Aug. 18, 1936. E. L. WALL 2,051,430

UNIVERSAL DIE SINKING ATTACHMENT FOR VERTICAL MILLING MACHINES

Filed Dec. 12, 1933 3 Sheets-Sheet 1

Fig. 2.

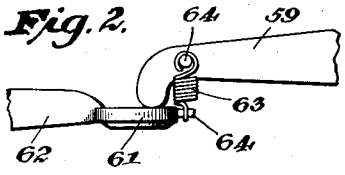
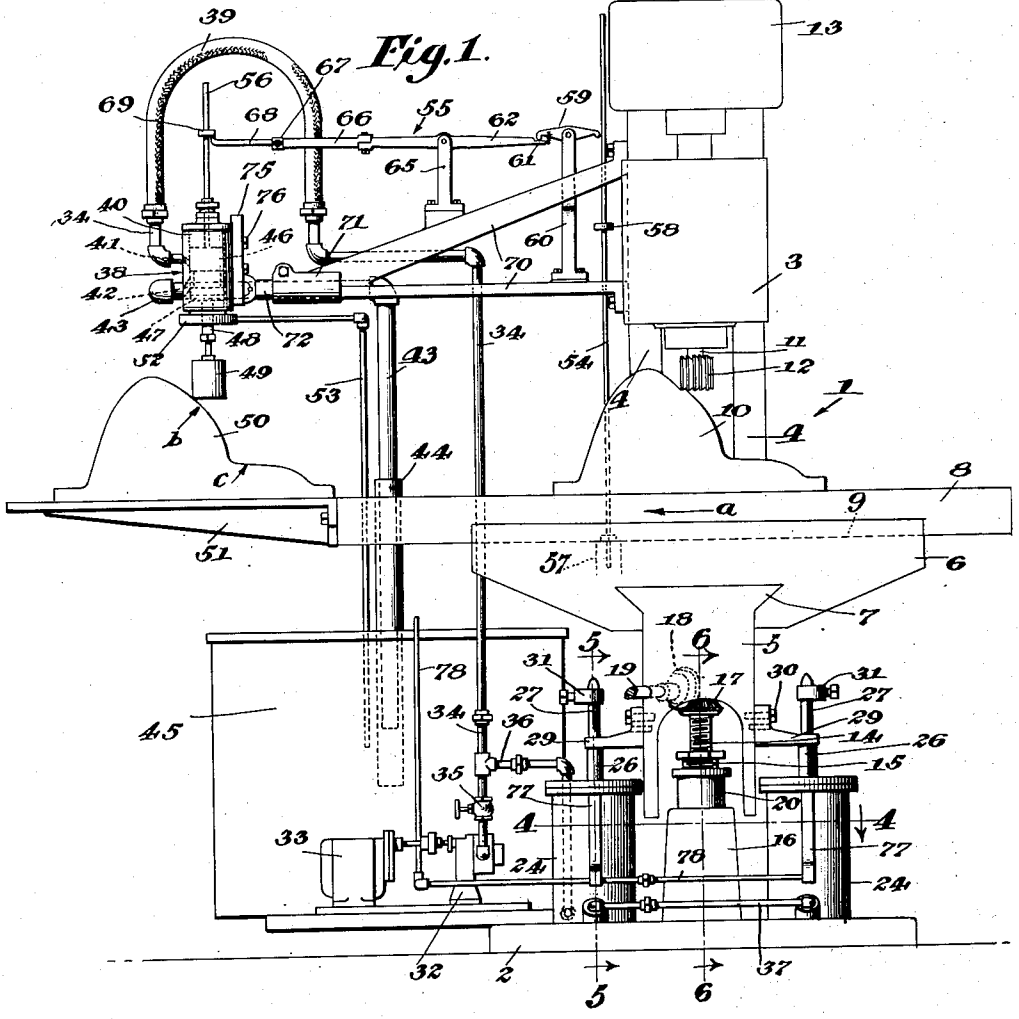


Fig. 1.



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Filed Dec. 12, 1933 3 Sheets-Sheet 2

Fig. 3.

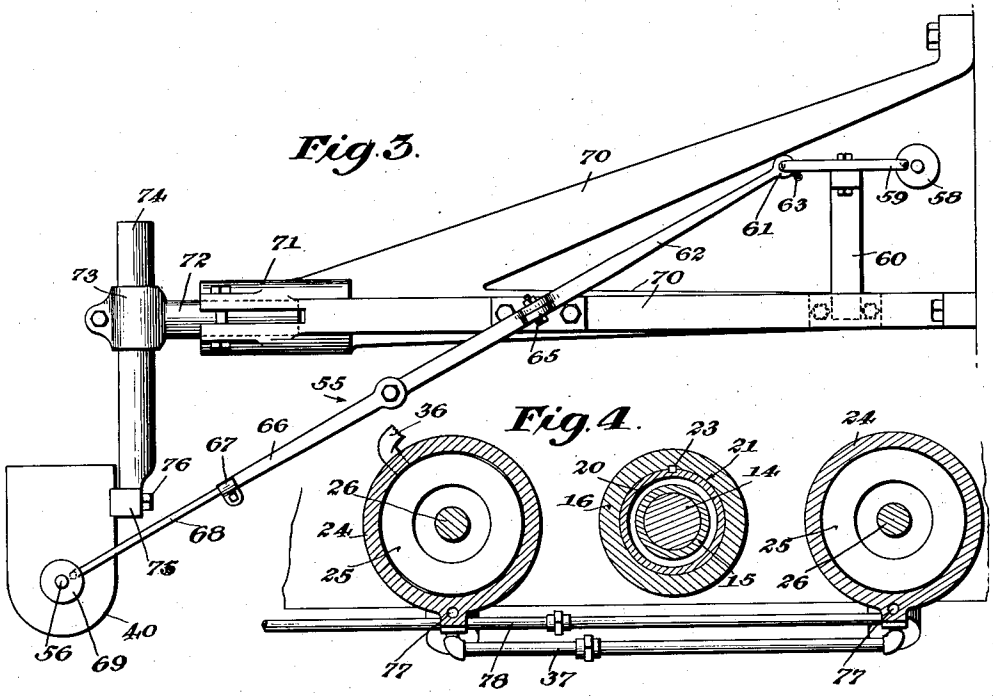


Fig. 4.

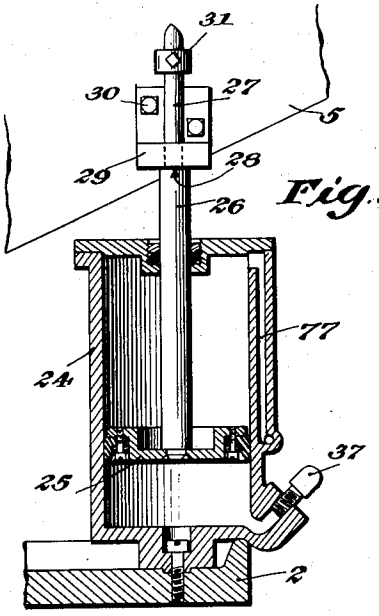
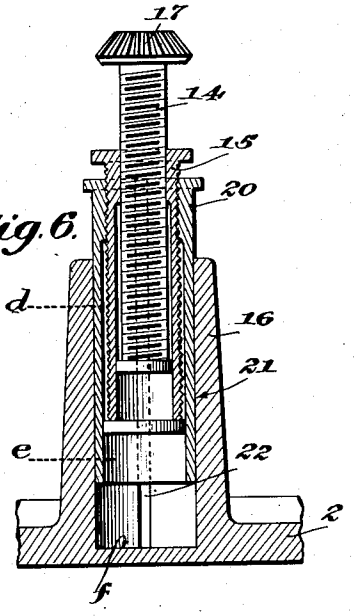


Fig. 5.

Fig. 6.



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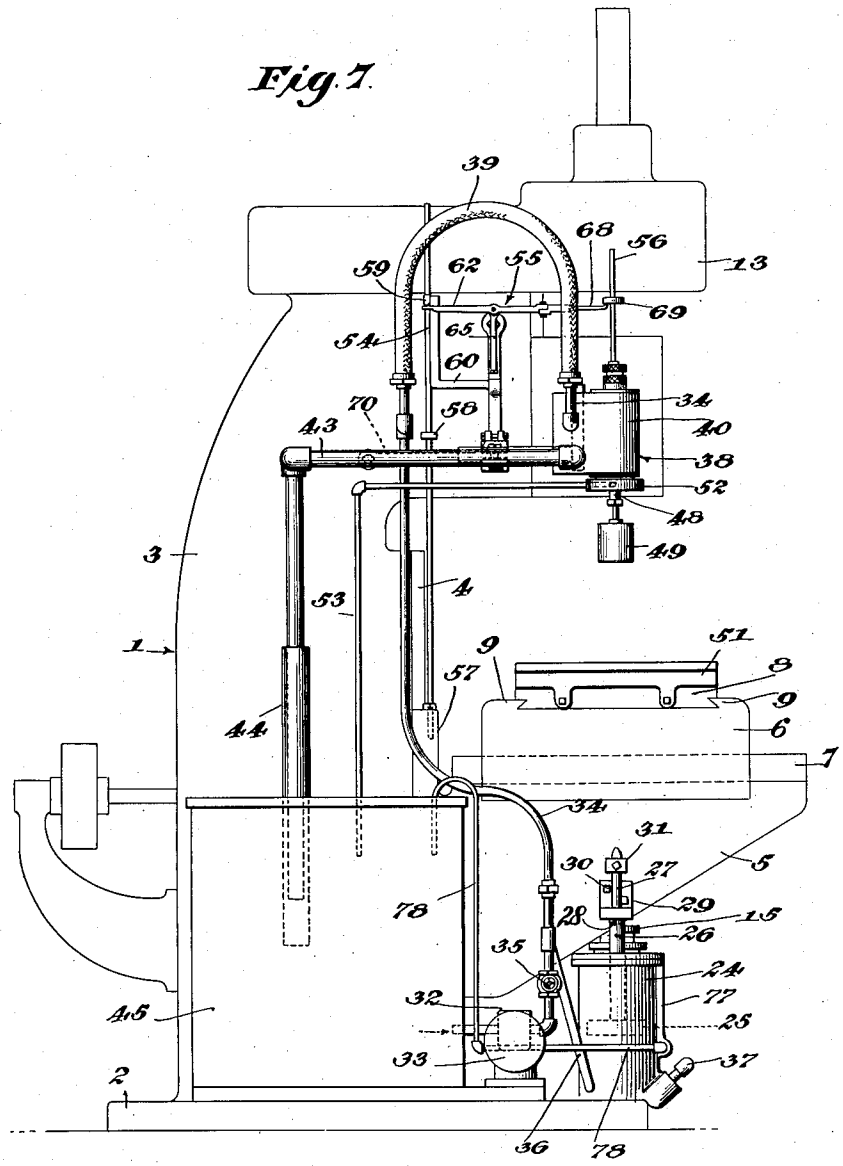
ATTORNEYS

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UNIVERSAL DIE SINKING ATTACHMENT FOR VERTICAL MILLING MACHINES

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Fig. 7.



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2,051,430

UNITED STATES PATENT OFFICE

2,051,430

UNIVERSAL DIE SINKING ATTACHMENT FOR VERTICAL MILLING MACHINES

Edmund L. Wall, Detroit, Mich., assignor, by mesne assignments, to Clearing Machine Corporation, Chicago, Ill., a corporation of Illinois

Application December 12, 1933, Serial No. 702,041

31 Claims. (Cl. 90—13.5)

This invention relates to improvements in duplicating machines, and its objects are as follows:—

First, to convert any vertical spindle milling machine into a modeling or duplicating machine by use of a relatively simple and inexpensive attachment, and this without disrupting the machine from its regular line of work.

Second, to provide a pressure fluid mechanism for raising and lowering the knee, saddle and table of the known machine, said table supporting both the pattern and work, said mechanism being under the automatic control of a tracer mechanism which, in turn, is governed by the profile of the pattern.

Third, to substitute the foregoing pressure fluid mechanism and its tracer control for the inner and outer knee screws of the known milling machine to do the chief work thereof automatically, but also to supplement said mechanism by the screws to enable producing an additional lift of the knee and its carried parts beyond the upward limit of said mechanism.

Fourth, to combine the usual manually operable knee screws and a pressure fluid mechanism in a known milling machine for raising and lowering the knee and its carried parts, either the screws or said mechanism being useable for the purpose.

Fifth, to provide a relatively simple modeling attachment for standard plain or straight milling equipment, enabling small shops to do die sinking and the like which work is ordinarily confined to expensive machinery and to specialized workers, the addition of the attachment greatly enlarging the scope of the standard equipment and not interfering in the least with its usual purposes.

Sixth, to provide an articulated linkage between the fluid release rod and the trip rod for the purpose of maintaining the necessary connection between the two regardless of the position of the tracer mechanism (within limits) with respect to the table.

Seventh, to provide a hand valve in the pressure fluid line for the purpose of holding the knee in any elevated position by preventing a return flow of fluid from the cylinders, from which position the knee is additionally adjustable by the usual manual hand wheel.

In the drawings,

Figure 1 is a front elevation of the die sinking or modeling attachment as applied to a vertical boring or milling machine, the outlines of the latter being shown in light lines.

Figure 2 is a detail view illustrating the spring connection in the articulated linkage.

Figure 3 is a plan view of the articulated linkage as well as the adjustable mount for the tracer mechanism.

Figure 4 is a horizontal section taken on the line 4—4 of Figure 1, particularly showing the association of the pressure fluid mechanism with the knee screws of the milling machine.

Figure 5 is a vertical section taken on the line 5—5 of Figure 1.

Figure 6 is a vertical section taken on the line 6—6 of Figure 1, particularly showing what might be called a knee screws adapter.

Figure 7 is a side elevation of the mechanism shown in Figure 1.

The attachment disclosed herein is shown applied to a vertical spindle milling machine. Its application is not limited to this particular machine, the attachment being capable of combination with any standard equipment. Such equipment is in common use for plain or straight milling purposes. Many shops possessing it are frequently called upon to do die sinking or reproduction work but are unable to do so because it is not within the scope of an ordinary milling machine to operate as would be required. A reproducing machine, as such, is usually very expensive so that none but those who virtually make it a business to do reproduction work can afford to include one in their equipment. This leads to the fundamental purpose of the invention, namely to enable almost any machine shop proprietor to do die sinking and modeling with his milling machine, presuming that he has one of the latter in his shop.

In the drawings the vertical spindle milling machine is designated 1. This comprises a base 2 on which there is a heavy, fixed stand 3. This has front guides 4 (Fig. 7) on which the knee 5 is vertically slidable. This knee carries a saddle 6 (Fig. 1) which is slidable in and out on ways 7, either toward the stand 3 or toward the operator in front of the machine. On top of the saddle 6 there is a table 8. The table 8 is slidable in crosswise directions on ways 9. The work 10 is secured to the table 8.

The spindle 11 is equipped with a cutter 12 to operate on the work. The spindle is rotated by mechanism inside of a spindle head 13. It remains relatively stationary with respect to the work 10, in other words does not move up and down. The knee 5 does move up and down, as previously stated, and as it does so the cutter 12

cuts into the work according to the extent of movement of the knee as is brought out below.

The means for sliding the saddle 6 in and out and for sliding the table 8 crosswise are omitted. These means commonly consist of hand wheels and gearing. Either the saddle 6 or the table 8 will be slid for the purpose of moving the work 10 past the cutter 12. For the purpose of this description the table 8 is taken as the movable member, and it is to be borne in mind that its direction of movement is crosswise of the machine.

The known means for vertically sliding the knee 5 comprises inner and outer knee screws 14, 15. The first is screwed into the other (Fig. 6), and in the known machine the outer screw 15 has a screw mounting in a hollow projection 16 upstanding on the base 2. The inner screw 14 carries a gear 17 with which meshes the pinion 18 (Fig. 1) on the inner end of a shaft 19 of a hand wheel (not shown). The hand wheel is manually operable in the present combination of the knee screws with the pressure fluid mechanism, but only at times, just as it is continually operable in the known unequipped machine.

The means for applying the attachment and so converting the foregoing machine into a modeling machine comprises the following structure:—The outer knee screw 15 is now screwed into an adapter 20 (Fig. 6) instead of into the hollow projection as explained before. The hollow projection has its bore 21 enlarged and made perfectly smooth with the exception of the groove 22 so that the adapter can slide vertically. A spline 23 (Fig. 4) prevents turning of the adapter during sliding. When the knee 5 is made to slide vertically by the pressure fluid mechanism the adapter 20 and its carried knee screws slide with it.

Cylinders 24 are lined up with the knee screw assemblage (Fig. 4). These cylinders have pistons 25 inside of them (Fig. 5), and each piston has an upwardly extending rod 26. The free extremity 27 of each rod is of reduced diameter. This provides a shoulder 28. The shoulders 28 normally abut brackets 29 carried by the knee 5. The brackets are secured at 30 in any desired manner. When pressure fluid is admitted to the lower ends of the cylinders the pistons 25 are raised and the knee 5, together with everything carried by it, is slid vertically in the upward direction. When pressure fluid is let out, the weight of the knee and its carried parts causes it to slide vertically in the downward direction. Collars 31 (Fig. 1) are secured to the upper ends of the extremities 27.

Pressure fluid is supplied by a pump 32 (Fig. 1). This is driven by a motor 33. The pressure fluid line 34 has a hand valve 35 by which the flow can be shut off especially in the return direction to the pump as when it is desired to hold the knee in any elevated position. It is from that position that the knee is additionally adjustable by use of the hand wheel on the shaft 19 (Fig. 1) to produce an additional lift of the knee.

The fluid line 34 has a branch 36 feeding the bottom of one of the cylinders 24. The bottoms of the cylinders are joined by a common pipe connection 37. The branch 36 joins the line 34 at a point above the hand valve 35. From there the pipe 34 continues on to a tracer mechanism 38, a flexible section 39 being connected in the pipe to allow for adjustments of the tracer mechanism.

The details of the tracer mechanism are fully brought out in my co-pending application, filed December 12, 1933, Serial No. 702,309. Briefly described its construction is as follows:—The tracer valve casing 40 has inlet and outlet ports 41 and 42 with which the respective pressure fluid line 34 and exhaust pipe 43 are connected. The latter includes a telescopic section 44 and discharges into a sump 45.

Communication between the ports 41 and 42 is controlled by a piston type valve plunger 46 vertically slidable in the valve casing 40. A light spring (not shown) tends to keep the valve structure pressed down against a disc 47 and the inlet port 41 closed. The disc is carried by a shank 48. This carries the tracer tip 49 on its exposed end. The tracer tip is intended to contact a pattern 50. The pattern is mounted on an extension 51 of the table 8.

A trough 52 is intended to catch any liquid leaking past the lower part of the valve plunger 46 and its actuating disc 47. The liquid thus caught is conducted off by a pipe 53 to the sump 45.

Thus far it will be understood that as long as the valve plunger 46 closes off the inlet port 41 and the pump 32 is in operation and is consequently building up pressure in the fluid line 34 the knee 5 will continue to rise. This advances the work 10 toward the cutter 12, and the latter continues to cut into the work until the tracer tip 49 encounters an eminence on the pattern 50. Such contact will displace the valve plunger 46 upwardly and establish communication between the ports 41, 42. A part of the pressure fluid is then by-passed to the sump 45, diminishing the upward pressure on the knee 5 to an extent in agreement with the amount of fluid by-passed.

In order to prevent the knee 5 from rising too far with the possibility of the cutter 12 cutting into the table 8, for example, when the lowest parts of the pattern and work reach the tracer tip and cutter, provision is made of an automatic fluid release which comprises nothing more than a trip rod 54, an articulated linkage 55 and a release rod 56. The rod 54 is affixed to a part 57 (Fig. 7) of the knee 5. It carries a stop 58. This stop is adapted to engage one end of a rocker 59. This is pivoted at its middle to a bracket 60. The other end of the rocker makes contact with the tappet 61 (Fig. 2) of a rocker 62. The contact is maintained by a spring 63 which is attached at its ends to pins 64 on the rocker 59 and tappet 61.

The rocker 62 is pivoted on a bracket 65. Its end opposite the tappet 61 is pivoted on a vertical axis to an extension 66. This is hollow and has a clamp 67 to receive and hold a finger 68. The finger is in position to engage the underside of a collar 69 on the release rod 56 when the valve plunger 46 is in the closed position. Should the table 8 rise too high the stop 58 will engage and turn the rocker 59 and the linkage 55 so as to lift the release rod 56 and valve plunger 46. The instantaneous by-passing of pressure fluid from port 41 to port 42 will stop the vertical movement of the knee 5.

Supporting means for the tracer valve casing comprises a braced arm 70 secured to a stationary part of the stand 3. The articulated linkage 55 and rocker 59 are supported by this arm. The latter includes a clamp 71 by which a rod 72 is slidably received. This rod has a clamp 73 (Fig. 3) receiving the right end 74 of a plate 75. This

plate has slots (not shown) to receive bolts 76 by which the plate and the tracer valve casing 40 are secured together. The foregoing mounting of the tracer mechanism enables almost a universal adjustment (within limits) of it with respect to the arm 70. The linkage 55 is adjustable to agree with the adjustments of said mechanism so that the finger 68 will always reach the collar 69.

The operation is readily understood. It is thought unnecessary to describe in detail how the attachment is applied to the existing machine, it being obvious that the arm 70 and extension 51 are bolted on, the other parts being mounted on the base 2 substantially in the manner illustrated. The chief change comprises boring out the hollow projection 16 (Fig. 6). Instead of having the outer screw 15 screwed into this projection, the adapter 20 is now interposed so that there may be free sliding of the knee screws in the projection as the knee 5 is propelled up and down.

Under ordinary circumstances the knee screws remain inactive insofar as concerns any action therefrom to move the knee 5. Their original function is now substituted for by the pressure fluid mechanism, but that mechanism is supplemented by the screws because there are times when it may be desired to elevate the table higher than the pistons 25 (Fig. 5) have capacity for. In such a case the knee screws begin where the pressure fluid screw leaves off.

Now to carry out the operation:—Imagine the pump 32 to be at work. It draws fluid from the sump 45 and discharges it under pressure into the fluid line 34. Consider the valve plunger 46 as closing off the inlet port 41. Pressure is being built up in the cylinders 24 so that the pistons 25 are forced to rise. Incidentally the air entrapped in the upper ends of the cylinders will escape at passages 77 (Fig. 5) which are piped at 78 to the sump. These passages and pipe comprise a breather conduit which prevents the creation of a vacuum behind the pistons.

Regard the table 8 as sliding leftward in the direction of arrow *a* (Fig. 1). This motion may be produced in any desired manner, usually by the cross feed which the machine has for the purpose. The work 10 and pattern 50 move with the table as a unit.

As long as the profile of the pattern 50 slants away from the tracer tip 49 as at *b* the valve structure will remain closed and maintain full pressure in the cylinders 24 so that the knee 5 is continuously elevated as the table 8 travels toward the left. The cutter 12, therefore, continuously cuts into the work 10.

Imagine the knee 5 to have been raised high enough and the table 8 slid leftward far enough to bring the stepped place *c* of the pattern 50 under the tracer tip 49. This requires a change in the conduct of the cutter 12. The change is produced in this way:—The rising of the knee moves the stepped place *c* upwardly under the tracer tip 49.

This displaces the valve plunger 46 upwardly to establish communication between the ports 41, 42. The pressure fluid will be by-passed at the tracer mechanism into the exhaust pipe 43 and therefore diminish the pressure in the cylinders 24. The lifting motion is checked according to the amount of fluid thus by-passed, and if enough fluid is by-passed the knee 5 will come to a stop in its vertical movement while the table 8 still progresses toward the left. The cutter 12 thus produces a substantial level part in the work to match the stepped place *c* in the pattern 50.

Whenever the tracer tip 49 encounters a high spot on the pattern the resulting inward or upward displacement of the valve structure 46 opens communication between the ports 41, 42 so that pressure fluid is by-passed into the sump 45 away from the cylinders 24. Should the tracer tip come over a cavity in the pattern the resulting closure of the valve structure enables the application of full pressure to the pistons 25 so that the knee 5 is elevated with full force. When the fluid pressure is diminished as brought out before, it is the weight of the knee 5 and its carried parts that causes the work 10 and pattern 5 to move downward. It will be understood that the push of the fluid pressure against the pistons is transmitted to the knee 5 by the shoulders 28 (Fig. 5) against the brackets 29.

Imagine the pistons 25 to have been moved to the highest points in the cylinders 24. Up to this time the screws 14, 15 have remained idle. Suppose it is desired to raise the knee 5 still higher. The operator now turns the shaft 19. This turns the screw 14, but instead of raising the knee 5 the screw 14 will at first drive 15 and 20 downwardly into the projection 16. The knee 5 acts as a fixed abutment whereas the adapter 20 has nothing as yet to prevent its downward sliding. When the pistons 25 are up as high as they will go the bottom end of the adapter 20 will be at the approximate position *d* (Fig. 6). Notice that the screws 14, 15 have stop flanges on the lower ends.

The assemblage 15, 20 will be driven downwardly until the stop collar of the screw 14 binds against the top of the bore in the screw 15. The lower end of the adapter 20 will then be in the approximate position *e* (Fig. 6). Continued turning of the screw 14 is then transmitted to the screw 15. This drives the adapter 20 downwardly until its bottom end strikes the floor *f*. The distance between *e* and *f* is only a little more than half of the distance between the stop flange on the screw 15 and the top of the bore of the adapter 20. The remaining space between said flange and the top of the bore is available for the additional elevation of the knee 5.

The brackets 29 then depart from the shoulders 28, and the raising motion of the knee 5 may continue until the brackets strike the collars 31. These are adjustable to limit the additional raising movement. When the foregoing manual operation is carried out the pistons 25 stand, so to speak, on the columns of dormant fluid beneath them in the cylinders 24. At such a time the hand valve 35 should be closed so that the fluid cannot escape through the pump. The valve structure 46 is also supposed to be closed so that the fluid cannot escape into the exhaust pipe 43.

As indicated earlier in the description, the manual elevation of the knee 5 by the mechanical means 19, etc., does not have to be deferred until the pistons 25 have been driven up in the cylinders as far as they will go. There may be times when it is desired to continue the lift of the knee by the manual mechanical means from any station of the pistons. For example, the pump 32 may get out of order. The only requirement is to shut off the pressure fluid line so that fluid cannot escape at either of the

valves. The shaft 19 is then turned in the proper direction to raise the knee.

I claim:—

1. A vertical spindle milling machine having a stand, table and manual mechanical means for normally moving the table vertically with respect to the stand; additional and pressure fluid operating mechanism for moving said table in the same direction vertically, and adapter means by which the pressure fluid mechanism may be rendered active when the said mechanical means is rendered inactive.

2. A vertical spindle milling machine having a stand, table and manual mechanical means for normally moving the table vertically with respect to the stand; means for suspending the action of said manual means, and means whereby pressure fluid mechanism may be substituted for said manual means when the latter is rendered inactive to move the table in the same direction.

3. A vertical spindle milling machine having a stand, table and manual mechanical means for normally moving the table vertically with respect to the stand; means for suspending the action of said manual means, means whereby pressure fluid mechanism may be substituted for said manual means when the latter is rendered inactive, to move the table in the same direction and pattern-actuated tracer mechanism for controlling said pressure fluid mechanism.

4. A vertical spindle milling machine having a stand, table and manual mechanical means for normally moving the table vertically with respect to the stand; pressure fluid actuated lifting mechanism for also moving said table vertically in the same direction and means operable to temporarily suspend the action of said mechanical means, until the pressure fluid lifting mechanism has reached the limit of its lifting operation.

5. A vertical spindle milling machine having a vertically movable knee and table, pressure fluid mechanism for elevating the knee, means for closing up said mechanism so that a column of fluid becomes a fixed abutment, knee screws supplementing said mechanism to elevate the knee from any position to which it was elevated by said moving mechanism, an adapter combined with said screws, and manual means for turning the screws until the adapter reaches a solid abutment whereafter additional knee elevation takes place by operation of the manual means.

6. A vertical spindle milling machine having a knee and table, pressure fluid moving mechanism for moving the knee to any elevation within the limits of said mechanism, and additional manual mechanical means operable upon the table and knee for further raising them in the same direction, said mechanical means being operable to pick up the moving operation either at the limit of elevation of the table by said fluid operated mechanism or at some intermediate point within the limits of operating the said fluid operated mechanism.

7. A milling machine having a vertical spindle and cutter, a vertically movable knee and a crosswise slidable table thereon, said table supporting the work and a pattern, pressure fluid moving mechanism for elevating the knee during crosswise sliding of the table, a pressure fluid line supplying said mechanism, a tracer mechanism in said line and including a valve structure to control the fluid in said line, and tracer means following the profile of the pattern during said crosswise sliding of the table, being adapted to vibrate the valve structure to elevate the knee and enable its lowering accordingly.

8. A vertical spindle milling machine having a vertically movable knee and table, pressure fluid moving mechanism including at least one cylinder having a piston loosely connected with the knee, a pressure fluid line to supply the cylinder with fluid to raise the piston, means for closing off the line to entrap the fluid in the cylinder beneath the piston, and manual mechanical means for additionally elevating the knee from the then standing position of the piston by virtue of said loose connection.

9. A vertical spindle milling machine having a vertically movable knee and table, pressure fluid moving mechanism including at least one cylinder, a piston in the cylinder and a rod on the piston, connector means on the knee making a loose connection with the rod so that the knee can move with respect to the rod, a pressure fluid line to supply the cylinder with fluid to raise the piston, means for closing off the line to entrap the fluid in the cylinder beneath the piston, and manual mechanical means for then elevating the knee so that it and its connector means move with respect to the rod.

10. A milling machine having a slidable work table, pressure fluid moving mechanism to slide the work table, means to entrap fluid in said mechanism to convert it into a solid abutment, and means for additionally sliding the work table from any standing position to the abutment.

11. A milling machine having a vertically slidable work table, pressure fluid moving mechanism for raising the table, a pressure fluid line to supply said mechanism, a valve in the line being openable to release the fluid from said mechanism and let the table lower by gravity, and manual mechanical means to raise or lower the table upon closure of the valve from any then dormant condition of said pressure fluid moving mechanism.

12. Means for converting a vertical spindle boring mill which has a vertically movable work table into a modeling machine, said means comprising fluid actuated moving means to raise the table and its carried work toward a cutter on the spindle, tracer means which is caused to vibrate by the profile of a pattern also carried by the work table, and a control embodying valve mechanism for said fluid pressure means, said valve mechanism being subject to the vibrations of the tracer, and by its responses operating to vary the force of said fluid pressure moving means.

13. Means for converting a vertical spindle boring mill into a modeling machine, said mill having a vertically movable and crosswise slidable work table and a stand, a tracer mechanism including tracer means which is caused to vibrate by the profile of a pattern carried by the table during crosswise sliding thereof, means attached to a part of the stand for firmly supporting the tracer mechanism over the work table, fluid pressure actuated moving means to raise the table and its carried work toward a cutter on the spindle, and a control valve for said fluid pressure moving means subject to vibrations of the tracer means and by its responses in said fluid pressure moving means operating to vary the force of said fluid pressure moving means.

14. Means for converting a vertical spindle boring mill into a modeling machine, said mill having a vertically movable and crosswise slid-

able work table to carry the work, an extension on the table to carry a pattern, a tracer mechanism and means by which it is firmly supported over the extension, said mechanism including tracer means which is caused to vibrate by the profile of said pattern during sliding of the table, automatically controlled fluid pressure actuated moving means for vertically moving the table during said sliding, and a control valve for said fluid pressure actuated moving means subject to the vibrations of the tracer means and by its responses in said fluid pressure means operating to variably cause raising and lowering of the table.

15. Means for converting a vertical spindle boring mill into a modeling machine, said mill having a cutter on its spindle and a vertically movable work table carrying the work and a pattern, pressure fluid moving mechanism for raising the table and work toward the cutter, a pressure fluid line to supply said mechanism with pressure fluid and including an exhaust, tracer mechanism coupled between the line and exhaust and having a valve structure for controlling the line, tracer means included in said mechanism being adapted to traverse the profile of a pattern and to control said valve structure, and an automatic fluid release operable when the table reaches a fixed high point with respect to the cutter to shift the valve structure and place the pressure fluid line in communication with the exhaust to stop the action of said moving means.

16. In a converted boring mill having a knee and work table vertically movable with its work toward a cutter on its vertical spindle, means attached to the table for carrying a pattern, pressure fluid moving mechanism for raising the table, tracer controlled means coacting with the pattern for controlling said mechanism, and an automatic fluid release coacting with the tracer control for stopping the operation of said moving mechanism, said fluid release comprising stop means on the knee, a release rod included in the tracer mechanism, and articulated linkage between the stop means and release rod.

17. A vertical spindle milling machine having a vertically movable knee and table, and a plurality of separately operable means for raising said table in the same direction and in the same vertical plane, one of the said means operable to raise the knee and table either before or after they reach the limit of their movement by the other of said means.

18. A vertical spindle milling machine having a vertically movable knee and table, and a plurality of separately operable means for raising said table in the same direction and in the same vertical plane, one of the said means operable to raise the knee and table either before or after they reach the limit of their movement by the other of said means, one of said raising means being fluid pressure operated.

19. A vertical spindle milling machine having a vertically movable knee and table, and a plurality of separately operable means for raising said table vertically and in the same plane, one of the said means operable to raise the knee and table either before or after they reach the limit of their movement by the other of said means, one of said raising means being fluid pressure controlled, and the other of said raising means being mechanical and manually operable.

20. A vertical spindle milling machine having a vertically movable knee and table, a plurality of different means for raising said table, one of the said means operable to raise the knee and table either before or after they reach the limit of their movement by the other of said means, one of said raising means being fluid pressure controlled, tracer mechanism to follow and being subject to vibrations by the profile of a pattern, and a control for the pressure fluid responsive to the vibrations of the tracer to vary the effective force of the pressure fluid operable means.

21. A vertical spindle milling machine of the type having a vertically movable knee and table, a knee screw and a bearing member in which the screw is threaded, an adaptor disposed between the screw and said member, said adaptor having threaded engagement with the screw and a sliding engagement with said member, fluid pressure moving means operating upon said knee to effect a sliding movement of the screw with respect to said member, tracer means which is caused to vibrate by the profile of a pattern carried by said table, and a control for said fluid pressure moving means subject to the vibrations of the tracer and by its responses to vary the force of said fluid pressure moving means.

22. A vertical spindle milling machine having a movable work support, fluid pressure operated raising means therefor, and an additional means operable independently of the said fluid pressure means for moving said support vertically and in the same plane beyond the limit of its movement by the said fluid pressure means.

23. A vertical spindle milling machine having a movable work support, fluid pressure moving means therefor, additional means for moving said support beyond the limit of its movement by the said fluid pressure moving means, tracer means which is caused to vibrate by the profile of a pattern carried by said support, and a control for said fluid pressure moving means subject to vibrations of the tracer and by its responces to vary the force of said fluid pressure moving means.

24. A duplicating machine comprising two slides movable in angularly related paths for supporting the work and a master pattern, a cutter for the work and a tracer for contacting and moving over the pattern, hydraulically actuated means for moving the work and the pattern respectively towards and away from the cutter and tracer in directions transverse to the angular paths of movement of the said slides, a tracer movable over and vibratable by the profile of the pattern, and means responsive in its operation to the vibrations of the tracer for automatically controlling the said hydraulically actuated means.

25. A duplicating machine comprising two slides movable in angularly related paths for supporting the work and a master pattern, a cutter for the work and a tracer for contacting and moving over the pattern, valve mechanism controlled by the tracer for moving the work and the pattern respectively towards and away from the cutter and tracer in directions transverse to the angular paths of movement of the said slides, and separably operable means cooperating with the tracer for automatically controlling the movement of the work to the cutter.

26. In a duplicating machine a slidable carriage for the work, a pattern support connected with the carriage, a cutter for the work, a tracer for the pattern, both said cutter and tracer mounted in fixed positions, an hydraulic system

embodying means for circulating a fluid medium under pressure for moving said carriage in a plane transverse to the plane of sliding movement thereof to bring the work and pattern respectively up to the cutter and tracer, means responsive in its operation to the action of the tracer upon the pattern, for controlling the pressure of the fluid medium and thereby control the movement of the carriage under the effect of such fluid pressure, and an additional and mechanical safety means, a portion of which latter is arranged in the path of movement of a movable part of the machine to be engaged and operated thereby during the raising movement of the carriage and operating to arrest such raising movement of the carriage.

27. In a duplicating machine, a work cutter mounted in a fixed position, a reciprocable work holder, a piston operatively connected with said holder, a cylinder containing the piston, a pipe line communicating at one end with the cylinder, a valve for controlling the other end of the pipe line, a fluid pump connected in the pipe line imposing pressure on the piston to keep the work against the cutter, a pattern tracer which is subject to vibration by the profile of a pattern to variably open the valve and cause variable drops of pressure in the pipe line, a source of supply of fluid, and means for conducting back to said supply fluid which may have leaked past said valve.

28. In a duplicating machine, a rotatable cutter and a tracer mounted in fixed positions, a slidable carriage for the work and a master, an hydraulic system for moving the carriage in a plane transverse to the plane of its sliding movement to bring and hold the work and master respectively in contact with the cutter and tracer, said system embodying a cylinder, a piston in the cylinder and operatively connected with the carriage, fluid pressure creating means in the system, a valve at one end of the system, the master engaging element of the tracer operating when vibrated by following the profile of the pattern to variably open the valve to cause variable drops in the system, the said carriage moving away from the work by gravity and in a direction opposed to the direction of movement under the influence of fluid pressure, and venting means in the system for overcoming suction caused by the movement of the piston in one direction.

29. In a duplicating machine, a work supporting carriage movable forwardly and backwardly, a piston connected with the carriage, a fluid pressure system operating upon the piston to move it and the carriage in one direction, means controlled by the vibrations of a tracer following the profile of a pattern to cause variable drops of pressure in said system, and venting means in the system for overcoming suction caused by the movement of the piston in one direction.

30. A vertical spindle milling machine having a vertically movable knee and table, a fluid pressure operated means for raising the knee and table and embodying a vertically movable plunger connected therewith, and separately operable means connected with the knee and table and operating to raise the knee and table either before or after they reach the limit of their movement by the said fluid pressure means, the said separately operable means embodying an element movable in a plane parallel with the plane of movement of said plunger.

31. A vertical spindle milling machine having a vertically movable knee and table, a fluid pressure operated means for raising the knee and table and embodying a vertically movable plunger connected therewith, and separately operable means connected with the knee and table and operating to raise the knee and table either before or after they reach the limit of their movement by the said fluid pressure means, the said separately operable means being independent of and laterally spaced from the said plunger and embodying an element movable in a plane parallel with the plane of movement of said plunger.

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