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2,573,333

VARIABLE SPEED STROKE POWER MECHANISM

Filed March 31, 1950

3 Sheets-Sheet 1

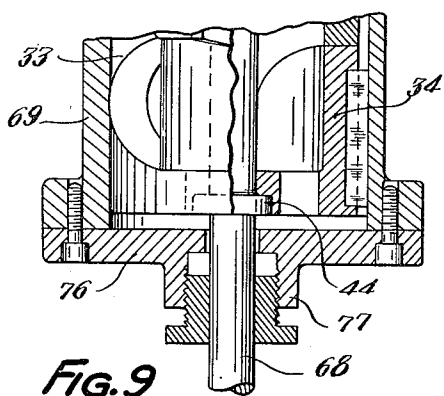
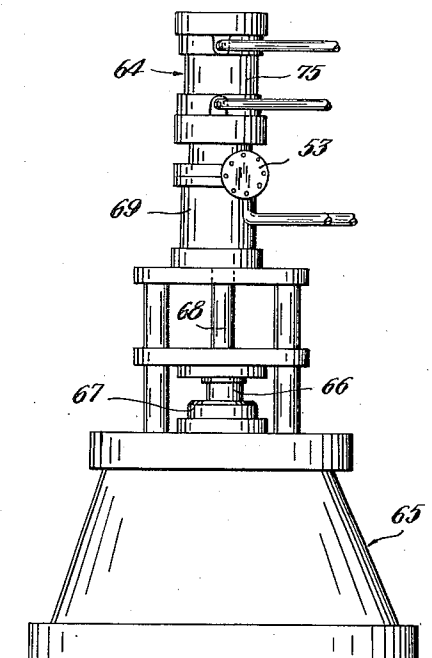
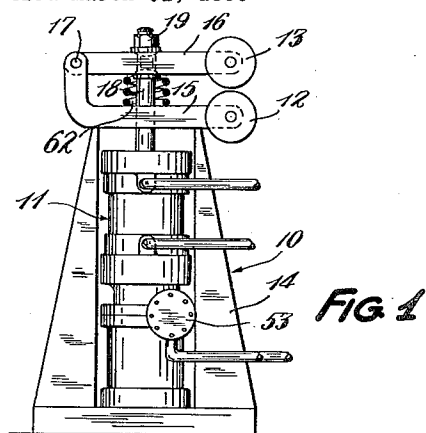


FIG. 7

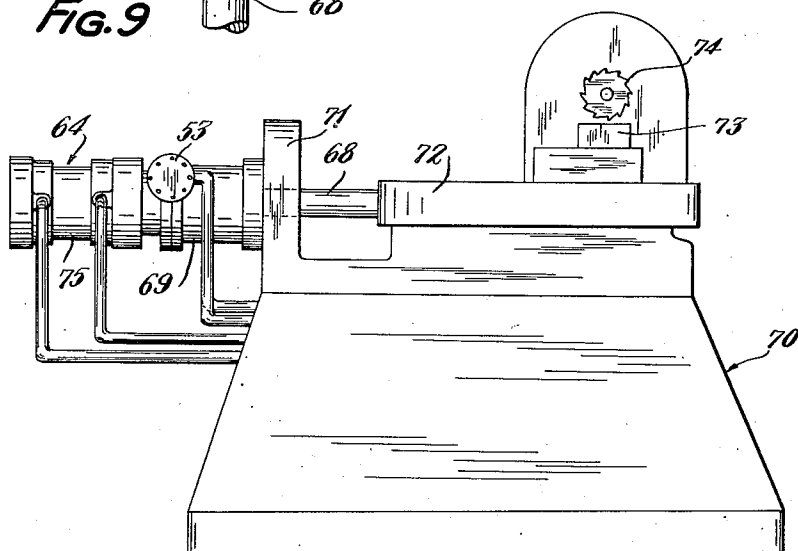


FIG. 8

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VARIABLE SPEED STROKE POWER MECHANISM

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3 Sheets-Sheet 2

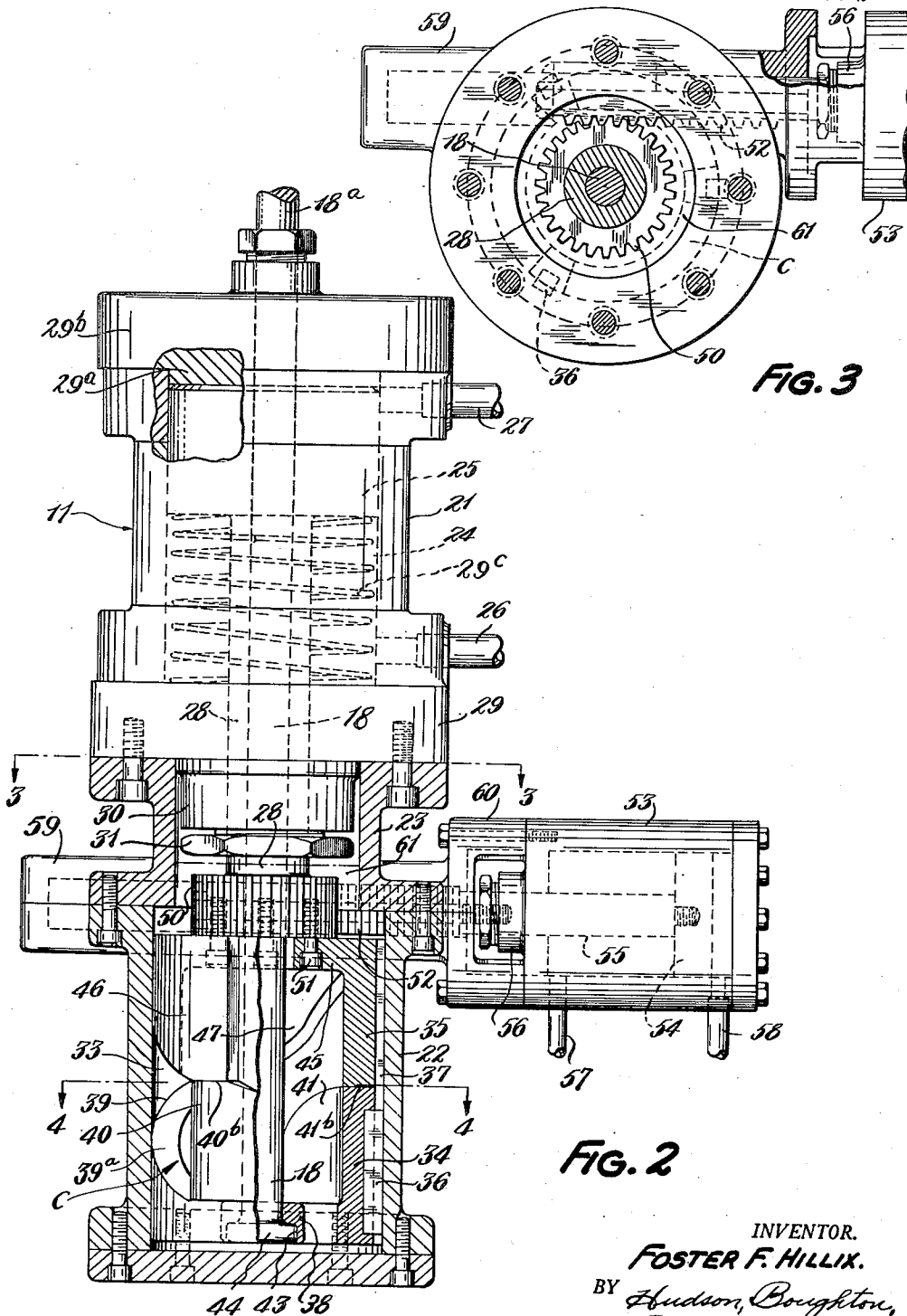


FIG. 2

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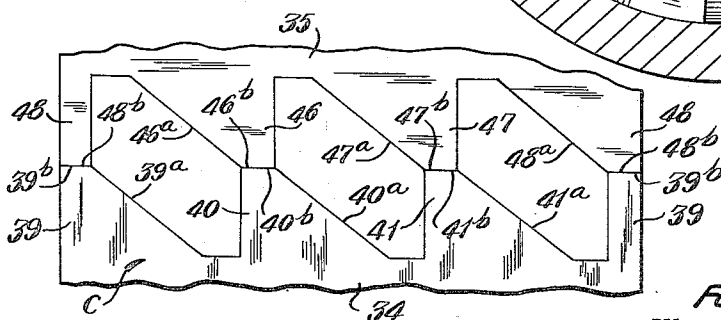
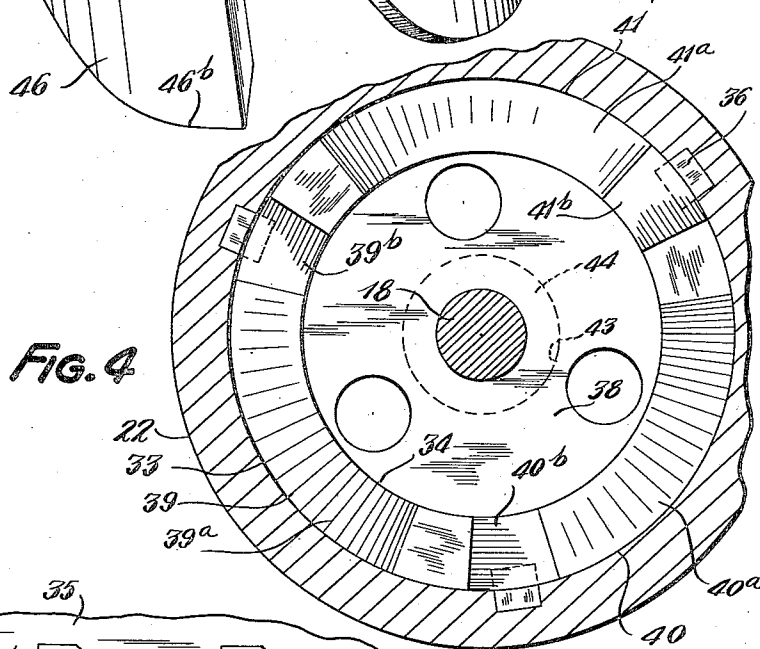
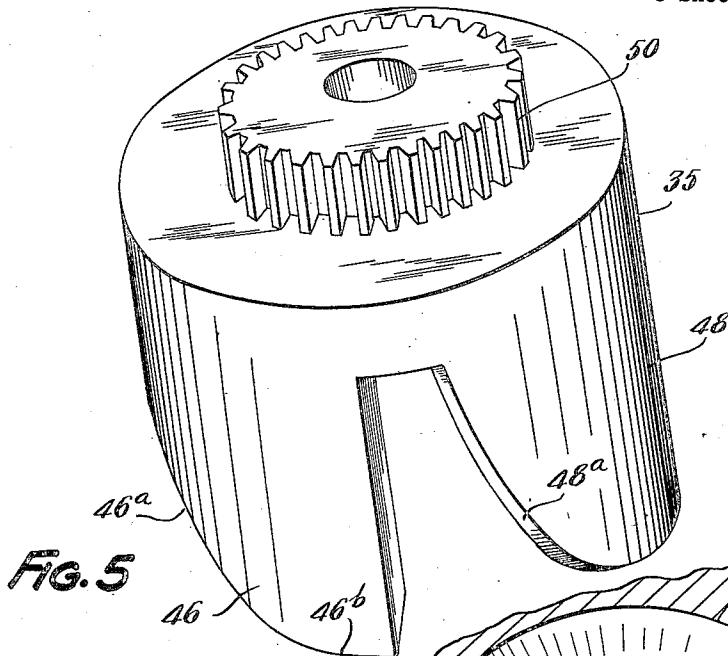
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VARIABLE SPEED STROKE POWER MECHANISM

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3 Sheets-Sheet 3



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VARIABLE SPEED STROKE POWER
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6 Claims. (Cl. 60—97)

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This invention relates to power mechanisms for machine tool operation and, more particularly, to an improved power mechanism of the hydraulic type by which different portions of the working stroke of a machine tool can be carried out at different desired rates of speed.

In many machine tools it is desirable to have the initial portion of the working stroke carried out as a relatively high-speed low-pressure stroke movement, as for example during the closing of the rolls of a rolling machine or during the closing of the dies of a punch press, and the subsequent or final portion of the working stroke carried out as a relatively low-speed high-pressure stroke movement for supplying the pinching force or working pressure which the rolls of the rolling machine or the dies of the punch press are to apply to the work. Such a high-speed low-pressure initial stroke movement used for closing a pair of rolls or dies is usually a movement of a substantial extent and the final low-speed high-pressure stroke movement is usually a small amount of movement. These variable stroke functions have been obtainable heretofore by the use of a reciprocable hydraulic cylinder but with the disadvantage that when the cylinder has been of a diameter to provide the desired low-speed high-pressure stroke movement, it then has had an objectionably large displacement volume in producing the high-speed low-pressure stroke movement.

Because of this large displacement volume of the hydraulic cylinder of the power mechanism it has heretofore been necessary to provide high-capacity high-pressure pumping equipment in order to supply the amount of oil required for proper actuation of the hydraulic cylinder. Such high-capacity high-pressure pumping equipment consumes an amount of electrical power which usually is wholly out of proportion to the work to be performed by the machine tool, has an initial high cost and is expensive to maintain in an efficient operating condition.

The present invention overcomes this difficulty and provides, as one of its objects, an improved power mechanism which embodies both a cam means and a hydraulic cylinder means and in which the cam means produces the desired relatively high-speed low-pressure stroke movement and the hydraulic cylinder means produces the desired relatively low-speed high-pressure stroke movement.

Another object of this invention is to provide an improved power mechanism of this character in which the cam means and the hydraulic cylin-

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der means are disposed in such cooperating relation that the hydraulic cylinder means delivers its working force to the machine tool through the cam means.

Still another object is to provide an improved power mechanism of the character mentioned in which the cam means comprises relatively rotatable cam members having cooperating cam surfaces for producing the relatively high-speed low-pressure stroke movement and cooperating flat surfaces through which the low-speed high-pressure stroke movement of the hydraulic cylinder means is transmitted.

A further object is to provide an improved power mechanism of the kind referred to in which the housing of the mechanism has coaxially aligned chambers, one of which is the main hydraulic cylinder chamber and the other is a cam chamber in which the cooperating cam members are axially movable and relatively rotatable.

Yet another object is to provide an improved power mechanism of the type mentioned in which gearing and an auxiliary power device are employed to produce the relative rotation between the cooperating cam members.

The invention can be further briefly summarized as consisting in certain novel combinations and arrangements of parts hereinafter described and particularly set out in the claims hereof.

In the accompanying sheets of drawings,

Fig. 1 is an elevation showing a rolling machine to which the present invention has been applied for causing opening and closing the rolls and for applying the desired pinching force thereto;

Fig. 2 is an elevation partly in vertical section showing the improved power mechanism on a larger scale and in detached relation;

Fig. 3 is a transverse section taken through the mechanism substantially as indicated by the irregular section line 3—3 of Fig. 2;

Fig. 4 is another transverse section taken on section line 4—4 of Fig. 2;

Fig. 5 is a perspective detail view showing the inner or rotatable cam member in detached relation;

Fig. 6 is a development view of the working portions of the cooperating cam members;

Figs. 7 and 8 are elevations illustrating a modified form of the improved power mechanism and showing other examples of uses of the improved mechanism, Fig. 7 being a punch press and Fig. 8 being a milling machine; and

Fig. 9 is a partial vertical section taken through

a portion of the cam means of the modified form of the improved power mechanism.

As one practical embodiment of this invention, Fig. 1 shows a rolling machine 10 to which the improved power mechanism 11 has been applied for causing closing and opening of a pair of rolls 12 and 13 and for supplying the pinching force or rolling pressure which the rolls are to apply to the work. The rolling machine 10 includes a suitable frame 14 having a stationary arm 15 on which the lower roll 12 is mounted. An upper arm 16 having pivotal connection with the stationary arm 15, as indicated at 17, is movable relative to the stationary arm for causing the roll 13 to be shifted relative to the roll 12 for opening and closing of the rolls and for applying the pinching force or rolling pressure which the rolls apply to the work.

The improved power mechanism 11 is suitably mounted in or on the frame 14 with its axially extending operating shaft or rod 18 projecting upwardly therefrom. The shaft 18 extends through or past the stationary arm 15 and has its shouldered upper end connected with the movable arm 16 by means of the retaining nut 19 so that axial movements of this shaft will cause the above mentioned work stroke movements of the roll 13. One or both of the rolls 12 and 13 can be driven by other suitable power means for accomplishing the desired rolling operation on sheet material fed to the rolls after they have been closed by the power mechanism 11.

The improved power mechanism 11 comprises an upright housing formed by connected vertically aligned housing sections which include upper and lower housing sections 21 and 22 and an intermediate housing section 23. This mechanism also includes the above mentioned shaft 18 which extends axially through these housing sections and projects from the upper end of the upper housing section 21 for operative connection with the machine tool, or the like, to which this power mechanism is applied.

The upper housing section 21 constitutes a double-acting main hydraulic cylinder having a cylinder chamber 24 in which a power piston 25 is reciprocally operable. Motive fluid from any available source, such as oil under a relatively high pressure, is adapted to be supplied to the cylinder chamber 24 through the conduits 26 and 27 connected with opposite ends thereof.

The power piston 25 includes an axial sleeve portion 28 which extends downwardly through the lower cover 29 of the hydraulic cylinder 24 and through a stuffing box 30 which is carried by this cylinder cover. A gland 31 disposed around the sleeve 28 has threaded engagement in the stuffing box 30 for subjecting packing material therein to pressure. The operating shaft 18 slidably extends through the piston 25 and the sleeve portion 28 of the latter and includes an upper shaft portion 18a which projects from the cylinder 24 for connection with the roll-carrying arm 16. The piston 25 has an initial position in abutting engagement with an axial projection 29a of the upper cylinder cover 29b against which the piston is initially held by a compression spring 29c. A thrust transmitting connection between the piston 25 and the shaft 18 is established through the sleeve portion 28 and the cam device C in the manner explained hereinafter.

The lower housing section 22 contains a cam chamber or cylinder 33 in which a pair of cooperating lower and upper annular cam members 34 and 35 comprising the cam device C are dis-

posed in axial alignment and in surrounding relation to the shaft 18. These cam members are axially slidable in the cam chamber and the upper or inner cam member 35 is also rotatable in this chamber. As will appear more fully hereinafter, the upper cam member 35 has only a limited amount of axial movement in the cam chamber 33 corresponding with the final closing movement of the roll 13 for applying the pinching force to the work, but the lower cam member 34 is capable of a substantial amount of axial movement corresponding with the sum of the initial closing movement of the roll 13 and the final closing movement thereof. The lower or outer cam member 34 is held against rotation by one or more keys 36 which are mounted in the outer periphery of this cam member and are slidable in keyways 37 of the housing section 22.

The lower cam member 34 comprises a transverse end wall 38 and an annular group of axially extending cam elements, in this instance three such cam elements, 39, 40 and 41 carried thereby. The cam elements 39, 40 and 41 comprise teeth-like projections having helical cam faces 39a, 40a and 41a thereon. At the inner ends of the cam teeth 39, 40 and 41, the inclined cam faces 39a, 40a and 41a thereof merge into flat thrust faces 39b, 40b and 41b which lie in a flat transverse plane extending perpendicularly to the axis of the shaft 18. The cam member 34 is connected with the lower end of the operating shaft 18 and, for this purpose, the transverse wall 38 is provided with a counterbored opening 43 and the shaft is provided with an enlargement or head 44 seating in this counterbored opening.

The upper cam member 35 is of a construction similar to the lower cam member 34 and comprises a transverse wall 45 and an annular group of axially extending tooth-like cam projections, in this instance three such cam teeth or projections, 46, 47 and 48. These cam teeth have helically extending cam faces 46a, 47a and 48a thereon which are similar to the helical cam faces 39a, 40a and 41a. The cam faces 39a, 40a and 41a slope in the same direction and at substantially the same slope angle as the cam faces 46a, 47a and 48a, as is shown in the development view of Fig. 6, but the cam faces 39a, 40a and 41a are located on one side, in this instance the right side, of the cam teeth 39, 40 and 41 and the cam faces 46a, 47a and 48a are located on the opposite or left side of the cam teeth 46, 47 and 48. At the lower ends of the cam teeth 46, 47 and 48, the helical cam faces 46a, 47a and 48a merge into flat thrust faces 46b, 47b and 48b which lie in a common flat transverse plane which is perpendicular to the axis of the shaft 18.

The teeth of each of the two cam members 34 and 35 are spaced apart circumferentially so that the teeth of one cam member will be engageable in the spaces between the teeth of the other cam member when the cam means is in a collapsed or retracted condition. The movement of the cam teeth into and out of such interfitting or telescoping engagement occurs as the result of relative axial movement between these two cam members and this relative axial movement is produced by or accompanies a cooperating camming engagement between the groups of helical cam faces 39a, 40a, 41a and 46a, 47a, 48a of the two cam members upon the occurrence of relative rotary movement between these cam members. In other words, when the cam members are in a collapsed or telescoped relation and the upper cam member 35 is rotated in a clockwise di-

rection relative to the lower cam member 34, the cooperating helical cam faces of the two sets of cam teeth will produce a spreading force between the cam members which will cause a relatively rapid downward movement of the shaft 18 as the result of a pull applied to the head 44 thereof by the lower cam member 34.

During this camming cooperation of the cam members 34 and 35, the upper cam member remains in the upper portion of the cam chamber 33 as shown in Fig. 2, but the cam member 34 moves back and forth in the cam chamber. When the cam device C is assuming its collapsed condition the lower cam member 34 shifts upwardly in the cam chamber 33 with the cam teeth 39, 40 and 41 thereof moving into meshing relation between the cam teeth 46, 47 and 48 of the upper cam member 35. When the cam device C is being expanded in the manner explained above, the lower cam member 34 shifts downwardly to a position adjacent to but spaced from the lower end of the cam chamber and its cam teeth 39, 40 and 41 move out of such meshing relation.

When the cam member 35 has been rotated through an angular distance sufficient to cause the camming contact to traverse the full length of the helical cam faces, the groups of flat thrust faces 39b, 40b, 41b and 46b, 47b, 48b of the two cam members will then come into opposed or registering relation, at which time the cam members will be in their fully expanded condition, as shown in Figs. 2 and 6. Rotation of the cam member 35 in the opposite direction, that is in a counter-clockwise direction, will cause the flat thrust faces to move out of their registering relation, and continued counter-clockwise rotation of the cam member 35 will cause the helical cam faces 46a, 47a, 48a and 39a, 40a, 41a to slide on each other in a downhill direction resulting in the cam members being returned to their initial or collapsed condition and permitting an upward or return movement of the shaft 18.

The power mechanism 11 includes gearing and an auxiliary power device for producing the above mentioned rotation of the cam member 35. As shown in Figs. 2 and 3, this gearing comprises a spur gear 50 mounted in fixed relation on the transverse wall 45 of the upper cam member 35 by means of the screws 51 and a rack 52 in meshing engagement with this gear. The auxiliary power device comprises a double-acting auxiliary hydraulic cylinder 53 having a piston 54 reciprocable therein. A piston rod 55 projecting from the auxiliary cylinder 53 through a stuffing box 56 has one end thereof connected with the piston 54 and its other end connected with the rack 52. Movements of the piston 54 as the result of hydraulic pressure fluid supplied to the cylinder 53 through conduits 57 and 58 actuate the rack 52 to cause rotation of the gear 50 and of the cam member 35 connected therewith.

The intermediate housing section 23 forms a connecting means between the upper and lower housing sections 21 and 22 and also cooperates with the lower housing section 22 in forming a hollow guide structure 59 for the rack 52 and a mount 60 for the auxiliary hydraulic cylinder 53. The intermediate housing section 23 also provides an intermediate chamber 61 into which the gland 31 and the gear 50 extend from opposite ends thereof.

In addition to serving as a rotating means for the cam member 35, the gear 50 also constitutes a thrust member which is engaged by the lower

end of the sleeve portion 28 of the main hydraulic piston 25. During the expansion of the cam device C by the rotation of the upper cam member 35, as explained above, the upward thrust reaction of the upper cam member is taken against the cylinder cover 29b to which it is transmitted through the sleeve portion 28 and the piston 25. A compression spring 62 embodied in the machine tool 10 and located between the roll-carrying arms 15 and 16 applies thrust to the shaft 18 which will maintain the cam members 34 and 35 in cooperating engagement at all times and will produce a return stroke of the shaft and cause the nesting or intermeshing of the cam teeth which takes place when the cam members assume their collapsed or telescoped condition.

In the operation of the improved power mechanism 11 when the cam members 34 and 35 are in an initially collapsed condition and the piston 25 is in its initial abutting engagement with the cylinder cover 29b, hydraulic pressure fluid is supplied through the conduit 57 to the auxiliary hydraulic cylinder 53, causing movement of the rack 52 toward the right to rotate the cam member 35 in a clockwise direction. This causes the axial expansion of the cam members, as explained above, and applies a relatively high-speed axial downward movement to the shaft 18. The extent of this axial movement will depend upon the axial length of the cam teeth and may be an axial movement of a substantial distance, such as several inches. This relative rotation of the cam members, in addition to producing the desired high-speed long-stroke movement of the shaft 18, also brings the flat end thrust faces of the cam members into aligned relation, as explained above. When the improved power mechanism 11 is operatively connected with the rolling machine 10, as explained above, this high-speed long-stroke movement of the shaft 18 will cause the desired relatively quick closing of the rolls 12 and 13 preliminary to the pinching pressure to be applied to the work by the rolls.

Immediately following the actuation of the auxiliary power device 53, hydraulic pressure fluid is supplied to the main cylinder chamber 24 through the conduit 27 to cause a downward power stroke of the main piston 25. This power stroke of the main piston causes the sleeve 28 thereof to apply a heavy downward axial thrust to the gear 50 which is transmitted through the cam member 35 and the flat thrust faces to the cam member 34 and thence to the head 44 of the shaft 18. This heavy downward thrust imparted to the shaft 18 causes the above mentioned heavy pinching pressure to be applied by the rolls to the sheet material fed therebetween.

This power actuation of the piston 25 can be a relatively short-stroke movement but will be a very heavy pressure because of the large effective area of the main piston on which the hydraulic fluid pressure will act. Since this power stroke of the main piston 25 is only a short-stroke movement and since the piston 54 of the auxiliary hydraulic cylinder 53 is of small diameter, it will be seen that the mechanism 11 can be operated with only a relatively small volume of hydraulic pressure fluid, such as can be furnished by relatively inexpensive small capacity pumping equipment. During this limited axial movement imparted to the upper cam member 35 by the short-stroke movement of the piston 25, the gear 50 remains continuously in mesh with the rack 52.

In the embodiment of the hydraulic pressure mechanism 11 above described, the power stroke

of the shaft 18 acts as a pulling force but, in some instances, it is desirable to have this power stroke function as a pushing force. Figs. 7 and 8 show a power mechanism 64 of a modified construction in which such a pushing force is obtained. Fig. 7 shows the power mechanism 64 as forming a part of a punch press 65 having cooperating punch and die members 66 and 67. The operating shaft 68 of the power mechanism 64 projects from the lower end of the cam cylinder 69 and is connected with the punch 66.

In Fig. 8 the power mechanism 64 is shown as forming a part of a milling machine 70. In this embodiment of the invention the power mechanism 64 is disposed in a horizontal position and is mounted on a bracket portion 71 of the frame of the milling machine. The shaft 68 projects from the lower end of the cam cylinder 69 and is connected with the reciprocable table 72 of the milling machine. Fig. 8 also shows a workpiece 73 mounted on the table 72 and a milling cutter 74 adapted to be driven by suitable power means and operable to perform milling operations on the workpiece.

In the operation of the punch press 65 of Fig. 7, the cam means of the power mechanism 64 produces a relatively high-speed long-stroke closing movement of the punch 66 relative to the die member 67 and the main hydraulic power cylinder 75 produces a subsequent short-stroke high-pressure movement of the punch 66 for performing the desired die operation on the work. Similarly, in the operation of the milling machine 70 of Fig. 8, the cam means 69 produces a relatively high-speed long-stroke travel of the table 72 for quickly bringing the workpiece 73 into adjacent relation to the milling cutter 74 and the main hydraulic power cylinder 75 causes a subsequent relatively slow-speed short-stroke movement of the table 72 for feeding the workpiece during the milling operation performed thereon by the cutter 74.

When the power mechanism assumes the modified form shown in Figs. 7 and 8, the operating shaft 68 projects from the cam cylinder 69, as mentioned above, and extends outwardly from the head 44 by which the lower cam member 34 is connected with this shaft. If desired, the bottom cover 76 of the cam cylinder 69 can be provided with a stuffing box 77 through which the shaft 68 extends and which will serve to retain lubricant in the cam chamber 33 when such lubricant is provided therein for lubricating the cam surfaces.

From the foregoing description and the accompanying drawings it will now be readily understood that this invention provides an improved power mechanism for use with various kinds of machine tools and by which a relatively high-speed low-pressure long-travel work stroke movement will be produced by cam means and a subsequent low-speed high-pressure short-travel work stroke movement will be produced by a main hydraulic cylinder. It will also be seen that the heavy working pressure provided by the main power cylinder is transmitted to the operating shaft through the cam means in a very direct and effective manner. Additionally, it will be seen that the cam means of this improved power mechanism includes relatively rotatable cam members and an auxiliary power device for producing such relative rotation. Furthermore, it will now also be understood that this improved power mechanism requires only a relatively small volume of hydraulic pressure fluid to be supplied

thereto such as can be provided by small capacity relatively inexpensive pumping equipment.

Although the improved power mechanism of this invention has been illustrated and described herein to a somewhat detailed extent it will be understood, of course, that the invention is not to be regarded as being limited correspondingly in scope, but includes all changes and modifications coming within the terms of the claims hereof.

Having thus described my invention, I claim:

1. A power device for machine actuation by successive work stroke movements comprising, a hydraulic cylinder, means connected with said cylinder for supplying motive fluid thereto, a rod projecting from said cylinder for operating connection with said machine, a pair of relatively rotatable cam members disposed in substantially coaxial relation to said rod and having cooperating cam portions responsive to relative rotation between the cam members for causing axial movement of said rod for producing one of said work stroke movements, a piston operable in said cylinder in response to pressure of said motive fluid for causing axial movement of said rod for producing another of said work stroke movements, connecting means effective on said rod for transmitting thereto the movement caused by said cam members and piston, and means for causing said relative rotation between said cam members.

2. A power device for machine actuation by successive work stroke movements comprising, a housing having therein a pair of substantially coaxially aligned chambers one being a hydraulic cylinder and the other being a cam chamber, means connected with said cylinder for supplying motive fluid thereto, a rod movable axially of said chambers and projecting from said housing for operating connection with said machine, a pair of cooperating relatively rotatable and axially movable cams in said cam chamber and one of which is connected with said rod for imparting movement thereto in response to such relative rotation between said cams for causing one of said work stroke movements, a piston operable in said hydraulic cylinder in response to pressure of said motive fluid, thrust means effective to impart the movement of said piston to said rod through said cams for causing another portion of said work stroke movement, and means for producing relative rotation between the cams.

3. A power device for machine actuation by successive relatively fast and relatively slow work stroke movements comprising, a housing having therein a pair of substantially coaxially aligned chambers one being a hydraulic cylinder and the other being a cam chamber, means connected with said cylinder for supplying motive fluid thereto, a rod movable axially of said chambers and projecting from said housing for operating connection with said machine, a pair of cam members axially movable and relatively rotatable in said cam chamber and one of said cam members being connected with said rod, cooperating helical cam elements carried by said cam members and being responsive to the relative rotation thereof for imparting axial movement to said rod for causing said relatively fast work stroke movement, a piston operable in said hydraulic cylinder in response to pressure of said motive fluid, cooperating flat thrust faces on said cam members for transmitting thrust from said piston through said cam members to said rod for causing said relatively slow work stroke movement, and

means for causing relative rotation between said cam members.

4. A power device for machine actuation by successive relatively fast and relatively slow work stroke movements comprising, a housing having therein a pair of substantially coaxially aligned chambers one being a hydraulic cylinder and the other being a cam chamber, conduit means connected with said cylinder for supplying motive fluid thereto, a rod movable axially of said chambers and projecting from said housing for operating connection with said machine, a pair of rotatable and non-rotatable cam members in said cam chamber, means connecting one of said cam members with said rod, helical cam elements on said cam members, flat thrust faces on said cam members, means for imparting rotary movement to the rotatable cam member for causing camming cooperation of said helical cam elements and for subsequently bringing said flat thrust faces into registration, said camming cooperation of said helical cam elements being effective to impart axial movement to said one cam member and said rod for producing said relatively fast work stroke movement, a piston operable in said cylinder in response to pressure of said motive fluid, and thrust means disposed between said piston and one of said cam members and effective for transmitting thrust to said rod through said cam members while said flat thrust faces are in registration for producing said relatively slow work stroke movement.

5. A power device for machine actuation by successive relatively fast and relatively slow work stroke movements comprising, a housing having therein a pair of substantially coaxially aligned chambers one being a main hydraulic cylinder and the other being a cam chamber, conduit means connected with said main cylinder for supplying motive fluid thereto, a rod movable axially of said chambers and projecting from said housing for operating connection with said machine, a pair of rotatable and non-rotatable cam members in said cam chamber, means connecting one of said cam members with said rod, helical cam elements on said cam members, flat thrust faces on said cam members, a gear connected with the rotatable cam member, a rack meshing with said gear, an auxiliary hydraulic cylinder, conduit means connected with said auxiliary cylinder for supplying motive fluid thereto, a piston operable in said auxiliary hydraulic cylinder in response to pressure of said motive fluid and being connected with said rack for actuating the same, said rack and gear being effective to impart rotary movement to said rotatable cam member for causing camming cooperation of said helical cam elements and subsequently bringing said flat thrust faces into registration, said camming cooperation of said helical cam elements being ef-

fective to impart axial movement to said one cam member and said rod for producing said relatively fast work stroke movement, a main piston operable in said main hydraulic cylinder in response to pressure of said motive fluid, and thrust means disposed between said main piston and one of said cam members and effective for transmitting thrust to said rod through said cam members while said flat thrust faces are in registration for producing said relatively slow work stroke movement.

6. A power device for machine actuation by successive relatively fast and relatively slow work stroke movements comprising, a housing having therein a pair of substantially coaxially aligned chambers one being a hydraulic cylinder and the other being a cam chamber, conduit means connected with said cylinder for supplying motive fluid thereto, a rod movable axially of said chambers and projecting from said housing for operating connection with said machine, a pair of axially aligned outer and inner annular cam members slidable in said cam chamber, means connecting said outer cam member with said rod, means holding said outer cam member against rotation in said chamber, said cam members having groups of annularly spaced inclined cam elements thereon and also having groups of annularly spaced flat thrust faces thereon adjacent the top of the inclined cam elements, said inner cam member being rotatable in said cam chamber for causing camming cooperation of said groups of inclined cam elements and for subsequently bringing said groups of flat thrust faces into registration, said camming cooperation being effective to impart outward axial movement to said outer cam member and to said rod for producing said relatively fast work stroke movement, means for imparting rotary movement to said inner cam member, a piston operable in said cylinder in response to pressure of said motive fluid, and thrust means disposed between said piston and said inner cam member and adapted to transmit piston thrust to said rod through said cam members while said flat thrust faces are in registration for producing said relatively slow work stroke movement.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,192,778	Stacy	Mar. 5, 1940
2,261,829	Cross	Nov. 4, 1941
2,466,815	Lightburn	Apr. 12, 1949
2,509,368	Price	May 30, 1950