

F. A. PARSONS

PROFILE COPYING MECHANISM

Filed July 18, 1938

4 Sheets-Sheet 1

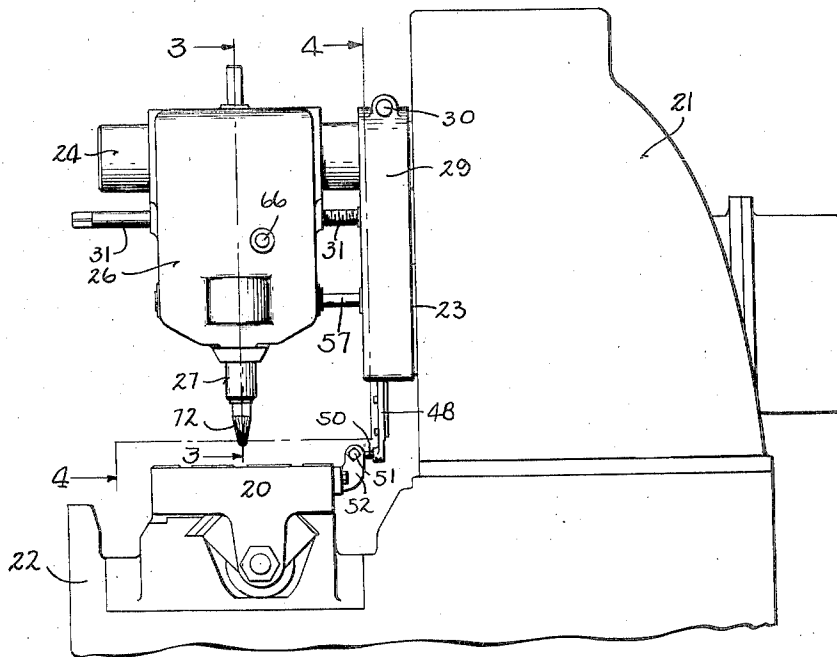


Fig. 1.

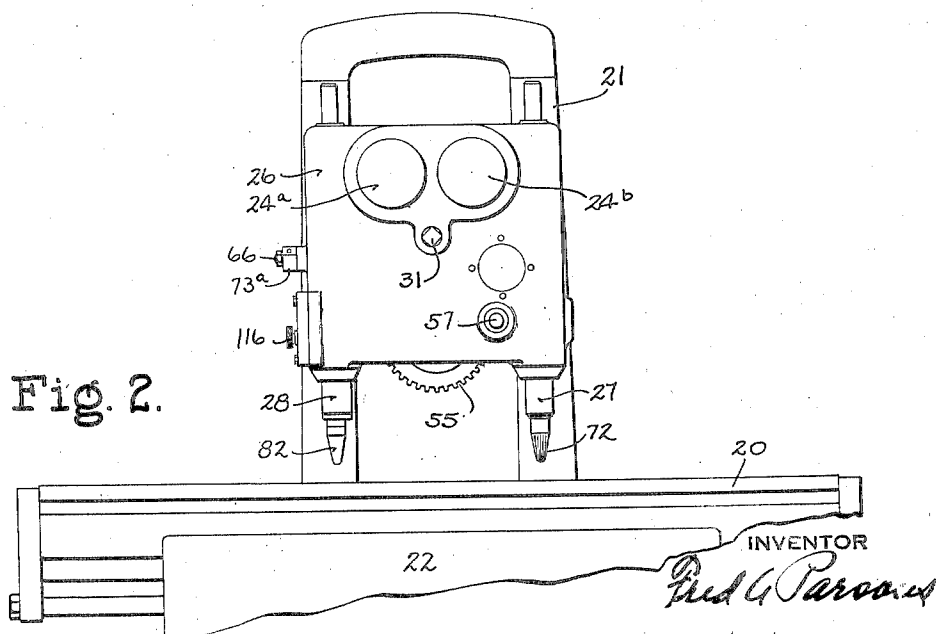


Fig. 2.

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March 11, 1941.

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2,234,775

Filed July 18, 1938

4 Sheets-Sheet 2

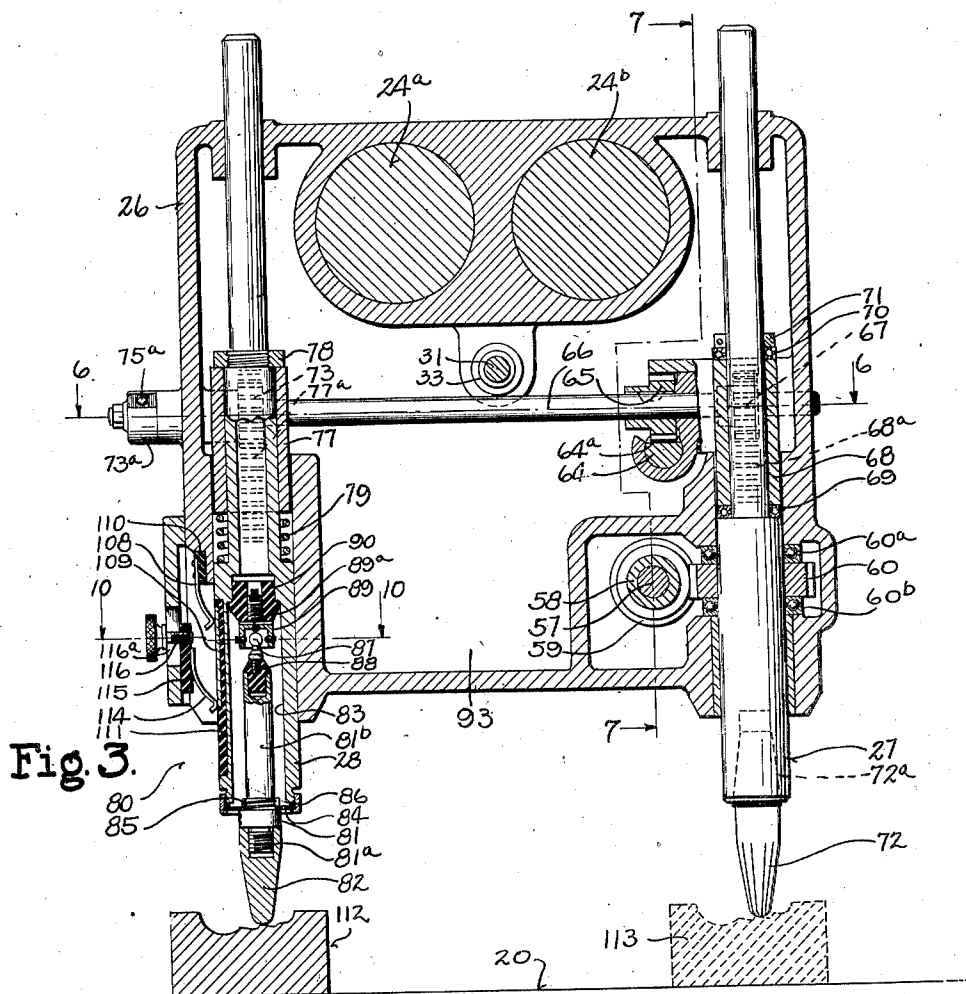


Fig. 3.

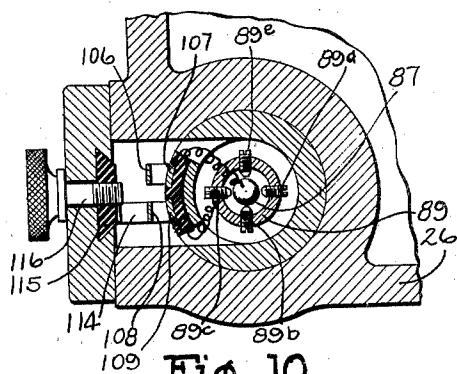
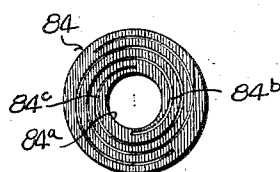


Fig. 10.



UNITED STATES PATENT OFFICE

2,234,775

PROFILE COPYING MECHANISM

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Application July 18, 1938, Serial No. 219,747

39 Claims. (Cl. 90—13.5)

This invention relates to machine tools for what is commonly termed copying operations, where a tool is caused to operate on a work piece to effect a contour corresponding to the pre-

5 formed contour of a pattern.
Such operations have in the past required substantially completely specialized machines. A primary purpose of this invention is to provide
10 mechanism for copying operations utilizing substantially without change the transmission and control mechanism of general purpose or standard machine tools in a manner permitting a minimum of additional mechanism in a form for convenient removal and replacement, whereby to alternatively convert the machine into a copying
15 machine or a general purpose machine, and particularly for milling machines.

A further purpose is to effect the desired combination of standard and additional mechanism
20 in such manner that the additional mechanism or attachment portion will be most readily and easily removable and replaceable, whereby to increase the effectiveness of the alternative use.

A further purpose is to effect an improved organization and arrangement of tool, tracer, pattern and work supports for a copying machine of the milling machine type, and particularly an organization capable of utilizing various of the mechanism of a milling machine of general purpose type.
30

For the tracer and tool movements required for copying operations it is usual to utilize a power train including some sort of interrupting or reversing means such as a reverser, usually either
35 hydraulic, electrical or mechanical in its nature, whereby to effect movement of the tracer and tool relative to the pattern and work piece respectively, and to interrupt or reverse such movement. The alternative positions of the interruptor or reverser are usually effected by power means controlled in accordance with the position
40 of the tracer relative to the pattern, and usually in a manner such that after the tracer point has moved to a predetermined position relative to the pattern face the interruptor or reverser is shifted to a stop or reverse position as the case may be. In such mode of operation any delay in the stopping or reversal of movement following the time when the tracer arrives at said predetermined
45 control position, contributes to inaccuracy of copying. Such delays may arise from various sources such, for example, as the time required for the tracer to move between said predetermined position effecting movement toward the
50 pattern and another position for effecting the

other result, the time required for the control means of the power shifter for the interruptor or reverser to act after the tracer has reached its other position, the time required for the power shifter to shift the interruptor or reverser to the stop or reverse position as the case may be, and the time required for the interruptor or reverser to act upon the parts which are driven there-through to stop or reverse the movement thereof. It is a purpose of the invention to provide transmission and control means for copying operations in the manner described, but of improved construction and organization, to operate with a minimum of time lag in the desired effect after the tracer point has been moved to said predetermined position relative to the pattern.

The reason for use of transmission and control mechanism such as just described is that, although it would be preferable to maintain the tracer in constant-pressure contact with the pattern as the tracer is traversed across it, it is impracticable to do so. An alternative is to utilize repeated forward movements of the tracer to effect repeated contacts with the pattern, whereby the successive contacts repeatedly position the tracer point in said predetermined control position relative to the pattern as the tracer moves across the face of the pattern. Where other conditions are equal the accuracy of the copying operation and the finish on the work piece are each improved in accordance with a decrease in the time interval between successive forward movements of the tracer to said predetermined control position. It is a purpose of the present invention to provide transmission and control means for copying operations in the manner described, but with a minimum time interval between successive movements of the tracer to predetermined control positions relative to the pattern.

A further purpose is to provide an improved form of interruptor or reverser control for copying machines, including electric contact means adapted for control from a tracer device in an improved manner.

A further purpose is to provide transmission and control means for copying operation including hydraulic interruptor-reverser positions controlled by an electric contact tracer device.

A further purpose is to provide improved transmission and control mechanism for copying including means simultaneously reciprocating a tracer and tool in a manner to effect continuous reciprocatory cycles normally of substantially equal period and equal length.

A further purpose is to provide improved trans-

mission and control mechanism such as just mentioned in which the reciprocatory cycles are of minimum period.

A further purpose is to provide improved alternatively available control mechanism such that in the one adjustment thereof the configuration of the pattern exclusively controls the depth of operation of the cutting tool, while in another adjustment the depth of cutting tool operation is controlled as just described during a portion of the traversing of the pattern by the tracer, but in another portion the control prevents exceeding a predetermined maximum depth of cut, irrespective of the form of the pattern.

A further purpose is to provide improved transmission and control mechanism for repeated movements of the tracer across the pattern in separate or individual paths laterally spaced by predetermined increments of cross movement, particularly in an improved combination with the structure for one or more of the previously mentioned objects or results.

A further purpose is generally to provide improved tracer controlled transmission and control mechanism to cause relative tool and work movement effecting a form on the work piece corresponding to the form of the pattern associated with the tracer.

A further purpose is generally to simplify and improve the construction and operation of machines for effecting copying operations, and particularly where cutting is effected by a rotating tool.

The invention includes the method and structure herein illustrated, described and claimed, and also such modifications of the method and structure illustrated and described as are equivalent to the claims.

Throughout the specification the same reference characters have been used to identify the same parts, and in the drawings:

Figure 1 is a partial right side elevation of a milling machine incorporating the invention.

Figure 2 is a partial front elevation of the same machine.

Figure 3 is a partial vertical section, taken approximately along line 3—3 of Fig. 1, and enlarged.

Figure 4 is a partial vertical section, taken approximately along line 4—4 of Fig. 1, and enlarged.

Figure 5 is a partial vertical section taken approximately along line 5—5 of Fig. 4.

Figure 6 is a horizontal section taken approximately along line 6—6 of Fig. 3, also line 6—6 of Fig. 7.

Figure 7 is a vertical section taken approximately along line 7—7 of Fig. 3.

Figure 8 is an enlarged section of a portion of the mechanism at the left in Fig. 6.

Figure 9 is a section taken on line 9—9 of Fig. 8.

Figure 10 is a semi-diagrammatic section taken along line 10—10 of Fig. 3 and enlarged.

Figure 11 is an enlarged view of a tracer support shown in Fig. 3.

Figure 12 is a diagram showing the operating relationship of certain of the transmission and control mechanism of the machine.

The invention is here shown in the form of an attachment for an otherwise standard milling machine. In Figs. 1, 2 there is shown the table 20, the column 21 and a portion of the bed or main frame 22 of a well known type of milling machine which is fully disclosed in my Patent No. 2,077,435, issued April 20, 1937, and which will

therefore not here be described in detail. The machine includes a rotatable spindle 23, Fig. 5 and an overarm or support structure unitarily denoted by the numeral 24, Fig. 1, and comprising in this instance horizontally spaced overarms 24a, 24b horizontally extended above the table 20. The spindle 23 and overarm structure 24 are unitarily carried by a vertically movable spindle carrier 25, of which a portion is shown in Fig. 5, which may be rigidly clamped in various positions of vertical adjustment relative to table 20. As disclosed in said patent the spindle 23 is provided with transmission and control mechanism for rotation in either direction at various speeds, and table 20 is provided with transmission and control mechanism for continuously automatically reciprocating the table. It will be understood that the machine of said patent is illustrative, but that the invention may be practiced in connection with other machines.

An attachment housing or frame 26 is unitarily carried by the support 24 and guided thereon for horizontal cross movement transverse to the path of longitudinal table reciprocation. Housing 26 may be provided with suitable gibs for adjustably determining the degree of sliding clearance on the supports 24a, 24b, and with suitable clamps for rigidly fixing the housing in desired positions on the supports, but since such gibs and clamps are well known in various forms they are not here shown. Housing 26 rotatably supports an axially vertical tool spindle 27 and a nonrotatable axially vertical tracer spindle 28, these spindles being spaced apart, in this instance longitudinally with reference to the path of table reciprocation although they may also be spaced transversely.

Another attachment housing or frame 29 is rigidly fixed on the overarm support 24 by the means of a clamp bolt 30. The housing 29 has journaled therein a rotatable screw 31 which is prevented from axial movement by a shoulder 31a and a collar 32, and extends forwardly to engage a nut 33 fixed in the housing 26.

Mechanism is provided for automatic rotation of screw 31, as follows: A ratchet wheel 34 is fixed on the screw and connected by gears 35, 36 with another ratchet wheel 37 rotatable on a stud 38. Levers 39, 40 are respectively pivoted on the screw and stud and respectively carry pivoted ratchet dogs 41, 42 normally urged by a spring 43 in a direction to engage the ratchet wheels. Either or both ratchet dogs may, however, be disengaged to rest against the abutment pins 41a, 42a. The levers 39, 40 are connected by a pivoted link 44 and lever 39 carries a gear segment 45 meshing with a gear segment 46 on a pivoted lever 47 having at its lower end a bar 48 extensibly connected therewith by the means of a slot 48a and bolts 49, the bar 48 having fixed therewith an abutment member 50 which, in the one direction of movement of table 20, will be contacted and shifted by an abutment screw 51 adjustably fixed with a table dog 52. In the other direction of table movement the abutment 50 will be contacted and shifted by an abutment screw 53 adjustably fixed with a table dog 54.

The dogs 52, 54 are adjustably fixed, as by a suitable T slot and bolts, on the rear table edge in positions for effecting shifting of the abutment 50 and lever 47 in opposite directions respectively at the limit of table movement in corresponding direction, and the construction is such that in either direction of table movement the screw 31 is revolved in the same direction,

whereby to effect a step by step cross feed movement of the housing 26 at the ends of the table stroke. The amount of the cross feed movement at either end of the table stroke may be regulated by the adjustment of abutment screws 51, 53, or by suitably positioning the table dogs, and the ratchet dogs 41, 42 may be selectively disengaged as previously described to avoid cross feed at either or both ends of the table movement. When both the ratchet dogs 41, 42 are disengaged the housing 26 may be manually positioned by a crank, not shown, applied to the squared end of the screw 31. The adjustment of the member 48 on the lever 47 provides for maintaining of the abutment 50 at the level to contact the abutment screws 51, 53 in various positions of vertical adjustment of the carrier 25.

The tool spindle 27 is rotatably driven by any suitable means. In the present instance the drive is from the machine spindle, whereby the rate changer and reverser of the milling machine may be utilized for change of rate and direction of the tool spindle, the drive being through a gear 55, fixed on the machine spindle, a pinion 56 meshed with gear 55 and fixed on a shaft 57 which is journaled in the housing 29 and prevented from axial movement by any suitable means, a sleeve 58 which is slidably splined with shaft 57 and journaled in the housing 26, being restrained from axial movement relative thereto by collars 58a, 58b, a helical gear 59 fixed on sleeve 58, and a helical gear 60 slidably splined on spindle 27, the gear 60 being prevented from axial movement by thrust races 60a, 60b engaging suitable thrust faces on the housing. The shaft 57 and sleeve 58 provide an extensible coupling permitting the adjustment and feed movement of the housing 26. As an alternative drive the spindle 27 may be rotated by a suitable motor (not shown) mounted unitarily with the housing 26 and connected to drive the spindle by suitable gearing (not shown).

The tool spindle 27 may be vertically reciprocated by the means of a piston device denoted in entirety by the numeral 61. Piston device 61 includes a cylinder 62 fixed with housing 26, a piston 63 and a piston rod 64, the piston rod having rack teeth 64a engaging a pinion 65 fixed on a shaft 66 upon which is also fixed a pinion 67 engaging suitable rack teeth 68a on a non-rotatable sleeve 68 which is restrained for vertical movement with the spindle 27 by the means of thrust bearings 69, 70 respectively engaging between a shoulder on the spindle and an abutment collar 71. Various forms of tools such as 72 may be removably aligned and fixed with the lower end of spindle 27 by any suitable means, such as the tapered shank 72a. During operation of the attachment the spindle 26 is continuously vertically reciprocated by the piston device 61 as will be later explained.

The nonrotatable tracer spindle 28 is connected for vertical reciprocation from piston device 61 along with tool spindle 27. For this purpose the shaft 66 is extended and carries a pinion 73, which is rotatably adjustably fixed with the shaft by the means of a sleeve collar 73a, Figs. 8, 9 carrying a worm 74 fixed on a shaft 75 which is rotatably adjustable by the means of a suitable wrench, not shown, applied to the squared end 75a of the shaft, the worm 74 engaging a worm wheel 76 fixed or integral with the extended hub of the pinion 72. Pinion 73 engages suitable rack teeth 77a on a sleeve 77 slidably engaging the spindle 28 but normally

in an axial position relative thereto which is fixed by an abutment collar 78, against which sleeve 77 is yieldably pressed by a spring 79 seated at the one end against a suitable abutment shoulder on the spindle 28. The arrangement is such that the tracer spindle 28 is normally vertically reciprocable in unison with the tool spindle 27 and with the same length of stroke, but the relative vertical position of the reciprocatory movement of the different spindles may be adjusted by rotatably adjusting the worm wheel 76 and if, during the course of its downward movement, the spindle 28 meets with resistance it may remain stationary while the sleeve 77 continues to move downwardly against the resistance of spring 79.

The tracer spindle 28, at its lower end, carries a tracer device denoted in entirety by the numeral 80, Fig. 3. A rod 81 has removably fixed at its lower end by any suitable means, such as the threaded stud portion 81a, a tracer point 82. A stem portion 81b extends upwardly to be housed within a bore 83 in the spindle. The tracer point and tracer rod are resiliently retained in a predetermined position relative to spindle 28 by the means of a yieldable member 84 of any suitable resilient material, Figs. 3, 11 having a bore 84a centering the member on the tracer rod, to which it is rigidly clamped by a suitable shoulder and a nut 85, the member being centered with the spindle 28 by the means of a threaded cap 86 inside which the periphery of the member is fitted and which rigidly clamps the member with the spindle. This mounting leaves the member portions intermediate the bore and periphery free for flexure permitting a certain amount of either vertical or pivotal movement of the tracer point 82 relative to the spindle, and to decrease the resistance to such movement the member may be cut away, as by the spiral grooves 84b, 84c which extend vertically therethrough, or in other suitable manner.

At its upper end the tracer rod 81 carries a ball shaped electrical contact member 87 which is insulated from the rod by the means of an insulator member 88. A cup shaped contact member 89 is rigidly fixed with the spindle 28 but insulated therefrom by a member 90. The member 89 carries various contacts for engagement by the contact member 87 including an adjustable contact screw 89a engageable when the tracer point 82 is moved upwardly relative to spindle 28, and adjustable contact screws 89b, 89c, 89d, 89e respectively engageable in different directions of pivotal movement of the tracer point. Unless some pressure is exerted against the tracer point either laterally or vertically no contact exists at any of the contact points but if the tracer point is displaced sufficiently to effect a contact an electric circuit is completed whereby to energize a solenoid 91, Fig. 12. The making and breaking of the circuit at these contact points controls the vertical reciprocation of the spindles 27, 28, as will be later described.

Referring to the diagram Fig. 12, a pump 92 draws fluid from a reservoir 93 and delivers fluid through a valve device 94 and a reverser valve 95 to piston device 61. The valve 95 includes a valve plunger 95a which is continuously urged to the left in Fig. 12 by a spring 96 but is forced to the right against the resistance of spring 96 whenever the solenoid 91 is energized. In the one direction the movement is limited by an adjustable abutment collar 97 and in the other direction by an adjustable abutment collar 98.

In the right hand position of the valve plunger 95a, to the right of the position shown in Fig. 12, the one end of the piston 63 is connected to the reservoir 93 through a channel 99, a port 95b, an annular groove 95c, a port 95d, a channel 100 and a back pressure device 101 of any suitable adjustable pressure type. At the same time the other end of the piston 63 is connected to receive the output of pump 92 through the valve 94, a channel 102, a pressure port 95e, an annular groove 95f, a port 95g, and a channel 103. The result is to move the piston 63 in a direction away from the shaft 66, Figs. 3, 12, whereby to move the spindles 27, 28 simultaneously upwardly. The valve 94 is any suitable form of shut off valve, adapted to open or close the passage leading to the reverser valve 95, and to direct the fluid back to the reservoir in the closed position of the valve. Valve 94a is any suitable form of overload relief valve of adjustable pressure type.

In the left hand position of valve plunger 95a, to the left of the position shown in Fig. 12, the piston 63 is oppositely connected to the pressure port 95e and back pressure valve 101, and the spindles 27, 28 are moved simultaneously downwardly, but in this instance at a relatively slow or feeding rate, since the piston displacement at the end which then receives the pressure fluid is not reduced by the area of the piston rod 64.

When the circuit of solenoid 91 is closed the valve member 95a is immediately shifted to the right in Fig. 12, and the piston 63 instantly starts the spindles 27, 28 moving upwardly. When the solenoid circuit is opened the spring 96 immediately shifts the member 95a to the left in Fig. 12 and the spindles 27, 28 start moving downwardly. In either direction of movement the device 101 maintains a controlled back pressure to prevent overrun or vibration and to prevent slack or lost motion in the hydraulic portion of the transmission during reversal.

The solenoid 91 is energized from a suitable line such as 104, Fig. 12, through a line switch 105 and through any of the several contact points associated with the spindle 28 and the tracer device 80. Current is carried from one contact point of switch 105 to the ball shaped contact member 87 through a brush 106, Figs. 10, 12, continuously engaging a sliding contact 107 in any of the vertical positions of the spindle 28. Another contact point of switch 105 is connected through solenoid 91 to the cup shaped contact member 89 by a similar brush 108 and sliding contact 109. Each of the brush and sliding contacts are suitably mounted on insulating blocks such as the blocks 110, 111, Fig. 3. When the tracer point 82, Fig. 3 is not in contact with a pattern, such for example as the pattern 112, Fig. 3, the tracer rod 81b is held by the yieldable member 84 in such position that the ball contact member 87 is not engaging any of the contact points 89a, 89b, 89c, 89d, 89e, Figs. 10, 12, but contact of the tracer point with the pattern such as may occur either in the downward movement of spindle 28, or in the cross movement of the housing 26, or in the longitudinal movement of table 20, will shift the tracer rod to cause the circuit through the solenoid 91 to be closed through one or another of the contact points, and the spindle 28 will instantly move upward until the tracer point disengages from the pattern and the circuit is broken. Breaking the circuit of the solenoid, however, starts the spindle 28 moving downwardly once more, as previously described, the downward movement con-

tinuing until the tracer point again contacts the pattern to start another upward movement.

It will be noted that the valve plunger 95A has a central position in which no fluid may pass to the piston device 61, but the valve is never retained in central position, being continuously urged in one direction or the other. The slightest displacement in either direction effects corresponding piston movement, and reversal from one to the other direction is substantially instantaneous with the making or breaking of the tracer circuit.

The fluid circuit as just described, provides upward movement of the tracer and tool at a rate which is relatively fast, as compared to the downward movement, since the effective area of piston 63 is less for the downward movement, being reduced by the area of piston rod 64. Pump 92, here shown of constant volume type, may instead be of any suitable variable volume type, whereby to alter the downward or cutting rate of movement of the tracer and tool with corresponding alteration in the fast upward movement; it is preferable, however, to provide for selective alteration of the downward rate while maintaining a constant upward rate of movement, and for this purpose there is provided an adjustable bleeder device, generally denoted as 920, Fig. 12. Bleeder device 920 preferably consists of any suitable adjustable volume type of positive delivery pump, adjustable by a controller 920A, preferably driven from the same power source as pump 92, and connected to continuously remove from the channel 99 the selectively predetermined volume of the fluid delivered by pump 92, which would otherwise be acting on piston 63 during the downward tool movement. During upward tool movement pump 920 merely pumps a portion of the waste fluid otherwise passing through channel 99 to the reservoir 93 but during downward movement the adjustment of pump 920 determines the rate of such downward movement. While, as stated the adjustable bleeder 920 is preferably a positive acting pump, any suitable form of adjustable throttle device may also be used. It will be understood that selective alteration of the downward rate of tool travel, while maintaining a constant relatively rapid upward rate may also be effected by a variety of conventional well known circuits, not here shown. The circuit here shown is, however, of advantage in that the reverser control is simplified and rendered more certain, particularly as to the construction and operation of the shiftable valve means.

The mode of operation just described effects a relatively rapid continuous vertical reciprocation of the spindles 27, 28 in exact unison, the limit of each downward movement being determined by the contact of the tracer point with pattern 112, and the upward movement in each instance continuing until the solenoid circuit is opened. As the tracer point is traversed relative to the pattern the cutter on the other spindle cuts the form of the pattern in the portion so traversed on the work piece. In the present instance the reciprocatory movement of the table and the step by step cross movement of the housing 26 may be utilized to cause the tracer point to automatically traverse the entire area of any pattern within the limits of the longitudinal and cross range available, but either the longitudinal or cross movements may also be manually effected, if desired. In either event both the longitudinal and cross feeds may be of any desired value.

In some instances it is preferable that the form of the pattern should not entirely control the form to be cut in the work piece 113. If, for example, the form to be copied contains recesses which are so deep that the side thrust or load set up on the tool 72 would otherwise become too great, it may be desirable to finish the work in successive operations, each limited to a predetermined maximum depth of cut. To limit the downward movement of the pattern and tool, whereby to correspondingly limit the load on the cutting tool irrespective of the total depth of the pattern recesses, the following mechanism is used:

For the sliding contact 109, Figs. 3, 12, there is provided a second brush 114 connected to the same contact point of switch 105 as is the brush 106, and carried on an insulating member 115, Figs. 3, 10 which is slidably guided for vertical adjustment. Member 115 and brush 114 may be clamped in any adjusted position by a locking screw 116 movable in a vertical slot 116a, and may be adjusted downwardly to a position in which the brush is below the sliding contact 109 in the lowest pattern controlled position thereof. In such position the pattern completely controls the downward movement of the tracer point and tool. The brush 114 may also be adjusted upwardly to a point where it is contacted by the lower end of the sliding contact member 109 when the lower end of tracer point 82 is at a predetermined level above the top of table 20, irrespective of the form of the pattern 112, whereby to complete the solenoid circuit, irrespective of the contacts previously described. In such case the pattern will control the downward movement only when such movement does not extend below the level just mentioned and at that level the downward movement will be reversed by the closing of the solenoid circuit through the brush 114 and sliding contact 109. By the mechanism just described a work piece requiring deep recesses may be finished in a series of operations, without undue pressure on tool 72, the maximum depth of cut and tool pressure in each operation being limited by the level of adjustment of brush 114.

It will be apparent that the removable tracer points 82 and cutting tools 72 may be of a variety of forms, according to different requirements. They should ordinarily be of similar form and size, but in certain instances the one may be larger than the other. If, for example, it is desired to finish the work piece with a roughing and a finishing operation the tracer point during the roughing operation may be sufficiently larger than the cutting tool for the tool to leave the desired thickness of work material for the subsequent finishing. In some instances it may be desirable that the tracer point be smaller than the cutting tool, whereby to finish the work piece in a form correspondingly larger than the pattern, as, for example, where the part finished is a die in which allowance must be made for shrinkage of metal in cooling.

The operation as previously described contemplates reversal of tracer movement from either lateral or vertical displacement of the tracer point. Reversal from lateral movement is included principally as a safety feature, operative when the tracer cross or vertical movement moves the tracer against substantially vertical surfaces on the pattern. In such case the lateral contact of tracer and pattern effects continued upward movement of the tracer and tool until

the tracer has moved above the obstruction, at which time normal operation of continuous vertical tracer reciprocation in substantially equal cycles will be resumed. Where there are no such obstructions presented by the pattern form the tracer and tool control may be solely from the vertical tracer movement, and in such case the tracer may be prevented from side movement, as, for example, by using substitute screws 89b, 89c, 89d, 89e formed of insulating material and set forward to prevent lateral displacement of the tracer, or by modification of the tracer mounting to prevent lateral displacement, or by other suitable means.

In the device here disclosed, and particularly if the reversal of tracer movement is controlled only by vertical tracer displacement as just mentioned, the form of the pattern may be automatically copied on the work piece with the highest degree of accuracy. The accuracy is primarily due to the features of the construction and operation which provide that the downward movement of the tracer and tool shall be stopped and reversed substantially instantly when the contact is effected which energizes the solenoid 91. Since the valve plunger 95a is substantially frictionless and requires only the slightest movement from forward to reverse positions, or vice versa, the solenoid may be constructed with a very light armature, requiring a minimum of time to be energized. Moreover, since the start of the upward movement does not require the opening of any circuit there is no lag caused by sparking or arcing of the contact points. The back pressure valve 101 contributes to avoiding lag in reversal by preventing time loss required to build up pressure in the reverse direction on piston 63. In addition, the transmission is such that the parts to be reversed are substantially frictionless, and of substantially no inertia, particularly since there are no rotating parts except the slow speed connecting shaft 66. All of the features just mentioned further contribute to accuracy by permitting repeated cycles of vertical reciprocation of very small period, whereby the copying positions or points are relatively very closely spaced on the work piece during the traversing of the work piece by the cutter. The latter result is further assisted by the relatively fast reverse or upward movement, and particularly because the complete forward and reverse cycle is effected merely by making and breaking a contact, that is to say with a minimum of tracer control movement.

The yieldable tracer supporting member 84 may be constructed to present very little resistance to tracer movement, and in such case the patterns such as 112 may be made relatively weak or soft material such as plaster of paris, or of wood. No cutting is ordinarily done during the upward movement of the tracer and upward movement may therefore, be a relatively very rapid rate, whereby the tracer point may operate against substantially vertical surfaces. Since the cross movements take place at the end of the table stroke they may ordinarily be effected when the tool is outside the cutting zone.

It will be apparent that the pumps 92, 920 and valves 94, 95, 101, etc. may be positioned at any suitable point in the housing 26, the lower portion of the housing forming the reservoir 93, as indicated in Fig. 3. In such case the pumps may be driven by any suitable train, not shown, from shaft 57. The reservoir 93, or both the pumps and reservoir, and certain of the other mech-

anism may, instead, be separate from the housing 26, and in such case the piston circuit will be completed by suitable pipe channels, flexible where necessary, in any suitable well known manner.

What is claimed is:

1. In a copying attachment for milling machines having a rotatable tool spindle, a reciprocable table and a main frame supporting said spindle and table, the combination of an attachment frame removably supported from said main frame, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for unitary removal therewith and spaced apart in a direction transverse to the axis of the supplemental spindle, and means under the control of said tracer member for movement of said supplemental tool spindle and tracer member relative to said attachment frame in substantially mutually parallel paths transverse to the path of reciprocation of said table.

2. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable tool spindle each supported from said main frame for relative bodily movement of said table and spindle, the combination of an attachment frame removably supported from said main frame and in a manner to participate in said relative bodily spindle and table movement, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for said relative bodily movement therewith, said supplemental spindle and tracer member being spaced apart in a direction transverse to the supplemental spindle axis, and means under the control of said tracer member for movement of said supplemental spindle and tracer member relative to the attachment frame in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table.

3. In a copying attachment for milling machines having a rotatable tool spindle, a reciprocable table and a main frame supporting said spindle and table, the combination of an attachment frame removably supported from said main frame, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for unitary removal therewith and spaced apart in a direction transverse to the axis of the supplemental spindle, said supplemental spindle and tracer member each being reciprocably movable relative to said attachment frame in paths substantially parallel to the axis of the supplemental spindle and transverse to the path of reciprocation of said table, and transmission mechanism under control of said tracer member to effect said reciprocatory movement of said supplemental spindle and tracer member.

4. In a copying attachment for milling machines having a rotatable tool spindle, a reciprocable table and a main frame supporting said spindle and table, the combination of an attachment frame removably supported from said main frame, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for unitary removal therewith and spaced apart in a direction transverse to the supplemental spindle axis, said supplemental tool spindle and tracer member being connected for mutually corresponding reciprocatory movement relative to said attachment frame in substantially parallel paths transverse to the path of reciprocation of said table, trans-

mission mechanism for said mutually corresponding reciprocatory movement including a shiftable reverser device, power means for shifting said reverser device, and means controlling the connection of said power means in accordance with movement of said tracer member.

5. In a copying attachment for milling machines having a main frame, a horizontally reciprocable table and a main spindle each supported from said main frame, and a slideway at a level above said table and supported from said main frame, the combination of a second frame guided by said slideway for horizontal bodily adjustment above said table in a path transverse to the path of table reciprocation, a second tool spindle and a tracer member spaced apart in a direction transverse to the second spindle axis and each supported from said second frame for bodily adjustment therewith, said second spindle and tracer member being connected for mutually corresponding vertical reciprocatory movement relative to said second frame and in substantially parallel paths, means for said bodily movement of said second frame, a transmission for said vertical reciprocatory movement of said spindle and tracer member, and means controlling said transmission from said tracer member during the downward portion of reciprocatory movement thereof.

6. In a copying attachment for milling machines having a main frame, a horizontally reciprocable table and a main spindle supported from said main frame, the combination of a second frame guided for horizontal bodily adjustment above said table in a path transverse to the path of table reciprocation, a second spindle and a tracer member spaced apart in a direction transverse to the spindle axis and each carried by said second frame for said bodily adjustment therewith, said second spindle and tracer member being connected for mutually corresponding reciprocatory movement relative to said second frame and in parallel paths, a transmission for said reciprocatory movement of said second spindle and tracer member, power means for said bodily adjustment of said second frame including dog means associated with said table, and means controlling said transmission from said tracer member to effect said reciprocatory movement.

7. In a copying attachment for milling machines including a main frame, a table supported from said frame for horizontal reciprocation, and a slideway at a level above said table and supported from said main frame, the combination of a second frame guided by said slideway for horizontal bodily adjustment above said table in a path transverse to the path of table reciprocation, a tool spindle and a tracer member spaced apart in a direction transverse to the spindle axis and each carried by said second frame for bodily adjustment therewith, said spindle and tracer member being connected for mutually corresponding vertical reciprocatory movement relative to said second frame in substantially parallel paths, means for said bodily movement of the second frame, a transmission for said mutually corresponding reciprocatory movement of said spindle and tracer member, and means controlling said transmission from the reciprocatory movement of said tracer member in various positions of the bodily adjustment of said second frame, said frames providing for adjusting the relative vertical spacing of said second frame and table whereby to simultaneously ad-

just the spacing of said spindle and tracer member above said table.

8. In a copying attachment for milling machines having a main frame, a table supported from said frame for horizontal reciprocation, a horizontal main spindle rotatably supported at a level above said table and axially transverse to the path of table movement, and overarm means for the support of arbors associated with said main spindle including an overarm supported from said main frame above said table, said overarm means providing adjusting guide surfaces extended in a direction parallel to the axis of said main spindle, the combination of an attachment frame removably located in a position above said table determined by said surfaces, a rotatable attachment spindle and a tracer member each supported from said attachment frame for unitary removal therewith and spaced apart in a direction transverse to the attachment spindle axis, said attachment spindle and tracer member being movable relative to said attachment frame in substantially parallel paths transverse to the path of table reciprocation, and means controlling said attachment spindle and tracer member movement from said tracer member during said movement thereof.

9. In a copying attachment for milling machines having a main frame, a table supported from said frame for horizontal reciprocation, a horizontal main spindle rotatably supported at a level above said table and axially transverse to the path of table movement, and overarm means including an overarm supported from said main frame above said table, said overarm means providing surfaces extended in a direction parallel to the axis of said main spindle, the combination of an attachment frame removably located in a position above said table determined by said surfaces, a rotatable attachment spindle and a tracer member each supported from said attachment frame and spaced apart in a direction transverse to the attachment spindle axis, said attachment spindle and tracer member being mutually correspondingly reciprocable relative to said attachment frame in substantially parallel paths transverse to the path of table reciprocation, and means controlling said correspondingly reciprocable movement from said tracer member during reciprocatory movement thereof, said overarm means surfaces providing a slideway for positioning said attachment frame in various adjustment positions in a path parallel with the axis of said main spindle.

10. In a milling machine having a rotatable tool spindle, a reciprocable table and a main frame supporting said spindle and table, the combination of a copying attachment frame removably supported from said main frame, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame and spaced apart in a direction transverse to the supplemental spindle axis, said supplemental spindle and tracer member being mutually correspondingly reciprocable relative to said attachment frame in substantially parallel paths transverse to the path of reciprocation of said table, and means controlling said corresponding reciprocation from said tracer member during reciprocatory movement thereof, the support for said attachment frame from said main frame providing for relative bodily adjustment of said frames in a direction transverse to the path of reciprocation of said table.

11. In a milling machine having a rotatable

tool spindle, a reciprocable table and a main frame supporting said spindle and table, the combination of a copying attachment frame removably supported from said main frame, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame and spaced apart in a direction transverse to the supplemental spindle axis, said supplemental spindle and tracer member being movable relative to said attachment frame in substantially parallel paths transverse to the path of reciprocation of said table, the support for said attachment frame from said main frame providing means for relative bodily adjustment of said frames in a direction transverse to the path of table reciprocation, power operable means for said adjustment including a dog associated with said table, and means controlling said parallel path spindle and tracer member movement from said tracer member during movement thereof relative to said attachment frame and in various positions of said relative adjustment of the attachment frame.

12. In a milling machine having a rotatable tool spindle, a reciprocable table and a main frame supporting said spindle and table, the combination of a copying attachment frame removably supported from said main frame, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for unitary removal therewith and spaced apart in a direction transverse to the supplemental spindle axis, said supplemental spindle and tracer member being connected for mutually corresponding movement relative to said attachment frame in substantially parallel paths transverse to the path of reciprocation of said table, and means controlling said supplemental spindle and tracer member movement from said tracer member during said movement thereof, said connection of the supplemental spindle and tracer member including means for relative adjustment thereof in said parallel paths.

13. In a milling machine having a main frame together with a reciprocable table and a rotatable tool spindle each supported from said main frame for relative bodily movement thereof, the combination of a copying attachment frame removably supported from said main frame to participate in said relative bodily spindle and table movement, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for said relative bodily movement therewith, said supplemental spindle and tracer member being spaced apart in a direction transverse to the supplemental spindle axis and connected for mutually corresponding reciprocatory movements relative to the attachment frame in substantially parallel paths transverse to the path of reciprocatory movement of said table, and means controlling said corresponding reciprocatory movement from said tracer member during reciprocatory movement thereof, said connection of the supplemental spindle and tracer member including means for relative adjustment thereof in said parallel reciprocatory paths.

14. In a milling machine having a main frame together with a reciprocable table and a rotatable tool spindle supported from said main frame for relative bodily movement of said table and spindle, the combination of an attachment frame removably supported from said main frame to participate in said relative bodily spindle and table movement, a rotatable supplemental tool spindle and a tracer member each supported from said attachment frame for said relative bodily move-

ment therewith, said supplemental spindle and tracer member being spaced apart in a direction transverse to the supplemental spindle axis and connected for mutually corresponding reciprocatory movements relative to the attachment frame in substantially parallel paths transverse to the path of reciprocatory movement of said table, and means controlling said corresponding reciprocatory movement from said tracer member during reciprocatory movement thereof, said connection of the supplemental spindle and tracer member including means for relative adjustment thereof in said corresponding reciprocatory paths, the support for said attachment frame providing for adjustment thereof in a direction transverse to the path of reciprocatory table movement while maintaining said control from said tracer member in various positions of such adjustment.

15. A copying machine including a main frame, a table supported from said frame for horizontal reciprocation, a horizontal slideway at a level above said table and supported from said main frame, a second frame above said table and guided in said slideway for horizontal bodily adjustment in a path transverse to the path of table reciprocation, a tool spindle and a tracer member spaced apart in a direction transverse to the spindle axis and each carried by said second frame for said bodily adjustment therewith, said spindle and tracer member being connected for mutually corresponding reciprocatory movement in substantially parallel paths transverse to the path of table reciprocation, means for said bodily movement of said second frame, a transmission for said mutually corresponding reciprocatory movement of said spindle and tracer member, and means controlling said transmission from said tracer member during the reciprocatory movement thereof, said main frame providing members adjustable for changing the relative vertical spacing of said slideway and table whereby to adjust the spacing of said second frame above said table, the connection of said spindle and tracer member including means for relative adjustment thereof in said corresponding reciprocatory paths.

16. In a milling machine having a main frame and a reciprocable table, the combination of a copying attachment frame removably supported on said main frame for bodily movement relative thereto in a path transverse to the reciprocatory table movement, a rotatable tool spindle and a tracer member each supported from said attachment frame for bodily movement therewith and connected for mutually corresponding reciprocatory movement relative to said attachment frame in substantially parallel paths transverse to the path of reciprocatory table movement, said spindle and member being spaced apart in a direction transverse to the axis of said spindle, means controlling said corresponding reciprocatory movement from said tracer member during reciprocatory movement thereof, and a power train for effecting said bodily movement of the attachment frame, said power train including an abutment member reciprocable in accordance with table reciprocation and another abutment member mounted for mutual abutment therewith during table reciprocation and in various positions of said bodily movement of the attachment frame.

17. In a copying machine the combination of a rotatable copying tool spindle and a tracer member connected for substantially correspond-

ing reciprocatory movement in mutually parallel paths, said spindle and member being also relatively movable, a transmission for said reciprocatory movement including a fluid operable piston device, and control means for said transmission including shiftable reverser valve means controlling the direction of movement of said piston device, a solenoid device for shifting said reverser valve means, to effect one direction of said piston device movement, and electric contact elements controlling the energizing of said solenoid device and relatively movable to circuit closing position upon said relative spindle and member movement, and means continuously operative to urge shifting of said reverser valve means to effect the other direction of said piston device movement.

18. In a copying machine the combination of a tool support and a work support relatively reciprocable in a straight line path, one of said supports being reciprocable in another path transverse to the first mentioned path, a tracer member reciprocable substantially correspondingly to the last mentioned support, transmission means for said transverse reciprocatory movement including a shiftable reverser device, means continuously urging said reverser device in one direction of its shifting movement, and other means under the control of said tracer member for intermittently urging said reverser device in the other direction of its shifting movement.

19. In a copying machine the combination of a tool support and a work support relatively reciprocable in a straight line path, one of said supports being reciprocable in another path transverse to the first mentioned path, a tracer member reciprocable substantially correspondingly to the last mentioned support, transmission means for said transverse reciprocatory movement including a fluid operable piston device and a pressure fluid source, control means for said transverse reciprocatory movement including reverser valve means shiftable for changing the direction of operation of said piston device, means continuously urging said reverser valve means in a direction to effect the one direction of said transverse reciprocatory movement, and other means under the control of said tracer member for intermittently urging said reverser valve means in a direction to effect the other direction of said reciprocatory movement.

20. In a copying machine the combination of a tool support and a work support relatively reciprocable in a straight line path, one of said supports being reciprocable in another path transverse to the first mentioned path, a tracer member reciprocable substantially correspondingly to the last mentioned support, transmission means for said transverse reciprocatory movement including a shiftable reverser device, means continuously urging said reverser device in a direction to effect one direction of said transverse reciprocatory movement, and means for intermittently shifting said reverser in a direction to effect the other direction of said transverse reciprocatory movement including electric contact elements relatively movable to open and closed circuit positions under the control of said tracer member.

21. In a copying machine having relatively movable tool and work supports, the combination of transmission means for said relative movement including a fluid operable reversible motor device and reverser valve means shiftable for controlling the direction of motor actuation; and means for

shifting said reverser valve means including a tracer member movable substantially correspondingly to one of said supports and power means under the control of said tracer member, said transmission means including means continuously operative to maintain simultaneously opposed material fluid pressures on the opposite pressure faces of said motor.

22. In a copying machine having relatively movable tool and work supports, the combination of transmission means for said relative movement including reverser means shiftable for controlling the direction of such movement together with means operative to effect a relatively higher speed of said relative movement in the one direction position of said reverser means than in the other, and means for shifting said reverser means including means continuously urging said reverser means toward the direction position effecting the relatively lower speed, a tracer member movable substantially correspondingly to one of said supports, and means under the control of said tracer member for intermittently shifting said reverser means to the direction position effecting the relatively higher speed.

23. In a copying machine having relatively movable tool and work supports, the combination of a tracer member movable substantially in accordance with the movement of one of said supports, transmission mechanism for said tool and work support movement including a fluid operable reversible motor device and reverser valve means shiftable to different direction positions, means continuously urging said reverser valve means toward one of said direction positions, means under the control of said tracer member for intermittently shifting said reverser valve means to its other position and means associated with said transmissions and operative in either direction position of said reverser valve means to maintain simultaneously opposed fluid pressure on the opposite pressure faces of said motor device.

24. In a copying machine having relatively movable tool and work supports and a tracer member movable substantially in accordance with the movement of one of said supports, the combination of transmission mechanism for said tool and work support movement including a fluid operable reversible motor device and reverser valve means shiftable to different direction positions together with means operative in either direction position of said reverser valve means to maintain simultaneously opposed fluid pressure on the opposite pressure faces of said motor device and means operative to effect a relatively higher speed of said tool and work support movement in one of the direction positions of said reverser valve means than in the other thereof, and means under the control of said tracer member for intermittently shifting said reverser valve means to the direction position effecting said relatively high speed.

25. In a copying machine having a work support and a tool support relatively movable toward one another in a forward copying direction and alternatively in a reverse direction and a tracer member movable substantially in accordance with the movement of one of said supports, the combination of power operable transmission mechanism for said relative support movement including reverser means shiftable to forward and reverse support direction positions, control means operative under the control of said tracer member to shift said reverser means to said reverse

direction position during forward movement of said supports, and other control means alternatively operable during said forward movement to shift said reverser means to said reverse direction position at a predetermined minimum spacing of said supports during said forward movement thereof.

26. In a copying machine having a work support and a tool support relatively movable toward one another in a forward direction and alternatively in a reverse direction and a tracer member movable substantially in accordance with the movement of one of said supports, the combination of power operable transmission mechanism for said support movement including reverser means shiftable to forward and reverse support direction positions, control means operative under the control of said tracer member to shift said reverser means to said reverse direction position during forward movement of said supports, and other control means alternatively operable to shift said reverser means to said reverse position at a predetermined minimum spacing of said supports during said forward movement thereof, said other control means being adjustable to vary the support spacing predetermined thereby.

27. In a copying machine the combination of a work support and a tool support relatively movable toward one another in a forward direction and alternatively in a reverse direction and a tracer member movable substantially in accordance with the movement of one of said supports, power operable transmission mechanism for said support movement including reverser means shiftable to forward and reverse support direction positions, and control means operative to shift said reverser means to effect said forward and reverse support directions of movement in repeated reciprocatory cycles including means continuously urging said reverser means toward its forward direction position and means operative under the control of said tracer member for intermittently shifting said reverser to said reverse position, and other means alternatively operable for shifting said reverser to reverse position at a predetermined minimum spacing of said supports.

28. In a copying machine having a work support and a relatively movable tool support, the combination of transmission mechanism for said support movement in repeated cycles of alternate copying direction toward one another and reverse direction, a first control device for said transmission including pattern and tracer members relatively movable substantially in accordance with the support movement to variably determine the limit of said copying direction of movement in accordance with variations in the configuration of said pattern member, and other control means alternatively operable to determine said limit of copying direction of movement for some of said cycles irrespective of the configuration of said pattern member and at a predetermined minimum spacing of said supports.

29. In a copying machine having a work support and a relatively movable tool support, the combination of transmission mechanism for said support movement in repeated cycles of alternate copying direction toward one another and reverse direction, a first control device for said transmission including pattern and tracer members relatively movable substantially in accordance with the support movement to variably determine the limit of said copying direction of movement in accordance with variations in the configuration of

said pattern member, and other control means alternatively operable to determine said limit of copying direction of movement for some of said cycles at a predetermined minimum spacing from one of said supports and irrespective of the configuration of said pattern member, said other control means being adjustable to alter said predetermined minimum spacing.

30. In a copying machine the combination of a tracer member, a power transmission for movement of said tracer member alternatively in opposite directions including a pressure fluid source, shiftable reverser valve means and a fluid operable motor, means continuously urging said reverser valve means in a direction effecting one direction of said tracer movement, and means under the control of said tracer member for shifting said reverser valve in the other direction.

31. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable main spindle supported from said main frame for relative bodily movement of said table and main spindle in a direction transverse to the path of table reciprocation, the combination of an attachment frame removably supported from said main frame in a manner to participate in said relative bodily table and main spindle movement, a rotatable attachment spindle and a tracer member each associated with said attachment frame to participate therewith in said relative bodily table and main spindle movement, said attachment spindle and tracer member being spaced apart in a direction transverse to the direction of said relative bodily movement and each reciprocable in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table, and means under the control of said tracer member for effecting said tracer member and attachment spindle reciprocable movement.

32. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable main spindle supported from said main frame for relative bodily movement of said table and main spindle in a direction transverse to the path of table reciprocation, the combination of an attachment frame removably supported from said main frame in a manner to participate in said relative bodily table and main spindle movement, a rotatable attachment spindle and a tracer member each associated with said attachment frame to participate therewith in said relative bodily table and main spindle movement, said attachment spindle and tracer member being spaced apart in a direction transverse to the direction of said relative bodily movement and each reciprocable in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table, transmission mechanism for said tracer member and attachment spindle reciprocable movement including reverser means supported from said attachment frame and adjustable for forward and reverse direction effects, and means operable under the control of said tracer member for adjusting said reverser means.

33. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable main spindle supported from said main frame for relative bodily movement of said table and main spindle in a direction transverse to the path of table reciprocation, the combination of an attachment frame removably supported from said main frame in a manner to participate in said relative bodily

table and main spindle movement, a rotatable attachment spindle and a tracer member each associated with said attachment frame to participate therewith in said relative bodily table and main spindle movement, said attachment spindle and tracer member being spaced apart in a direction transverse to the direction of said relative bodily movement and each reciprocable in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table, transmission mechanism for said tracer member and attachment spindle reciprocable movement including a reverser device adjustable to forward and reverse direction positions, means continuously urging said reverser device toward one of said positions, and means operable under the control of said tracer member for shifting said reverser device to the other of said positions.

34. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable main spindle each supported from said main frame for relative bodily movement of said table and main spindle in a direction transverse to the path of table reciprocation, the combination of an attachment frame removably supported from said main frame in a manner to participate in said relative bodily table and main spindle movement, a rotatable attachment spindle and a tracer member each associated with said attachment frame to participate therewith in said relative bodily table and main spindle movement, said attachment spindle and tracer member being spaced apart in a direction transverse to the direction of said relative bodily movement and each reciprocable in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table, transmission mechanism for said tracer member and attachment spindle reciprocable movement including a reverser device adjustable to forward and reverse direction positions, means operable under the control of said tracer member for adjusting said reverser device alternately to its different positions whereby to effect tracer member controlled reciprocable movement of said tracer member and attachment spindle, and other control means for adjusting said reverser device alternatively to its different positions whereby to effect said reciprocable movement of the tracer member and attachment spindle independently of the tracer member control.

35. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable main spindle each supported from said main frame for relative bodily movement of said table and main spindle in a direction transverse to the path of table reciprocation, the combination of an attachment frame removably supported from said main frame in a manner to participate in said relative bodily table and main spindle movement, a rotatable attachment spindle and a tracer member each associated with said attachment frame to participate therewith in said relative bodily table and main spindle movement, said attachment spindle and tracer member being spaced apart in a direction transverse to the direction of said relative bodily movement and each reciprocable in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table, transmission mechanism for said tracer member and attachment spindle reciprocable movement including a fluid oper-

able motor and shiftable reverser valve means, and means under the control of said tracer member for shifting said reverser valve means.

36. In a copying attachment for milling machines having a main frame together with a reciprocable table and a rotatable main spindle each supported from said main frame for relative bodily movement of said table and main spindle in a direction transverse to the path of table reciprocation, the combination of an attachment frame removably supported from said main frame in a manner to participate in said relative bodily table and main spindle movement, a rotatable attachment spindle and a tracer member each associated with said attachment frame to participate therewith in said relative bodily table and main spindle movement, said attachment spindle and tracer member being spaced apart in a direction transverse to the direction of said relative bodily movement and each reciprocable in substantially mutually parallel paths transverse to the path of reciprocatory movement of said table, a transmission for said tracer member and attachment spindle reciprocable movement including a shiftable reverser, means for shifting said reverser including electric contact elements adjustable to open and closed contact positions, and means under the control of said tracer member for adjusting said contact elements.

37. In a copying machine the combination of a tool support and a work support relatively movable in a predetermined path, a tracer member reciprocable together with one of said supports in substantially mutually parallel paths transverse to the first mentioned path, mechanism for effecting said transverse reciprocatory movement of the last mentioned support and said tracer member including a power train for one direction thereof and comprising a device shiftable for alternatively connecting or interrupting said power train, means continuously urging said shiftable device toward a position connecting said power train, a pattern member adapted to be contacted by said tracer member during the last mentioned direction of movement thereof, and means under the combined control of said tracer member and pattern member for shifting said device to a position interrupting said power train upon said contact of the tracer and pattern member, said mechanism also including means operable for the other direction of movement in said transverse paths upon interruption of said power train, whereby to effect continuous reciprocatory movement of said last mentioned support and tracer member.

38. A copying machine including a main frame, a table supported from said frame for horizontal reciprocation, a horizontal slideway at a level above said table and supported from said main

frame, a second frame above said table and guided in said slideway for horizontal bodily adjustment in a path transverse to the path of table reciprocation, a tool spindle and a tracer member spaced apart in a direction transverse to the spindle axis and each carried by said second frame for said bodily adjustment therewith, said spindle and tracer member being connected for mutually corresponding reciprocatory movement in substantially parallel paths transverse to the path of table reciprocation, means for said bodily movement of said second frame, said connection of said spindle and tracer member including a driver member common to said spindle and tracer member and a plurality of driven members respectively individual to the spindle and to the tracer member, a transmission for actuating said driver member to effect said mutually corresponding reciprocatory movement of said spindle and tracer member, and means controlling said transmission from said tracer member during the reciprocatory movement thereof, said main frame providing members adjustable for changing the relative vertical spacing of said slideway and table whereby to adjust the spacing of said second frame above said table, the connection of said spindle and tracer member including means for relative adjustment thereof in said corresponding reciprocatory paths.

39. A copying machine including a stationary frame, a table supported from said stationary frame, a second frame supported from said stationary frame at a level above said table, a rotatable tool spindle and a tracer member spaced apart in a direction transverse to the axis of said spindle and each carried by said second frame, a connection between said spindle and tracer member for mutually corresponding reciprocable movement thereof relative to said second frame in paths substantially mutually parallel with said spindle axis, said connection including a driver member common to said spindle and tracer member and a plurality of driven members respectively individual to the spindle and to the tracer member, a transmission for actuating said driver member to effect said mutually corresponding spindle and tracer member movement, and means controlling said transmission from said tracer member during said reciprocable movement thereof, said main frame having slideways associated therewith for relative reciprocation of said table and second frame in a substantially horizontal path and for relative adjustment thereof in a path transverse to the path of said relative reciprocation, the connection of said spindle and tracer member including means for relative adjustment thereof in said mutually corresponding reciprocable paths.

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