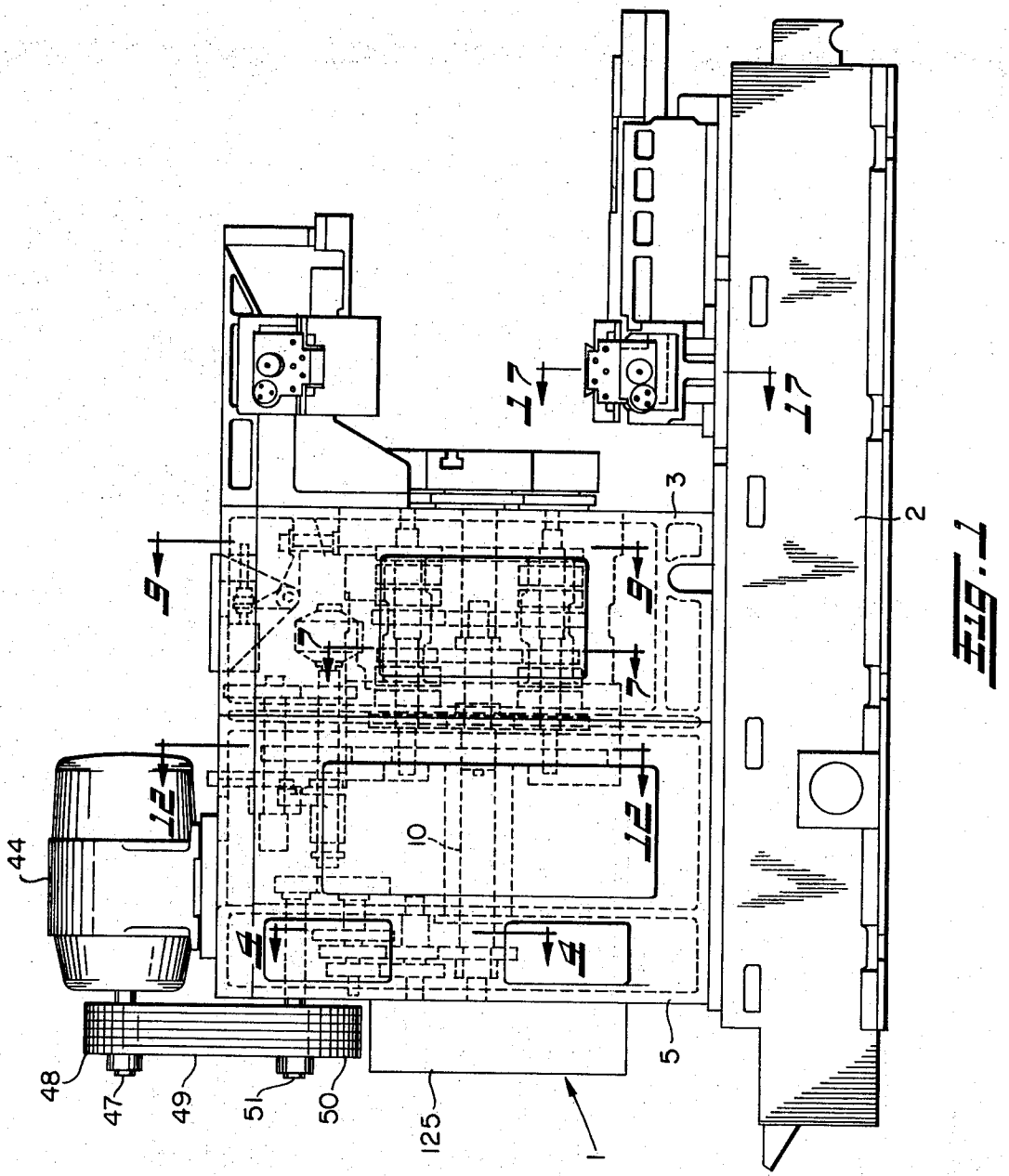


FIG. 1

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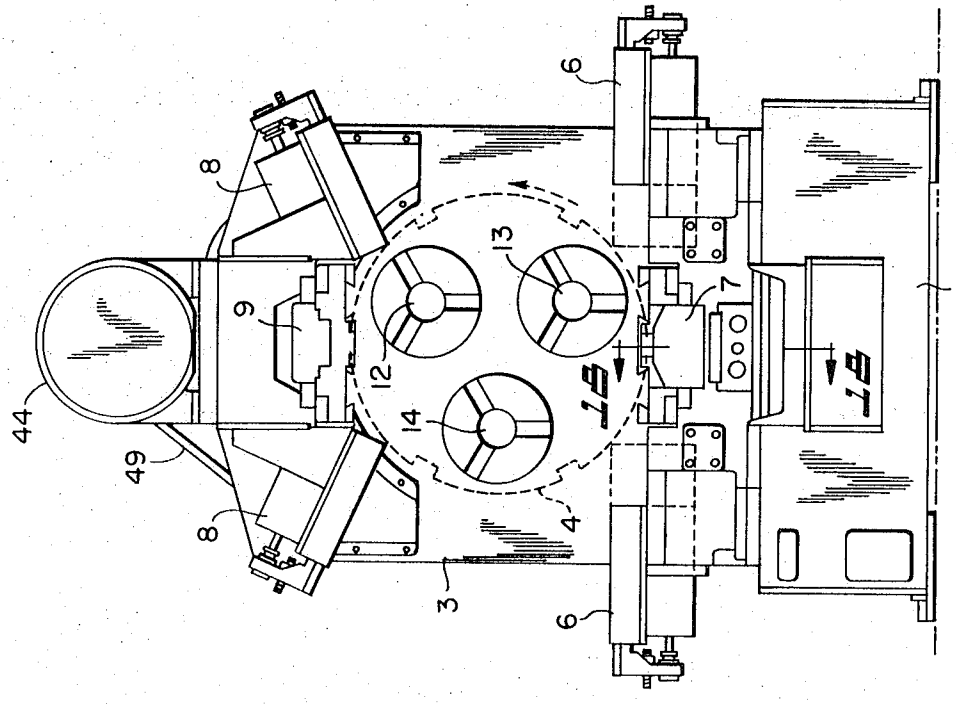

FIG. 2

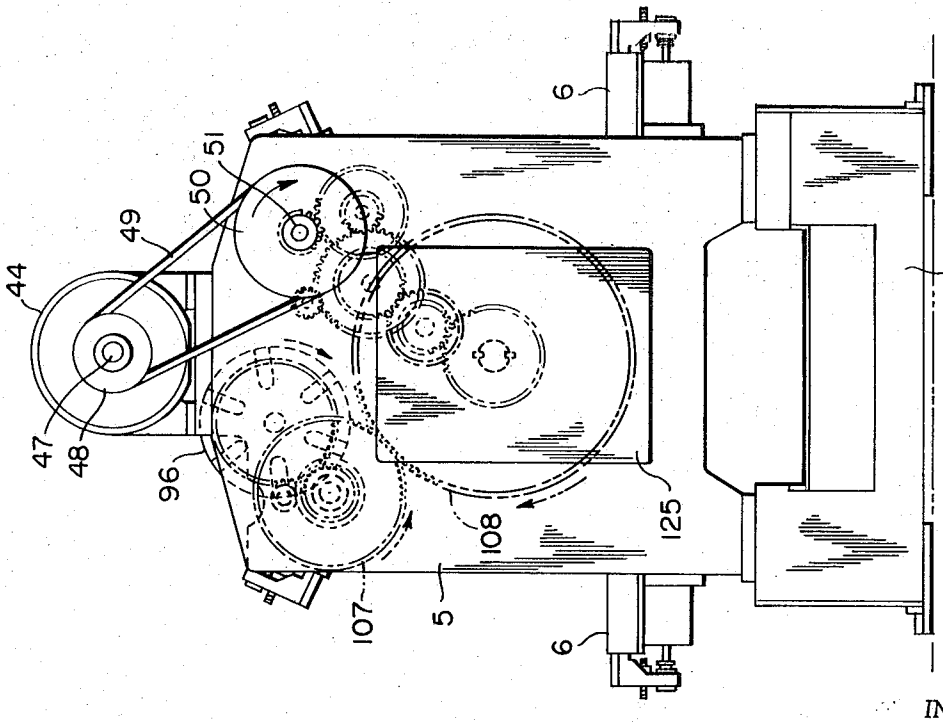

FIG. 2A

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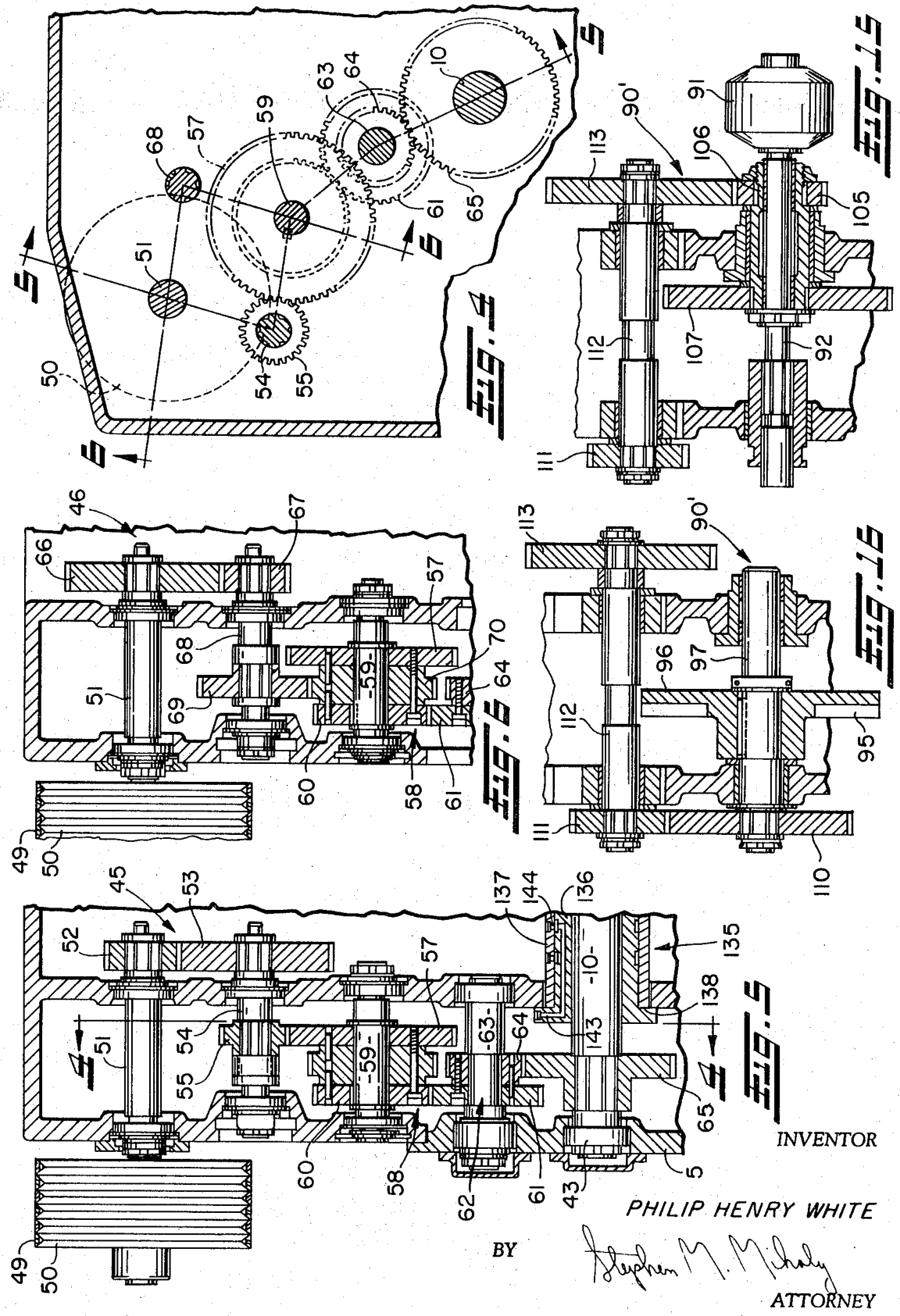
FIG. 3
FIG. 4
FIG. 5
FIG. 6
FIG. 7
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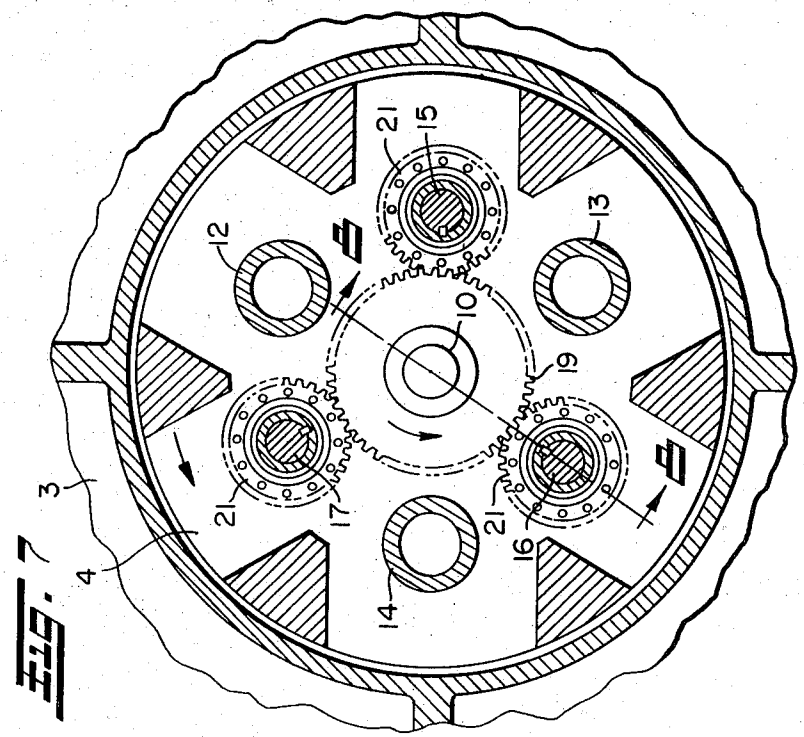

FIG. 7

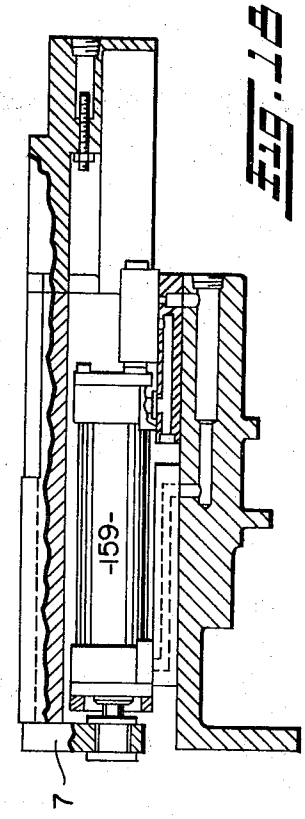

FIG. 18

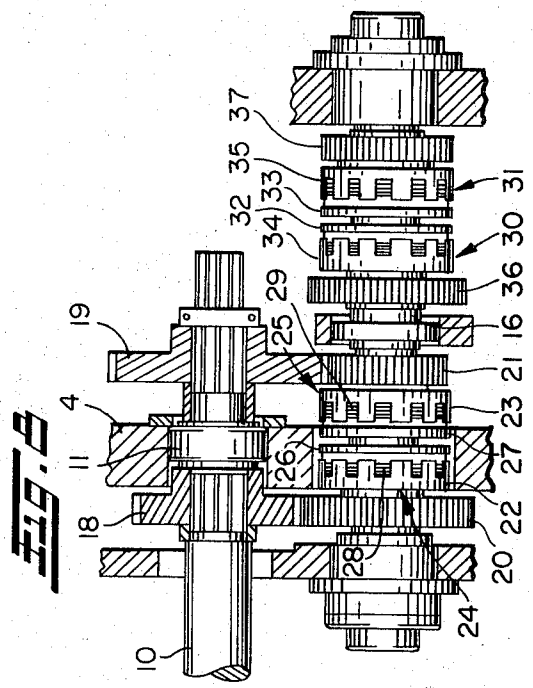

FIG. 8

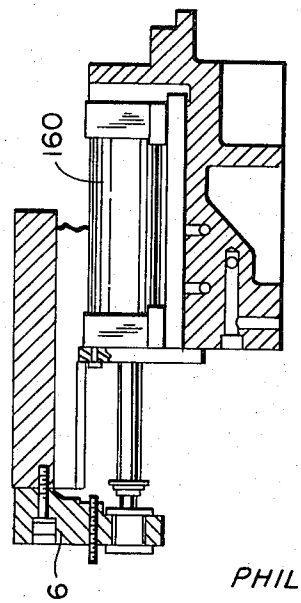

FIG. 17

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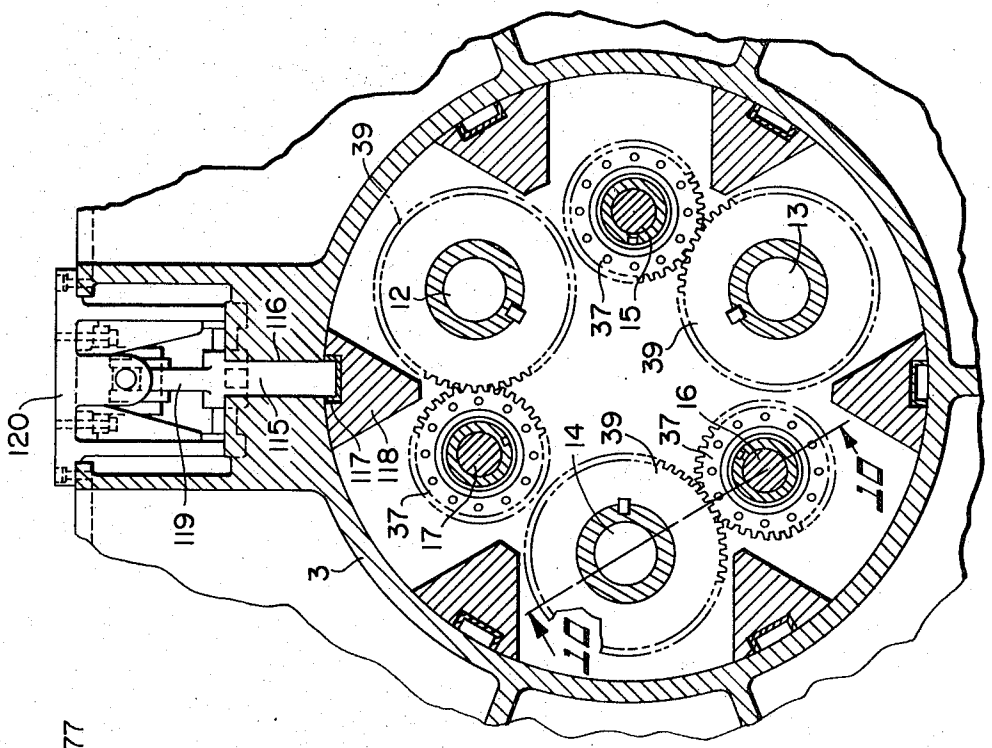

FIG. 6

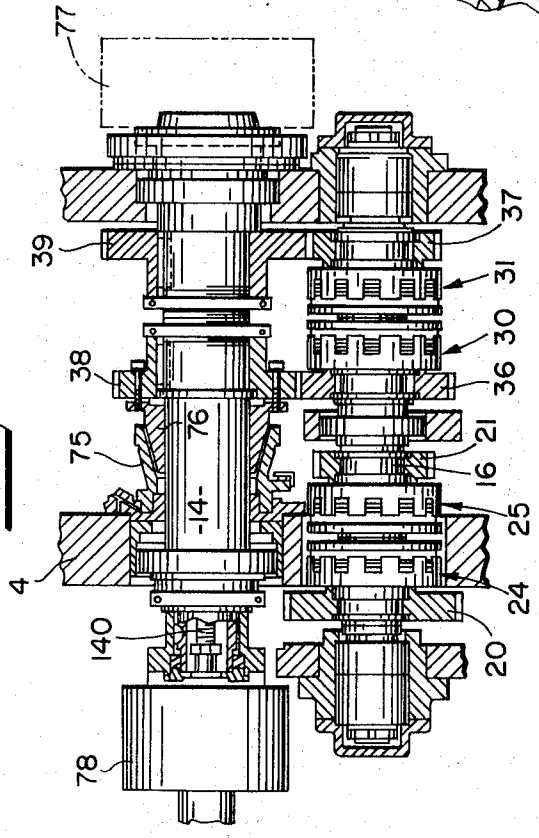

FIG. 10

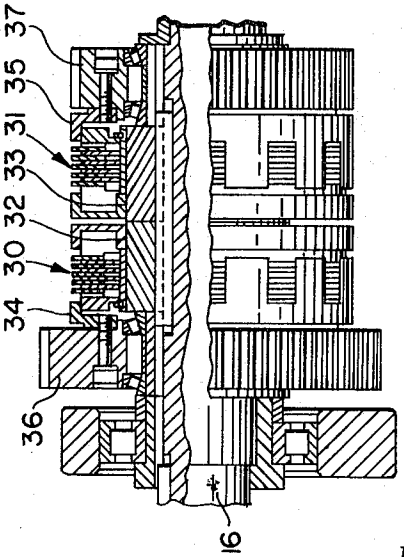

FIG. 11

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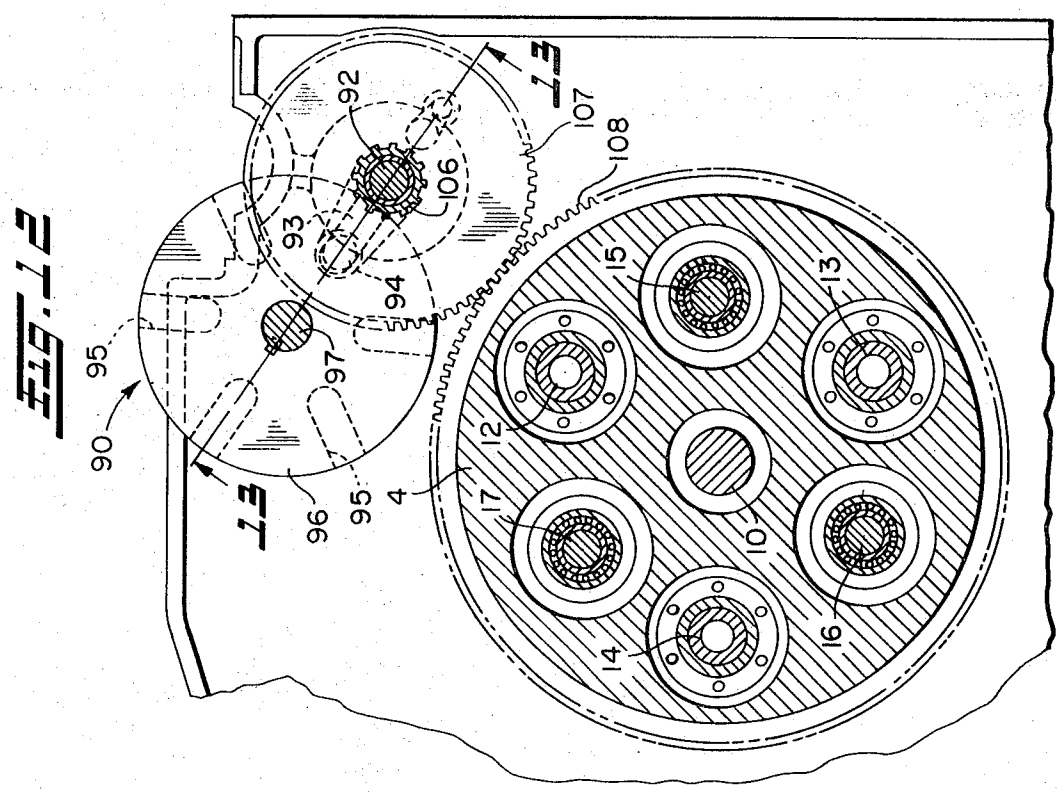

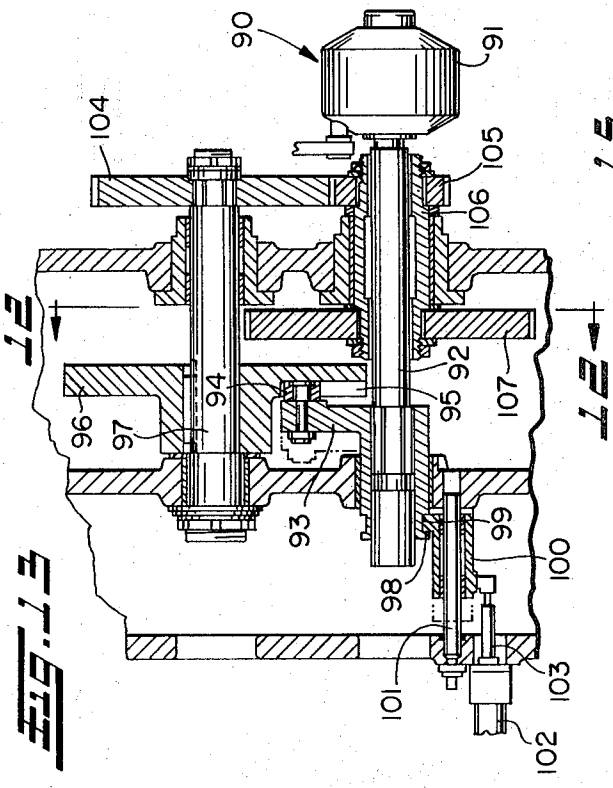

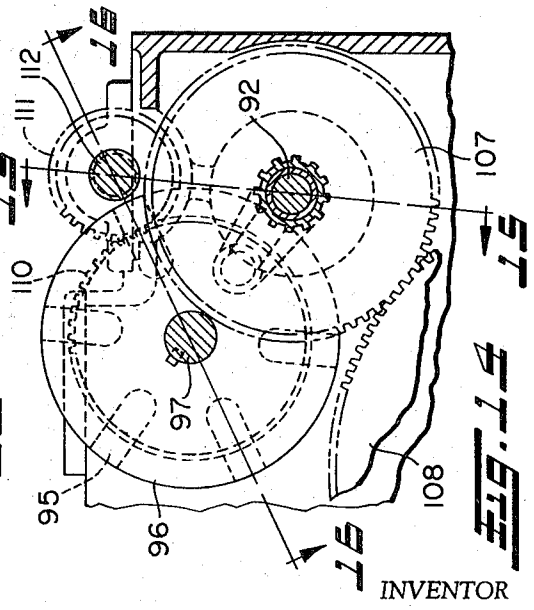

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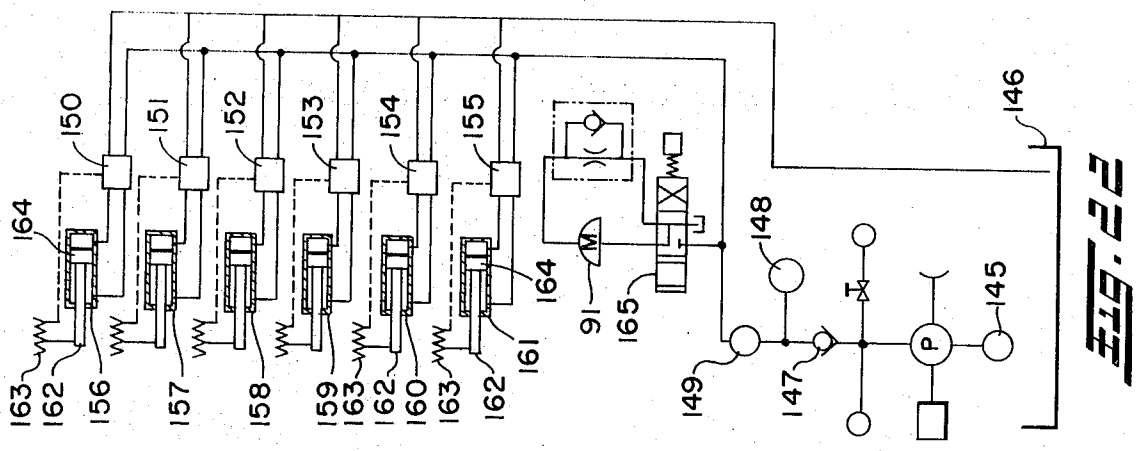

FIG. 22

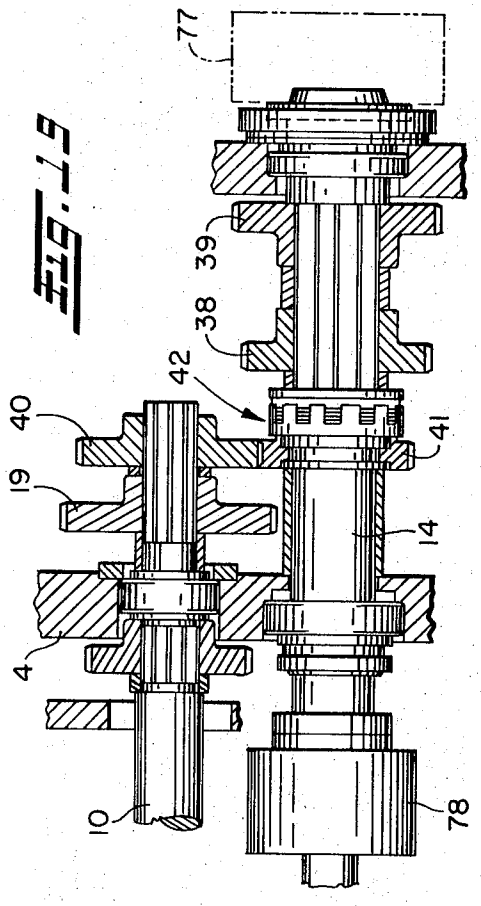

FIG. 17

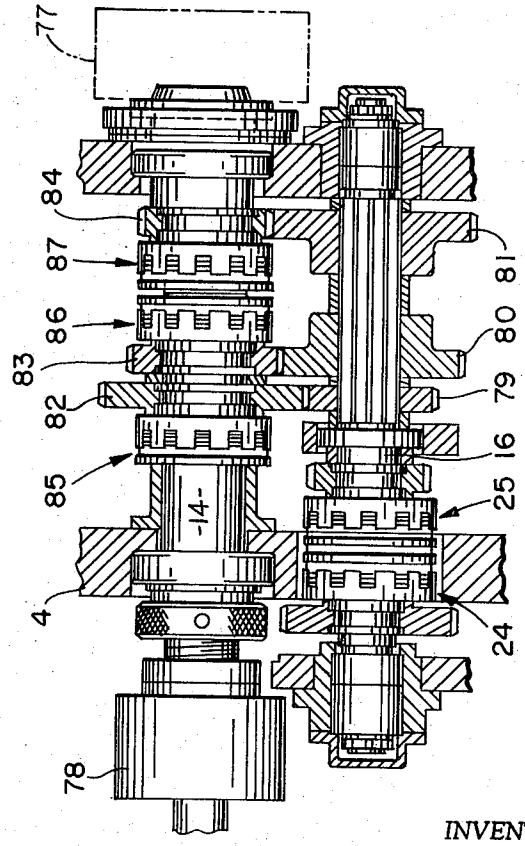

FIG. 20

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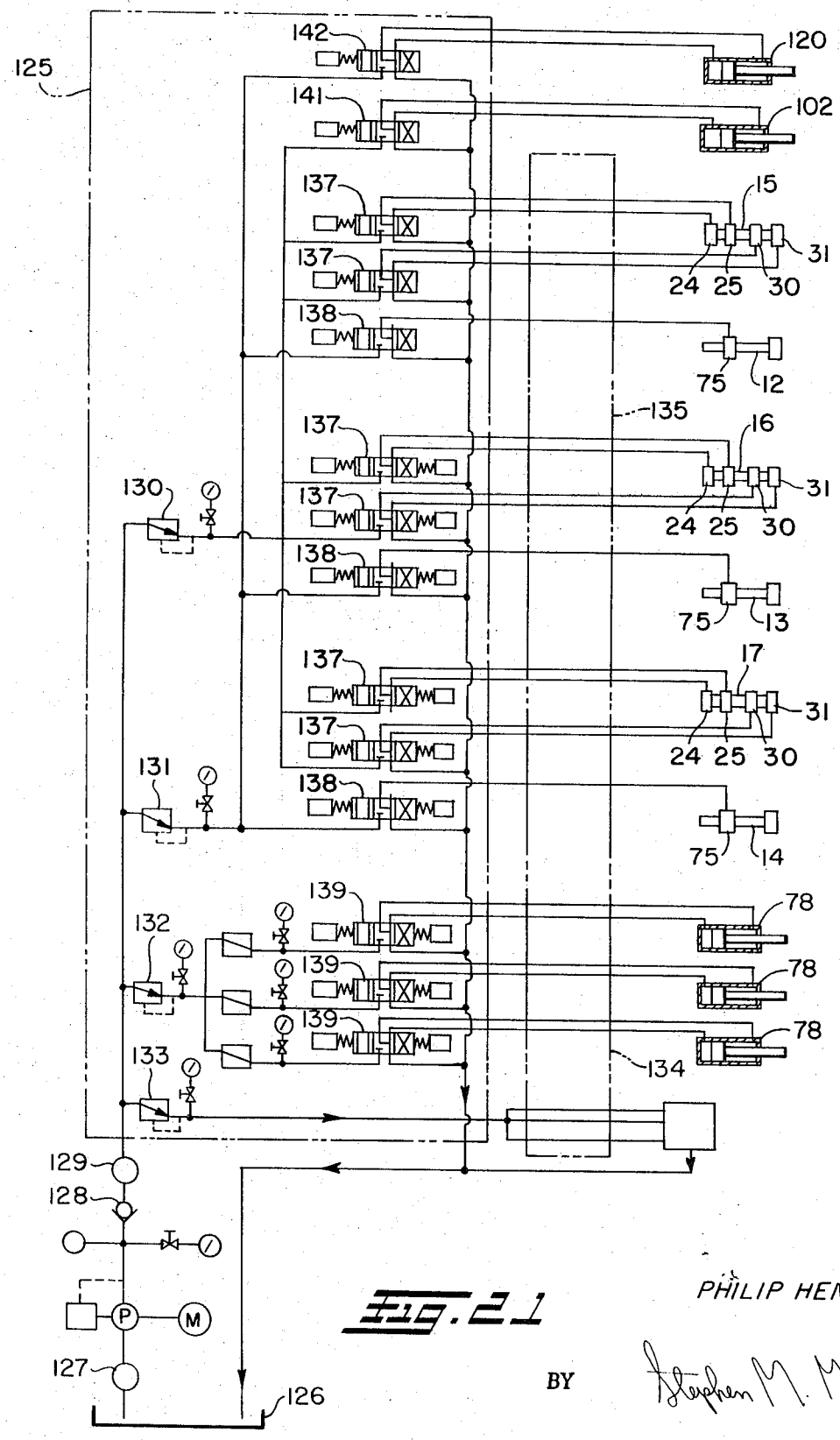

Fig. 2 1

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MULTIPLE SPINDLE MACHINE WITH VARIABLE SPEED DRIVE

BACKGROUND OF THE INVENTION

The present invention relates generally as indicated to a multiple spindle machine with variable speed drive and more particularly to a multiple spindle machine including an indexable spindle carrier having a plurality of spindles mounted thereon which may be simultaneously driven forward at the same or different speeds or in reverse and independently braked as desired.

Heretofore, it has been conventional practice to provide a common drive for driving all of the spindles of a multiple spindle machine at the same speed for any given machining operation, even though better machining techniques and less cycle time might be achieved by driving different spindles at different speeds because a machine having variable speed capabilities was previously considered to be too large and costly. A two-speed spindle arrangement has been devised, but not one that will drive plural spindles at three or more speeds or in reverse, and such two-speed arrangement uses cam or cylinder operated yokes for actuating spindle shaft mounted clutches, which add considerably to the cost and complexity of the machine.

SUMMARY OF THE INVENTION

With the foregoing in mind, it is a principal object of this invention to provide a multiple spindle machine in which the spindles may be simultaneously driven forward at three or more speeds or in reverse, and may also be independently braked as desired.

A further object is to provide such a multiple spindle machine which is relatively inexpensive to manufacture and compact.

Yet another object is to provide a multiple spindle machine of the type described with novel means for indexing the spindle carrier from one work station to another, and for locking the spindle carrier in place during machining operations.

These and other objects of the present invention may be achieved by providing a multiple spindle machine with a lesser number of spindles than usual to permit greater machining capabilities and make room for the inclusion of a plurality of counter shafts, equal in number to the number of spindles. Associated with each counter shaft are a plurality of input and output clutches which when selectively engaged will cause the main drive shaft to rotate the associated spindle shafts at different speeds. An additional clutch may be provided on the spindle shafts for reverse drive. Actuation of the clutches is achieved through hydraulic pressure fed through the counter shafts or spindle shafts from a stationary manifold which contains the valves for the clutches.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. **1** is a side elevation view of a preferred form of multiple spindle machine constructed in accordance with the present invention;

FIGS. **2** and **3** are respectively front and rear elevation views of the machine of FIG. **1**;

FIG. **4** is an enlarged fragmentary transverse section through the drive from the motor to the main drive shaft of the machine of FIG. **1**, taken on the plane of the line **4—4** of FIGS. **1** and **5**;

FIG. **5** is an enlarged fragmentary longitudinal section through the low speed range drive from the pulley shaft to the main drive shaft, taken on the plane of the line **5—5**, FIG. **4**;

FIG. **6** is an enlarged fragmentary longitudinal section through the high speed range drive from the pulley shaft to the jack and range shaft, taken on the plane of the line **6—6** of FIG. **4**;

FIG. **7** is an enlarged fragmentary transverse section through the spindle carrier of the machine of FIG. **1** illustrating the drive from the main shaft to the counter shafts or clutch shafts, taken on the plane of line **7—7**;

FIG. **8** is a fragmentary longitudinal section through one of the counter shafts and main drive shaft of FIG. **7**, taken on the plane of the line **8—8** thereof;

FIG. **9** is a transverse section through the carrier of FIG. **1** showing the drive between the counter shafts and associated work spindles and the locking device for the carrier, taken on the plane of the line **9—9** of FIG. **1**;

FIG. **10** is a fragmentary longitudinal section through one of the spindle shafts and counter shafts of FIG. **9**, taken on the plane of the line **10—10**;

FIG. **11** is an enlarged partial section through two of the spindle clutches on the couner shaft of FIG. **10**;

FIG. **12** is an enlarged fragmentary transverse section through a single indexing mechanism for the spindle carrier of the machine of FIG. **1**, taken on the plane of line **12—12** of FIGS. **1** and **13**;

FIG. **13** is a fragmentary longitudinal section through the single indexing mechanism of FIG. **12**, taken on the plane of the line **13—13** thereof;

FIG. **14** is an enlarged fragmentary transverse section similar to FIG. **12**, but of a double indexing mechanism for the spindle carrier of FIG. **1**;

FIGS. **15** and **16** are fragmentary longitudinal sections through the double indexing mechanism of FIG. **14**, taken on the planes of the lines **15—15** and **16—16**, respectively;

FIG. **17** is a fragmentary longitudinal section through the lower cross slide of FIG. **1** taken on the plane of the line **17—17** thereof;

FIG. **18** is a fragmentary longitudinal section through the lower end slide, taken on the plane of the line **18—18** of FIG. **2**;

FIG. **19** is a fragmentary longitudinal section showing a modified form of main shaft having a reverse drive connection with one oft the spindle shafts;

FIG. **20** is a fragmentary longitudinal section showing a modified form of drive connection between the counter shafts and spindle shafts wherein the clutches are on the spindle shafts rather than on the counter shafts and the individual spindle brakes have been eliminated;

FIG. **21** is a schematic of the hydraulic system for operating the various clutches, a portion of the carrier indexing mechanism, and the carrier locking mechanism; and

FIG. 22 is a schematic of the hydraulic system for operating the various tool slides and another portion of the carrier indexing mechanism.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 through 3 show the general arrangement of the various parts of a preferred form of multiple spindle machine 1 constructed in accordance with this invention, which desirably consists of a base 2 upon which rests a housing 3 for the spindle carrier 4 and a further housing 5 containing the indexing and drive mechanisms for the machine. Adjacent the front end of the base 2 are the lower cross and end working tool slides 6 and 7, and similar upper cross and end working tool slides 8 and 9 may be supported by the top of the housing 3 adjacent the forward end therof. Other arrangements of tool working slides may be provided as desired.

The spindle carrier 4 is supported on its outer diameter in the housing 3 as shown for example in FIG. 9 to permit indexing of the spindle shafts 12,13 and 14 carried by the spindle carrier 4 from one work station to another, in a manner to be more fully explained hereafter. While the particular number of work spindles provided may be varied within limits, it is preferred that there be less work spindles than work stations, not only to increase the capacity of the machine for accommodating larger workpieces than the typical multiple type spindle machine without substantially increasing the overall size of the machine as described, for example, in United States Pat. No. 3,404,589, granted to Roger W. Brown and Robert R. Rhodehamel on Oct. 8, 1968, but also to provide additional space for the inclusion of a plurality of counter shafts or clutch shafts 15, 16 and 17 which are desirably equal in number to the number of spindle shafts and occupy positions which would normally be occupied by every other spindle shaft. The counter shafts 15, 16 and 17 are suitably journalled in the spindle carrier 4 for rotation by the main drive shaft 10 which in the preferred form shown in FIG. 8 herein has two or more different diametral pitch gears 18 and 19 splined thereto and in meshing engagement with two additional gears 20 and 21 on each of the counter shafts. Such additional gears 20 and 21 are bearing mounted on the counter shafts 15, 16 and 17 and are also bolted or otherwise secured to the outer sleeve portions 22 and 23 of input disk clutches 24 and 25. Such outer sleeve portions are free to rotate with the gears 20 and 21 until either of the input clutches 24 or 25 is hydraulically energized to cause their associated inner sleeve portions 26 or 27 and disks 28 or 29 which are keyed to the counter shafts to engage the outer sleeve portions 22 or 23 for driving the counter shafts through the engaged input clutch to rotate the counter shafts at one of two different speeds.

Also mounted on the counter shafts 15,16 and 17 axially spaced from the first pair of input clutches 24 and 25 is a second pair of output clutches 30 and 31 having inner sleeve portions 32 and 33 that rotate with the counter shafts and drive outer sleeve portions 34 and 35 when selectively hydraulically energized to rotate the associated gears 36 and 37 which are bearing mounted on the counter shafts but are secured to the outer sleeve portions 34 and 35 for rotation thereby as clearly shown in FIGS. 8 and 11. These latter gears 36 and 37 in turn mesh with gears 38 and 39 keyed to each of the spindle shafts 12, 13 and 14 (see FIG. 10). From the foregoing, it will now be apparent that the input clutches 24 and 25 control the input of rotation from the main drive shaft 10 to the counter shafts 15,16 and 17 and are engaged on an alternate basis to give two speeds to the counter shafts, whereas the output clutches 30 and 31 control the output of rotation from the counter shafts 15,16 and 17 to the work spindle shafts 12, 13 and 14, and are engaged on an alternate basis to give four speeds to each work spindle shaft. An increase in the number of input clutches will increase the number of speeds available by the number of output clutches and vice versa, whereas a reduction in the number of input or output cltuches will reduce the number of available speeds in a similar manner. Thus, for example, if three input clutches are provided on the counter shafts rather than two, by alternate engagement of the input clutches, the counter shafts may be driven at three different speeds, and if there are two output clutches, six different speeds are available to the work spindle shafts. Similarly, if only two input clutches, are provided on the counter shafts but three output clutches, then although the counter shafts may only be driven at two different speeds, the work spindles may still be driven at six different speeds. If, on the other hand, only two input clutches are provided on the counter shafts and one output clutch, then engagement of the input clutches on an alternate basis will give two speeds to the counter shafts either of which may be transferred to the spindle shafts upon engagement of the single output clutch to provide two speeds to the spindle shafts, and so on.

As illustrated in FIG. 19, reverse drive from the main drive shaft 10 to the work spindle shafts 12, 13 and 14 may be achieved by providing an additional gear 40 splined to the main drive shaft and in meshing engagement with gears 41 freely rotatable on the spindle shafts except when the associated clutches 42 are engaged to provide a direct drive from the gears 41 to the work spindles through the clutches 42.

The main drive shaft 10 has its outer end journalled in bearings 43 in the housing 5 as shown in FIG. 5 and is driven by a motor 44 situated on top of the housing 5 (see FIG. 1) either through a low range drive 45 (FIG. 5) or a high range drive 46 (FIG. 6), as desired. Mounted on the motor shaft 47 is a pulley 48 which is connected by a series of V-belts 49 to a pulley 50 mounted on a shaft 51 journalled in the housing 5. The shaft 51 is common to both the low range drive 45 and high range drive 46. Whenever it is desired to run the main drive shaft 10 at the low speed range, a small diametral pitch gear 52 is provided on the inner end of the shaft 51 as shown in FIG. 5 which drives a larger dia-metral pitch gear 53 on a jack shaft 54. Also mounted on the jack shaft 54 is a small diametral pitch gear 55 meshing with the larger gear 57 of a three gear unit 58 pinned together and keyed to a range shaft 59. The smaller gear 60 of the three gear unit 58 in turn meshes with the larger gear 61 of a two gear unit 62 keyed to a shaft 63 having direct drive with the main shaft 10 through the smaller gear 64 which meshes with a gear 65 splined to the main shaft 10.

To obtain the high speed range for the main drive shaft 10, the gear 53 on the jack shaft 54 is removed and the small gear 52 on the shaft 51 is replaced with a larger gear 66 which meshes with a smaller gear 67 on another jack shaft 68 offset from the jack shaft 54

as shown in FIGS. 4 and 6. The jack shaft 68 has a gear 69 keyed thereto which has a somewhat larger diametral pitch than the gear 55 on the jack shaft 58 and meshes with the smaller middle gear 70 of the three gear unit 58 on the shaft 59, thus to drive the main shaft 10 at a higher speed through the meshing gears 60,61 and 64,65.

Braking of the work spindle shafts 12, 13 and 14 may be achieved by journalling brake cones 75 on the spindle shafts which are keyed to the spindle carrier 4 to permit relative axial movement of the brake cones into and out of engagement with conical sleeves 76 bolted or otherwise secured to one of the fixed gears 38 on the spindle shafts as shown in FIG. 10. Normally, the brakes 75 are only applied when the work spindles 12, 13 and 14 are in the loading position to facilitate loading and unloading of a workpiece from the spindle work chucks 77 which are opened and closed by actuation of the hydraulic chucking cylinders 78 secured to the inner ends of the spindles, as further shown in FIG. 10. While one spindle shaft is being braked at one station, the other spindle shafts may be continued to be rotated and machining operations performed on the workpieces held thereby for continuity of production because the spindle shafts 12, 13 and 14 and clutch shafts 15, 16 and 17 rotate inside the spindle carrier 4 and are indexed therewith.

Where two or more output clutches 30 and 31 are provided on the counter shafts 15, 16 and 17, the brake cones 75 and associated conical sleeves 76 may be eliminated and spindle shaft braking may still be accomplished by disengaging the input clutches 24 and 25 and engaging two output clutches 30 and 31, the different gear ratios causing the lockup of the work spindle shafts.

A similar multi-speed drive arrangement may be achieved by providing the input clutches 24 and 25 on the counter shafts 15, 16 and 17 as before, but instead of mounting the output clutches 30 and 31 on the counter shafts, two, three or more fixed drive gears 79,80 and 81 may be provided on the counter shafts in meshing engagement with the associated rotatable gears 82,83 and 84 of output clutches 85,86 and 87 on the work spindle shafts 12,13 and 14, as shown in FIG. 20. Braking may be achieved by disengaging the input clutches 24 and 25 and engaging two of the output clutches, as before. The space gained by the elimination of the separate spindle shaft brakes 75,76 as shown in FIG. 10 provides the additional room needed for the third output clutch 87 on one of the counter shafts 15,16 and 17 and associated work spindle shafts 12, 13, and 14 and fixed gear 81 on the other to achieve additional speed arrangements.

For indexing the spindle carrier 4 from one work station to another, there is provided a carrier indexing mechanism 90 which in the form shown in FIGS. 12 and 13 consists of a hydraulic actuator 91 which may be actuated to oscillate its associated shaft 92 for swinging movement of an indexing arm 93 splined thereto. The indexing arm 93 has a roll 94 mounted on its outer end which is adapted to be received in any one of a series of circumferentially spaced slots 95 in an indexing plate 96 keyed to a shaft 97 for rotation in the housing 3. The slots 95 extend radially inwardly from the outer periphery of the indexing plate 96 to permit entry of the roll 94 into the slots at the start of each index and exit of the roll from the slots to stop each index. The indexing arm 93 is axially slidable on the actuator shaft 92 and has an annular groove 98 at one end in which is received a projection 99 from a slide 100 slidable along a rod guide 101 in the housing. A hydraulic reset cylinder 102 has its rod 103 connected to the slide 100, whereby actuation of the hydraulic cylinder at the end of the index of the indexing plate 93 will cause withdrawal of the roll 94 from a slot 95 to permit the indexing arm 93 to swing back to the original starting point for entry into the next slot 95 by actuation of the hydraulic cylinder 102 in the reverse direction, thus readying the indexing mechanism 90 for the next index.

Keyed to the outer end of the shaft 97 is a gear 104 in meshing engagement with a gear 105 fixed to a sleeve 106 mounted for relative rotation about the actuator shaft. The opposite end of the sleeve 106 has a further gear 107 fixed thereto which is in meshing engagement with a ring gear 108 secured to the spindle carrier 4, whereby indexing movement of the indexing plate 96 is transmitted to the carrier 4 through the meshing gears 104, 105 and 107, 108. By proper selection of the size of these latter gears, the carrier 4 may be indexed to the some angular extent as the indexing plate 96, whereby the angular spacing of the slots 95 in the indexing plate 96 will determine the extent of movement of the carrier 4 for each indexing movement of the plate 93, which will ordinarily be determined by the number of work stations present. In this particular case, there are desirably twice as many work stations as there are work spindle shafts, and since three spindle shafts are preferred, there is desirably six work stations and six slots 95 in the indexing plate each spaced 60° apart. However, it will be apparent that the number of work stations may be increased or decreased depending upon the particular job application. Moreover, instead of obtaining a single indexing movement of the spindle carrier 4 for each indexing movement of the indexing plate 96, double indexing of the spindle carrier may be achieved by modifying the indexing mechanism 90' to include a gear 110 on the inner end of the shaft 97 for driving a gear 111 splined to another shaft 112 journalled in the housing 3. See FIGS. 14–16. Splined to the other end of the shaft 112 is another gear 113 desirably having the same diametral pitch as the gear 104 and in meshing engagement with the gear 105 keyed to the rotatable sleeve 106 thus to drive the ring gear 108 attached to the spindle carrier 4 through the gear 107 in the same manner as before, but causing the spindle carrier to move twice as far or one-third of a revolution for every index of the indexing plate 96. Thus, with six work stations and only three work spindles, the work spindles will bypass every other work station during each index of the indexing plate. Variations in the extent of movement of the spindle carrier for every index of the indexing plate may be achieved by a proper selection of gears.

After each index of the indexing plate 96, the spindle carrier 4 may be locked in place during each machining operation by hydraulic actuation of a locking pin 115 which as shown in FIG. 9 is mounted in a radial bore 116 in the housing 3 adjacent the forward end of the spindle carrier for radial movement into and out of engagement with any one of a plurality of recesses 117 in carrier blocks 118 equally spaced around the periphery of the spindle carrier. The locking pin 115 is carried by a double ended lever 119 and hydraulic cylinder 120

which is actuated just prior to the indexing motion to lift the locking pin **115** from a recess **117** in one of the carrier blocks **118** in alignment therewith and drop the locking pin back into the next recess **117** which is brought into alignment with the locking pin after the indexing movement has been completed.

The pressure reducing valves and direction valves for operation of the various input and output clutches, spindle shaft brakes, indexing reset cylinder, and locking pin are contained in a stationary manifold **125** secured to the rear of the housing **5.** A typical hydraulic schematic diagram for the machine of this invention can be found in FIG. **21,** which shows an oil reservoir **126** from which oil is drawn by a pressure compensated variable volume pump P through a filter **127** and pumped through a check valve **128** into an accumulator **129** before entering the stationary manifold **125.** The accumulator **129** precludes any sudden momentary pressure drop which might otherwise occur as when one or more of the chucks **77** is opened or closed for loading, and the check valve **128** prevents the accumulator from discharging back through the pump when the system is switched off. From the accumulator **129** the oil passes through any one of four reducing valves **130, 131, 132** and **133** in the stationary manifold **125** which are set at various pressures depending upon the pressure requirements. These pressure reducing valves supply oil to the various directional valves within the stationary manifold **125** which control the flow to outlets on the inner face **134** of the stationary manifold. From there the oil is fed to a rotary manifold **135** which as shown in FIG. **5** consists of a stationary cylinder **136** and rotatable cylinder **137.** The stationary cylinder **136** is secured to the housing **5** against rotation and has a flange **138** at one end containing a plurality of inlets **143** corresponding in number to the manifold outlets for connection thereto by tubes. Rotatably mounted about the stationary cylinder **136** is the rotatable cylinder **137** which is secured to an extension of the spindle carrier **4** for rotation therewith and has a multitude of grooves **144** therein communicating with grooves in the stationary cylinder for discharge of the fluid which is then piped to the spindle carrier so that preset pressures may be maintained at each spindle position after each index for flow to the spindle bearings, clutches, spindle shaft brakes, and chucking cylinders.

The first pressure reducing valve **130** supplies oil to the directional valves **137** that control the flow to the input and output clutches **24, 25** and **30, 31,** each directional valve controlling the operation of two such clutches. The fluid for actuating the clutches passes through a rotary seal at the ends of the associated counter shafts or spindle shafts, depending upon which shafts the clutches are mounted on, and through the center of the shafts to the clutches. Twelve clutches are shown, four on each of the counter shafts, which are operated by six control valves **137.**

The second pressure reducing valve **131** supplies oil to directional control valves **138** for controlling the flow to the spindle shaft brakes **75,** which are normally actuated only when the spindle shafts **12, 13** and **14** are in the loading position. The third pressure reducing valve **132** supplies fluid to the directional valves **139** for controlling the operation of the chucking cylinders **78** which pull on the draw rod **140** through the spindle shafts to clamp the chuck jaws on the part to be machined, whereas the fourth pressure reducing valve **133** supplies oil at a low pressure to the bearings B and the gears in the spindle carrier **4.**

The first pressure reducing valve **130** also supplies fluid to a directional valve **141** which controls the operation of the reset cylinder **102** for indexing machanism **90,** whereas the second pressure reducing valve **131** supplies fluid to a directional valve **142** which operates the locking pin cylinder **120** for releasably locking the spindle carrier **4** against movement.

For operating the four cross slides **6** and **8** and two end working slides **7** and **9,** there is provided a second variable volume pump P' (see FIG. **22**) which pulls oil through a filter **145** from a reservoir **146** in the base **2** of the machine and pumps the oil through a check valve **147** and past an accumulator **148** and filter **149** for flow to the various servo valves **150–155** which actuate the cylinders **156–161,** one such servo valve and cylinder being provided for operating each work slide upon which are mounted the cutting tools. A command signal to the selected servo valves **150–155** causes the torque motor units associated therewith to pull the servo spools off center allowing fluid to pass to one end of the associated cylinders and actuate the associated work slides. The cylinder rods **162** are tied to linear potentiometers **163** which feed back signals denoting the positions of the slides at any given moment. When the slides reach a certain designated position, the signals from the potentiometers will cause the servo valves to move to neutral position blocking the flow and stopping movement of the slides. To retract the cylinders, the servo valves are moved to full open position for high speed return of the pistons **164,** which are cushioned out at the end of their stroke.

The fluid from the pump P' also drives the oscillating motor **91** that moves the indexing arm **93** to index the carrier **4.** The speed of movement on index is controlled by a flow control valve **165,** whereas the return movement to starting position is a fast return.

From the foregoing, it will now be apparent that the various forms of multiple spindle machines disclosed herein permit separate control of each of the spindle shaft speeds, which is made feasible from a size and cost standpoint because of the unique manifold arrangement for supplying hydraulic fluid for actuating the various clutches. A novel indexing and braking arrangement is also provided, and where two or more clutches are provided on the counter shafts or work spindle shafts, the separate brakes on each of the spindle shafts may be eliminated because braking may be achieved by simultaneously actuating two output clutches. The space gained by eliminating the brakes will provide room for another clutch for varying the speed of the spindle shafts. Reverse drive is also obtainable.

Although the multiple spindle machines disclosed herein are shown for use in chucking applications, it will be apparent that the same principles are also applicable to bar machines which would enable optimum surface feet to be supplied for the various cutting tools.

I, therefore, particularly point out and distinctly claim as my invention:

1. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating

said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shafts at any given speed, and additional fluid operated clutch means associated with said spindle shafts and drive shaft for selectively independently driving said spindle shafts in the reverse direction.

2. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, and fluid operated brake means associated with each of said spindle shafts for selectively independently stopping said spindle shafts.

3. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, said means for rotating said main drive shaft comprising a motor and low and high range drives for selectively connecting said motor to said main drive shaft, said low and high range drives having a common input shaft driven by said motor, and a pair of offset jack shafts having different diametral pitch gears thereon in meshing engagement with different size gears on a further jack shaft, said pair of jack shafts and input shaft being adapted to be alternately provided with different driving gear combinations for driving said main drive shaft through said further jack shaft at different speeds.

4. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, said means mounting said spindle carrier for indexing movement comprising a pivotally mounted indexing arm, a rotatable indexing plate having a plurality of circumferentially spaced slots engageable by said indexing arm during pivotal movement of said indexing arm in one direction to index said indexing plate, means for causing such pivotal movement of said indexing arm, and a gear train driven by said indexing plate for indexing said spindle carrier.

5. The machine of claim **4** further comprising means mounting said indexing arm for axial movement toward and away from said indexing plate to permit withdrawal of said indexing arm from one slot at the end of said index and return movement of said indexing arm to the original starting point for entry into the next slot.

6. The machine of claim **4** wherein said gear train comprises a first gear keyed to the same shaft to which said indexing plate is keyed for rotation thereby, a second gear in meshing engagement with said first gear supported by a sleeve rotatably mounted on a shaft supporting said indexing arm for pivotal movement, and a third gear keyed to said sleeve having meshing engagement with a ring gear on said spindle carrier.

7. The machine of claim **4** wherein said gear train comprises a first gear keyed to the same shaft to which said indexing plate is keyed for rotation thereby, a second gear keyed to a second shaft and in meshing engagement with said first gear, a third gear keyed to said second shaft, a fourth gear in meshing engagement with said third gear and supported by a sleeve rotatably mounted on a shaft supporting said indexing arm for pivotal movement, and a fifth gear keyed to said sleeve having meshing engagement with a ring gear on said spindle carrier.

8. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, and locking pin means mounted for radial movement into and out of circumferentially spaced recesses in the outer periphery of said spindle carrier for releasably locking said spindle carrier in place after indexing.

9. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, and a stationary cylinder to which fluid is supplied for operating said clutch means, and a rotatable cylinder mounted for rotation about said stationary cylinder and secured to said spindle carrier for indexing movement therewith, said stationary and rotatable cylinders having flow passages therein through which fluid may be supplied to said clutch means at each index position of said spindle carrier.

10. The machine of claim **9** further comprising a stationary manifold containing pressure reducing valves and direction valves for controlling the flow to said stationary cylinder.

11. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement between a plurality of work stations, a main drive shaft, means for rotating said main drive shaft at a given speed, and drive means including a plurality of fluid operated clutch means associated with each of said spindle shafts and said main drive shaft for selectively independently driving said spindle shafts in one direction at any one of at least three different speeds during rotation of said main drive shaft at any given speed, said drive means including counter shafts rotatably mounted in said spindle carrier intermediate said spindle, said clutch means being operative to transmit the drive from said main drive shaft to said spindle shafts through said counter shafts, there being at least two of said fluid operated clutch means for selectively driving each of said counter shafts at two different speeds by said main drive shaft while rotating at a constant speed, and at least two additional fluid operated clutch means for selectively connecting each of said counter shafts to the respective spindle shafts to provide at least a four speed drive to each of said spindle shafts.

12. The machine of claim 11 further comprising still another fluid operated clutch means between said counter shafts and spindle shafts to provide at least a six speed drive to each of said spindle shafts.

13. A multiple spindle machine comprising a spindle carrier, a plurality of spindle shafts rotatably mounted in said spindle carrier, means mounting said spindle carrier for indexing movement, a main drive shaft, means for rotating said main drive shaft at a given speed, a plurality of counter shafts rotatably mounted in said spindle carrier and corresponding in number to the number of spindle shafts, first clutch means associated with each of said counter shafts and main drive shaft which when engaged cause said main drive shaft to drive said counter shafts, and at least two additional clutch means associated with each of said spindle shafts and counter shafts which when alternately engaged cause said counter shafts to drive said spindle shafts at different speeds during rotation of said main drive shaft at any given speed, and when simultaneously engaged with said first clutch means disengaged, cause braking of said spindle shafts.

14. The machine of claim 13 wherein said two additional clutch means when engaged operate gear drives between said counter shaft and spindle shafts, said gear drives having different ratios which cause a lockup of said counter shafts and spindle shafts when operated simultaneously.

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