Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

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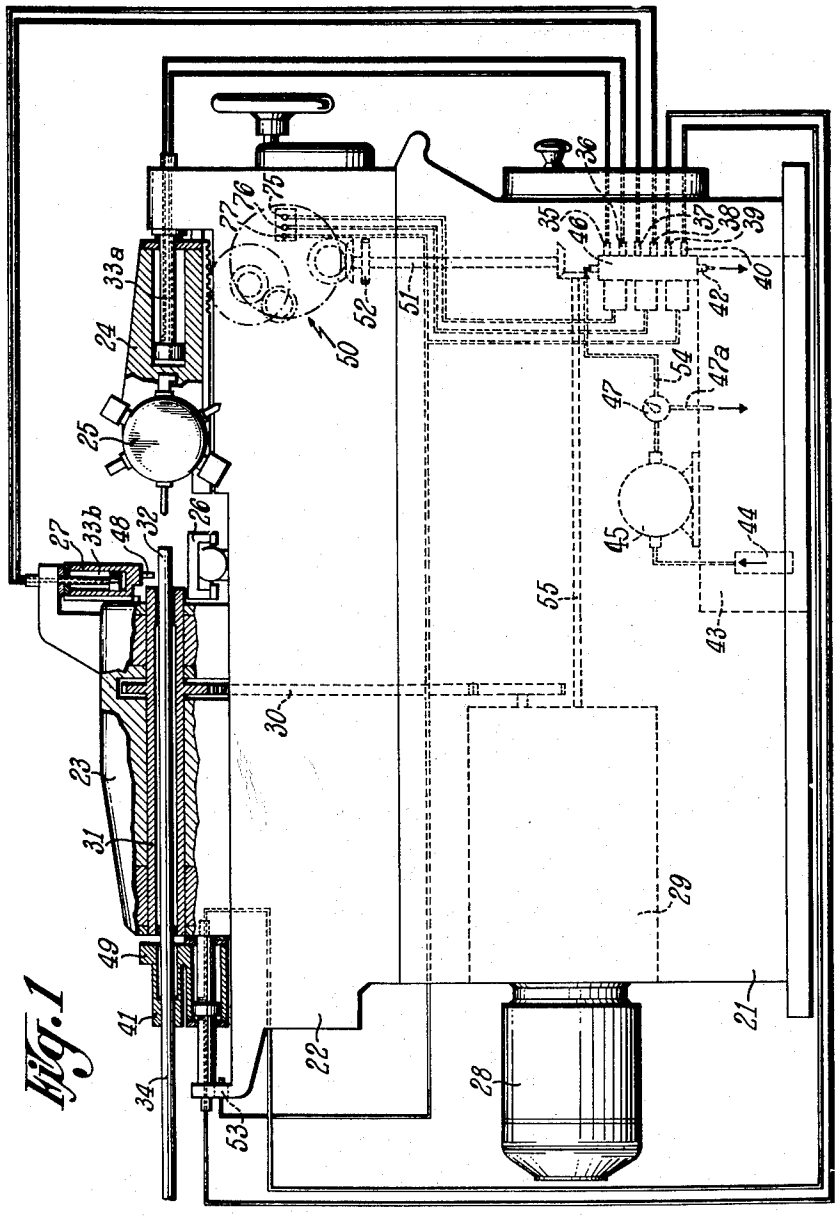


Fig. 1

INVENTOR
Karl Spohn

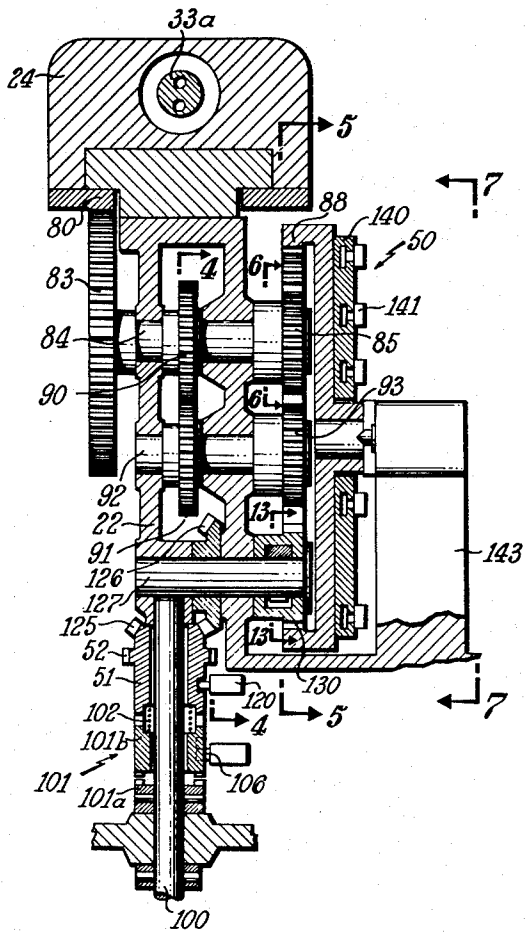
BY

Michael S. Striker
ATTORNEY

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 2

Fig. 2



INVENTOR
Karl Spohn

BY

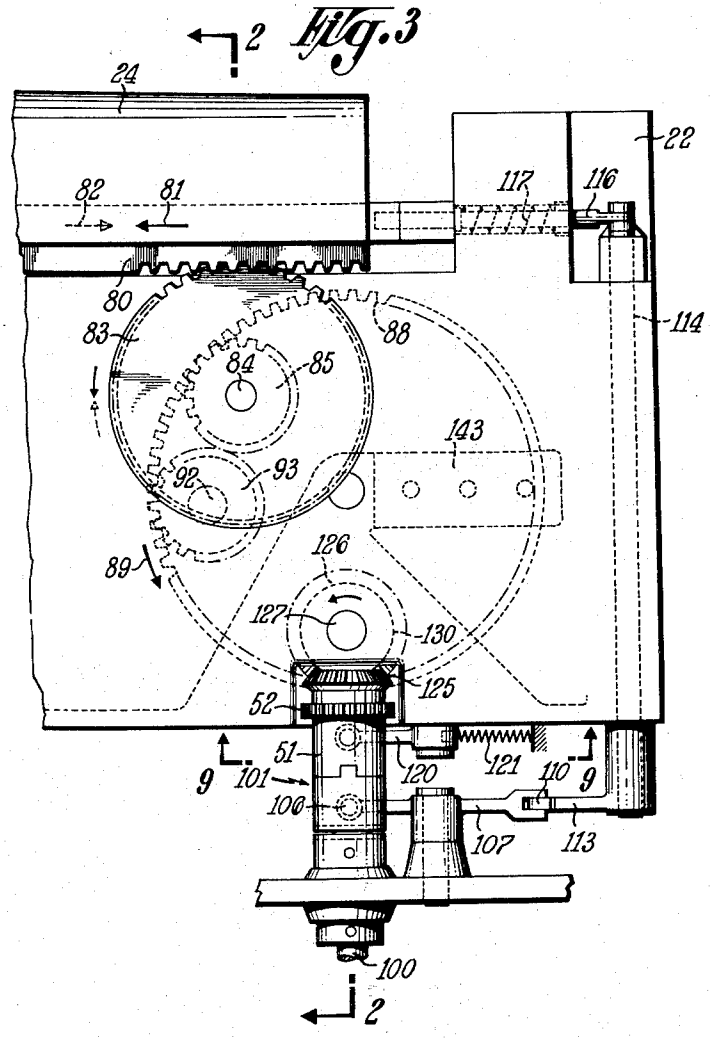
Michael S. Striker
ATTORNEY

Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 3

Fig. 3



INVENTOR
Karl Spohn

BY

Michael S. Striker
ATTORNEY

Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 4

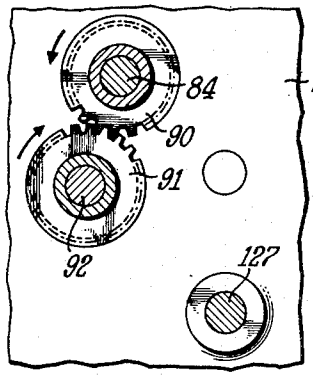
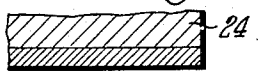
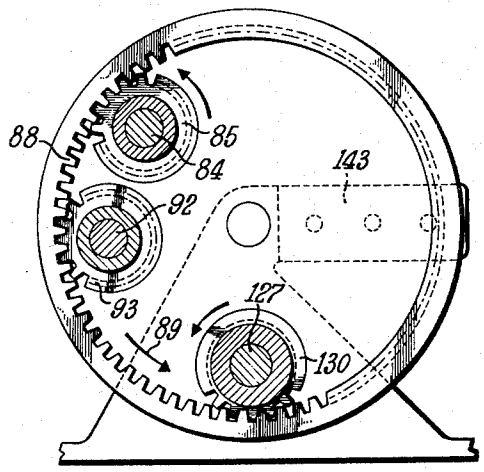


Fig. 4

Fig. 5





INVENTOR
Karl Spohn

BY

Michael S. Striker
ATTORNEY

Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 5

Fig. 6

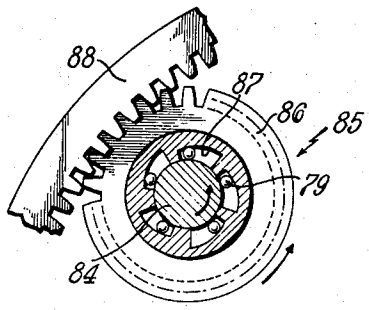


Fig. 9

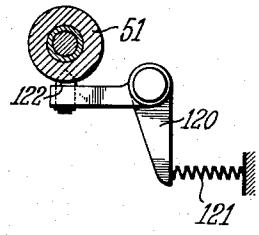


Fig. 7

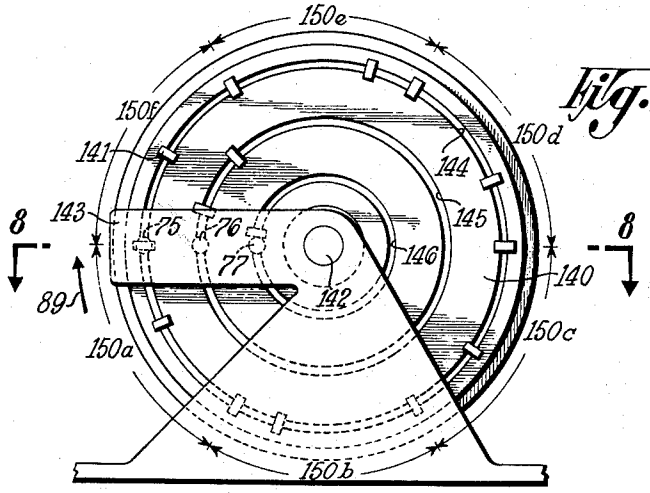
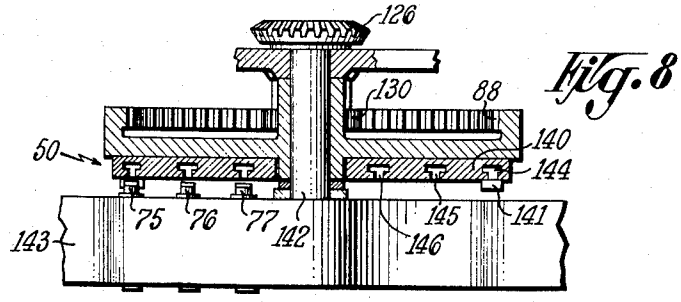


Fig. 8



INVENTOR
Karl Spohn

BY

Michael S. Striker
ATTORNEY

Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 6

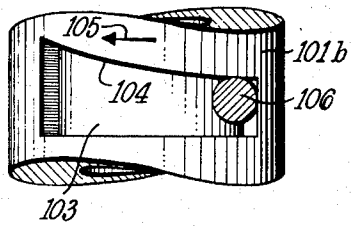


Fig. 10

Fig. 11

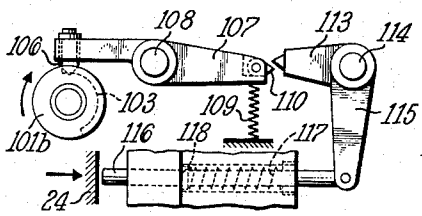


Fig. 12

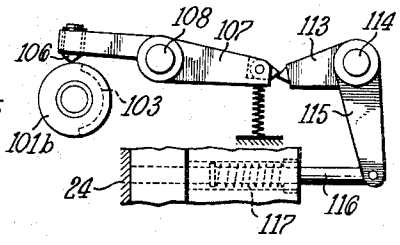


Fig. 17

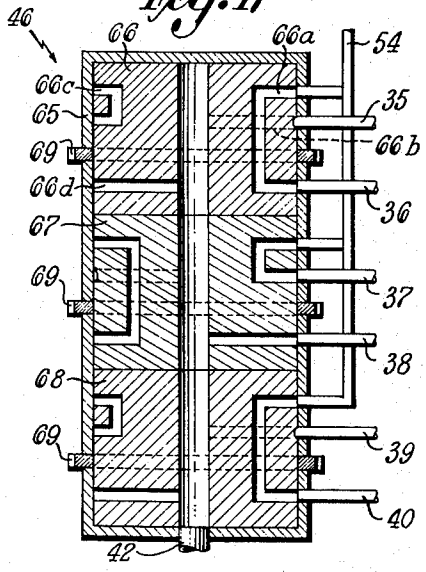
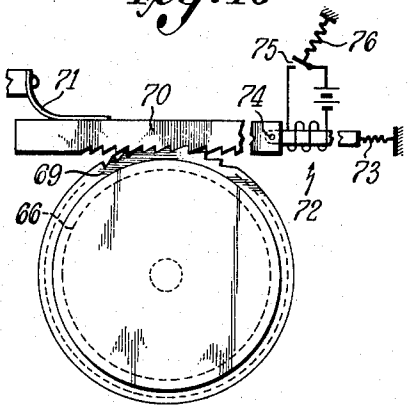


Fig. 18



INVENTOR
Karl Spohn

BY

Michael S. Striker
ATTORNEY

Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 7

Fig. 13

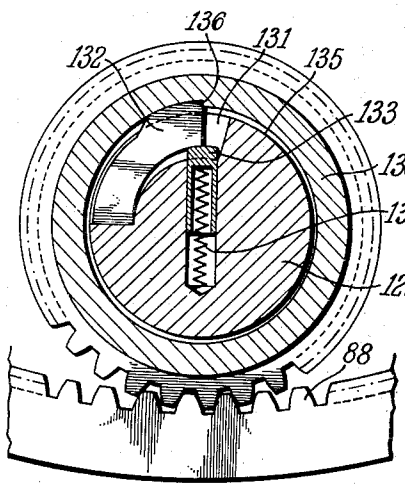


Fig. 15

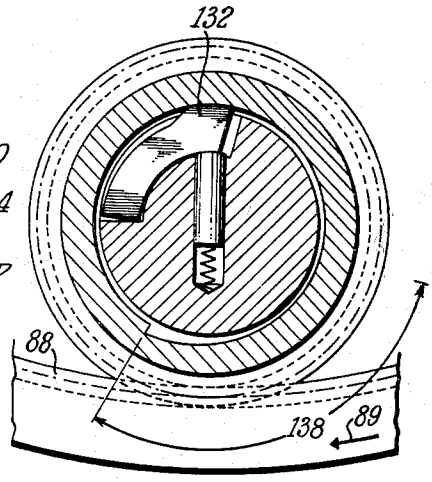


Fig. 14

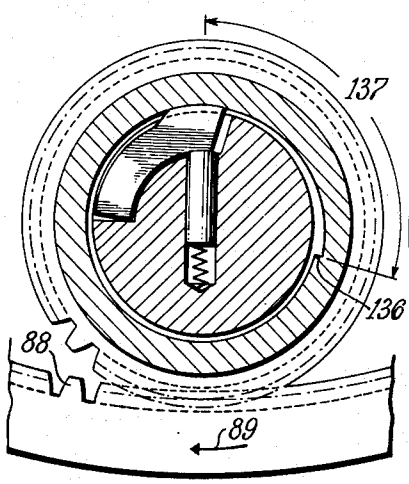
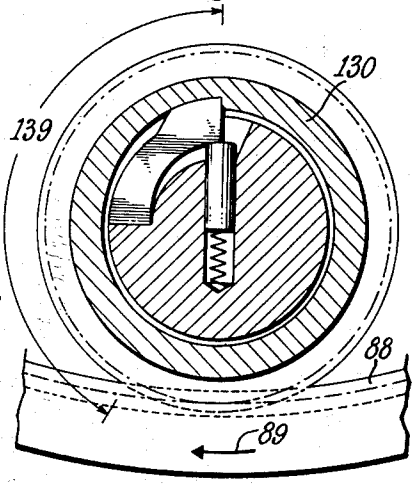


Fig. 16



INVENTOR
Karl Spohn

BY

Michael S. Striker
ATTORNEY

Dec. 10, 1963 K. SPOHN 3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Filed March 6, 1962 8 Sheets-Sheet 8

Fig. 19

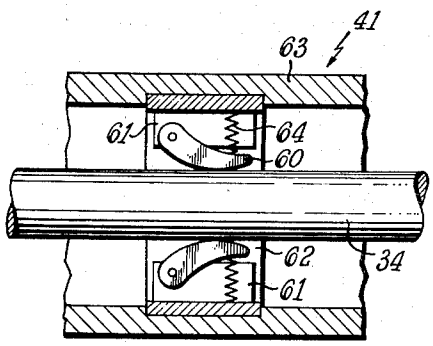
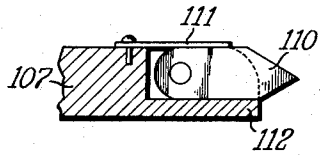


Fig. 20



INVENTOR
Karl Spohn

BY

Richard S. Sprague
ATTORNEY

United States Patent Office 3,113,371 Patented Dec. 10, 1963

3,113,371

CONTROLS FOR AUTOMATIC MACHINE TOOLS AND THE LIKE

Karl Spohn, Damaschkestrasse 15, Oberesslingen (Neckar), Germany

Filed Mar. 6, 1962, Ser. No. 177,816
Claims priority, application Germany Mar. 28, 1958
7 Claims. (Cl. 29—42)

The present invention relates to controls of the type used, for example, for automatically operating machine tools which are capable of automatically carrying out a series of operations on a workpiece.

This application is a continuation-in-part of copending application Serial No. 802,990, filed March 30, 1959, and entitled Control Device for Automatic Machine Tools and the Like.

Machine tools of the above type, for example, may be provided with a control device which includes a plurality of especially constructed cams designed to control the machine tool so that its carries out the desired series of operations in the desired sequence. Because of the great expense involved in the construction of such control cams, a device of this type is practical only where an extremely large number of identical workpieces are to be provided. Where a relatively small number of workpieces are required, it is impractical to construct special cams.

For the case where the machine tool is required to work on a relatively small number of workpieces, it is possible to provide adjustable controls such as a cam arrangement having adjustable camming portions, but even this construction has serious disadvantages. Thus, with an arrangement of this type it is necessary to arrange the controls so that the different operations take place one directly after the other, and therefore when it is desired to change only one of the series of operations, it is essential to make adjustments for all of the subsequent operations, so that with a structure of this type the adjustment is very time consuming and often results in errors.

One of the objects of the present invention is to provide a control arrangement of the above type which is suitable for operation on a relatively small number of workpieces and which at the same time lends itself to easy, convenient changes in the several operations without requiring any changes to be made for the controls of those operations which are to remain unchanged.

Another object of the present invention is to provide a device of the above type with a means for automatically locating a control actuating structure at a starting position for each of the operations performed by the machine.

It is also an object of the present invention to provide a structure capable of locating an actuating means for the controls of the machine tools at a starting position at the beginning of each operation irrespective of the distance of the actuating means from this starting position at the end of the immediately preceding operation.

An additional object of the present invention is to provide a simple, rugged structure which is capable of operating reliably to accomplish the above results and which is compact and easy to adjust.

With the above objects in view, the present invention includes, in a machine tool which is capable of performing automatically a series of operations on a workpiece, a carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position. An actuating means is provided for actuating at least part of the controls of the machine tool, and this actuating means is movable along a given path and has along this path a plurality of equidistantly spaced starting positions respectively corresponding to the location of the carriage means in its rest position at the beginning of each of the series of operations. A transmission means transmits movement of the carriage means to the actuating means to move the latter in the same direction from each of its starting positions toward the next following starting position during movement of the carriage means both away from and back to its rest position, this actuating means being spaced at the end of each operation at a haphazard distance from the next following starting position depending upon the particular operation. Finally, a moving means cooperates with the actuating means for moving the latter at the end of each operation through the remaining distance up to the next following starting position, irrespective of the size of this remaining distance.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings in which:

FIG. 1 is a schematic front elevation of a machine tool provided with the structure of the invention;

FIG. 2 is a sectional view on an enlarged scale of the structure of the invention which is incorporated into the machine tool of FIG. 1, the section of FIG. 2 being taken along line 2—2 of FIG. 3 in the direction of the arrows;

FIG. 3 is a fragmentary, partly schematic, elevation of the structure of FIG. 2 as seen in the direction of the arrow A;

FIG. 4 is a fragmentary partly sectional view of part of the structure of FIGS. 2 and 3, illustrating the operation thereof, and FIG. 4 is taken along line 4—4 of FIG. 2 in the direction of the arrows;

FIG. 5 is also a partly sectional elevation of the structure of FIGS. 2 and 3, illustrating the operation thereof, and FIG. 5 is taken along line 5—5 of FIG. 2 in the direction of the arrows;

FIG. 6 is a fragmentary sectional elevation of one of the one-way drives used in the structure of the invention, FIG. 6 being taken along line 6—6 of FIG. 2 in the direction of the arrows;

FIG. 7 shows in elevation the control-actuating means which is used in the particular embodiment of the invention which is illustrated in the drawings, and FIG. 7 is taken along line 7—7 of FIG. 2 in the direction of the arrows;

FIG. 8 is a sectional plan view of the structure of FIG. 7 taken along line 8—8 of FIG. 7 in the direction of the arrows;

FIG. 9 is a partly sectional and partly schematic illustration of a releasable detent assembly used in the structure of the invention, FIG. 9 being taken along line 9—9 of FIG. 3 in the direction of the arrows;

FIG. 10 is a schematic illustration of part of the automatic control structure of a one-revolution clutch assembly used in the structure of the invention;

FIG. 11 is a plan view of the one-revolution clutch assembly shown in FIG. 11 in its rest position;

FIG. 12 shows the one-revolution clutch assembly of FIG. 11 in the position it takes immediately after this assembly has been actuated so as to carry out one revolution;

FIG. 13 is a fragmentary sectional view on an enlarged scale of a special one-way drive constructed according to the present invention and used in the structure of the invention, FIG. 13 being taken along line 13—13 of FIG. 2 in the direction of the arrows;

FIG. 14 shows the position which the structure of FIG. 13 takes after the tool-carrying carriage has moved away from its rest position;

FIG. 15 shows the position which the structure of FIG. 13 takes after the tool-carrying carriage has returned to its rest position;

FIG. 16 illustrates how the structure of FIG. 13 operates to advance the actuating means through the remainder of the distance required to locate it at the next following starting position;

FIG. 17 is a schematic illustration of a hydraulic control assembly which may be used in the machine tool of FIG. 1 and which is automatically actuated with the structure of the invention;

FIG. 18 is a schematic, partly sectional plan view of a structure for actuating the hydraulic control of FIG. 17;

FIG. 19 is a schematic illustration on an enlarged scale of one possible type of work-advancing structure which may form part of the machine tool with which the structure of the invention is used; and

FIG. 20 is a fragmentary partly sectional illustration of an element of the one-revolution clutch assembly.

Referring to FIG. 1, the machine tool illustrated therein includes a lower supporting frame **21** and an upper frame **22** carried by the frame **21**. A headstock **23** is carried by the frame **22** and a movable tailstock **24** is guided for movement to the left and right, as viewed in FIG. 1, by suitable ways of the frame **22**, this tailstock **24** being in the form of a carriage which carries the tools which perform the several operations, these tools being carried in a well-known manner by the rotary turret **25** which is carried by the carriage **24** in a conventional manner. An additional transverse carriage **26** may be provided on the machine tool, and a further carriage **27** is provided, this latter carriage **27** also moving transversely with respect to the axis of the work.

The various parts of the machine tool are driven from an electric motor **28** which is constantly running during operation of the machine tool, and in a gear box **29** is located a transmission which is operated by the motor **28**, part of this transmission being used to deliver the drive from the motor **28** to a sprocket chain **30** connecting at its lower end to a sprocket wheel driven from the transmission in the gear box **29** and at its upper end to a sprocket wheel which is coaxially fixed to the rotary hollow spindle **31** which is supported in a well-known manner by the headstock **23** and through which the work extends. Thus, the front end of the work forms the workpiece **32** which projects forwardly beyond the hollow spindle **31**, and this workpiece **32** is derived from an elongated bar **34** which at the end of an operation or cycle of operations is advanced by a predetermined distance so as to locate the next workpiece at the front end of the bar **34** in position to be worked on by the tools during the next cycle of operations, as is well-known in the art. At the end of a cycle of operations the carriage **27** moves downwardly, and a cut-off tool **48** carried thereby cuts off the workpiece **32** from the bar **34** and then upon return of the carriage **27** to its rest position the bar **34** is advanced in order to locate the next workpiece in position. The finished workpiece which falls from the bar **34** may be received in any suitable chute or the like so as to be guided to a suitable collecting container, for example.

The feeding of the bar **34** is carried out by a carriage **49** through which the bar **34** passes, and at its rear end the carriage **49** carries a work-gripping structure **41** which grips the work to advance it at each forward stroke of the carriage **49**.

This work-gripping structure **41** may, for example, take the form shown in FIG. 19 where work-gripping elements **60** are illustrated. These elements are pivotally carried by radially extending plates **61** which are fixed to and extend inwardly from a rotary sleeve **62** which is free to rotate in the sleeve **63** which is fixed to and forms part of the carriage **49**. At their inner faces which are directed toward the axis of the bar **34** the work-gripping elements **60** may be knurled, for example, so

that they will have a relatively high coefficient of friction with respect to the bar **34**, and they are urged toward the bar **34** by the springs **64**, respectively. As is apparent from FIG. 19, whenever the work-gripping means **41** is shifted to the left, as viewed in FIG. 19, the gripping fingers **60** will slide with respect to the bar **34** which will therefore remain stationary, while when the work-gripping means **41** is shifted to the right, as viewed in FIG. 19, these fingers **60** will frictionally engage and press against the bar **34** so as to advance the latter to the right. Therefore, whenever the carriage **49** of FIG. 1 is moved to the left the bar **34** will remain stationary while when it is moved to the right the bar **34** will be advanced to the right so as to locate the next workpiece in position to be operated on.

FIG. 1 diagrammatically illustrates the structure for controlling the movement of the carriages **24**, **27**, and **49**. Thus, three controls are provided, and it is pointed out that only this relatively small number of controls are shown solely for the purpose illustrating the invention. In an actual machine there would be many more controls. In the illustrated example the carriage-moving structure is shown as being hydraulic, although it is to be understood that any other type of carriage-moving structure could be used, since this particular feature forms no part of the invention. As is apparent from FIG. 1, the frame **22** fixedly carries a piston-and-cylinder assembly **33***a* which cooperates with the carriage **24**. This assembly includes a piston rod which is fixed to the frame **22** at its upper right end, as viewed in FIG. 1, and a piston fixed to the left end of the piston rod, this piston and piston rod extending into a hollow cylindrical portion formed in the interior of the carriage **24**. The hollow cylinder in the carriage **24** has, of course, a fluid-tight engagement with the piston rod. It will be noted that a piston-and-cylinder assembly **33***b* cooperates with the carriage **27**, in this case the piston rod being fixed at its upper end with the piston located at the lower end of the piston rod in the hollow interior cylindrical chamber formed in the carriage **27**, and there is also a piston-and-cylinder assembly **33***c* associated with the carriage **49**, the piston rod of this assembly being fixed at its right end to the headstock **23** with the piston located at the left end of the piston rod, and of course in this case also the cylinder has a fluid-tight sliding engagement with the piston rod. In the case of the carriage **49**, it will be noted that the piston rod extends in both directions from the piston and that the cylinder has slidable, fluid-tight engagement with both of the piston rods which extend from the opposite ends of the stationary piston of this embodiment.

Each of the piston rods of the assemblies **33***a*–**33***c* is formed with a pair of bores which extend parallel to the axis of the piston rod. Thus, in the assemblies **33***a* and **33***b* one of the bores extends through the piston rod and through the piston to one side of the cylindrical chamber and the other bore has an outlet from the piston rod on the other side of the piston within the cylindrical chamber, so that depending upon which of these bores receives fluid under pressure the carriage will move in one direction or the other. In the case of the carriage **49**, the right piston rod has a bore which terminates short of the piston itself and communicates with the cylindrical chamber, and the left piston rod also has a bore which communicates with the cylindrical chamber and terminates short of the piston, so that in this case also depending upon which of the bores receives fluid under pressure the carriage **49** will move in one direction or the other. A pair of hydraulic fluid conduits **35** and **36** respectively communicate with the bores of the piston-and-cylinder assembly **33***a*, a pair of conduits **37** and **38** respectively communicate with the bores of the piston-and-cylinder assembly **33***b*, and finally a pair of conduits **39** and **40** respectively communicate with the bores of the piston-

and-cylinder assembly 33*c*. The flow of fluid in these conduits is controlled through a valve assembly 46 which may have the construction schematically illustrated in FIG. 17. The hydraulic fluid is derived from a tank 43 located in a lower part of the frame 21 and a pump 45 is carried by the tank 43 at its upper part and sucks the oil or the like out of the tank 43 through an inlet which is provided with the filter 44. The pump 45 discharges through a pressure conduit 54 to the valve assembly 46, and the fluid flows from the valve assembly 46 back to the tank 44 through the return outlet 42. The pressure conduit 54 carries a valve 47 of known construction which automatically opens when the pressure rises above a predetermined value so that when this safety valve 47 is automatically opened the fluid will automatically return to the tank through the conduit 47*a* in a manner well-known in the art.

One possible construction of the valve assembly 46 is shown diagrammatically in FIG. 17. Referring to FIG. 17, it will be seen that the valve assembly 46 includes a housing 65 in which three identical valves 66, 67, and 68 are located in the manner shown in FIG. 17, these valves being turnable about their common axis, and each of these valves being in the form of a cylindrical body. The valve 66 has a passage 66*a* which in the position of the valve 66 shown in FIG. 17 communicates with the pressure conduit 54 so that through the passage 66*a* the fluid under pressure is delivered to the conduit 36. The conduit 35 at this time communicates with a passage 66*b* which communicates with the central axial bore of the valve 66, and all of these central axial bores of the valves communicate with each other and with the conduit 42, so that fluid can return through the conduit 35 back to the tank 43. As may be seen from FIG. 1, with the valve assembly 46 in the the position shown in FIG. 17 the fluid under pressure will flow along the conduit 36 through the bore of the piston rod into the cylindrical chamber on the right side of the piston so as to advance the carriage 24 to the right, as viewed in FIG. 1, and the carriage 24 is shown at the end of its movement to the right where it has again reached its rest position. The fluid displaced from the cylindrical chamber by movement of the carriage 24 to the right flows along the conduit 35 and through the passage 66*b* back into the tank as described above. When the valve 66 is turned through 180° about its axis from the position shown in FIG. 17, the passage 66*c* of the valve 66 will communicate with the pressure conduit 54 and will deliver fluid under pressure to the conduit 35 so that at this time the fluid under pressure will be delivered to the left side of the piston in the cylinder of the carriage 24 and will therefore advance the carriage 24 to the left, as viewed in FIG. 1, away from its rest position, and this will of course bring a tool into engagement with the workpiece to perform an operation thereon. The work is of course rotating as a result of the drive transmitted from the motor 28, this work being held by gripping elements at the right end of the spindle 31, and these gripping elements may be similar to the elements 60 shown in FIG. 19. Of course, the rotary sleeve 62 which carries the element 60 rotates with the bar 34. When the valve 66 has been displaced through 180° from its position shown in FIG. 17, so that the fluid under pressure is delivered in the above-described manner to the conduit 35, the conduit 36 communicates through the passage 66*d* with the central discharge bore of the valve 66, so that at this time the fluid at the right of the piston in the cylinder of the carriage 24 can flow back through the conduit 36 and the passage 66*d* to the tank.

The valve 67 which is identical with the valve 66 is shown in FIG. 17 displaced through 180° with respect to the position of the valve 66, and thus in the position shown in FIG. 17 it is the conduit 37 which receives the fluid under pressure while fluid returns through the conduit 38. As may be seen from FIG. 1, the conduit 37 communicates with the bore of the piston rod of assembly 33*b* which communicates with the cylinder of carriage 27 at the upper side of the stationary piston therein, so that the fluid under pressure raises the carriage 27, and the carriage 27 is shown in FIG. 1 in its upper rest position to which it has been raised by the fluid under pressure in the conduit 37. The fluid returns out of the cylinder of the carriage 27 from the lower side of the piston therein through the conduit 38. Of course, when the valve 67 is displaced through 180° from the position shown in FIG. 17 the fluid under pressure will be delivered to the conduit 38 so that the carriage 27 will be lowered, and at this time the fluid from the upper side of the piston in the cylinder of the carriage 27 will return through the conduit 37.

The valve 68 is identical with the valves 66 and 67, and in the position of the valve 68 shown in FIG. 17 the fluid under pressure is delivered to the conduit 40 which communicates with the right piston rod which extends into the cylinder of the carriage 49, so that this fluid under pressure displaces the carriage 49 to the right, as viewed in FIG. 1, in order to advance the work, and the carriage 49 is shown in FIG. 1 in its right end position. This movement of the carriage 49 to the right displaces fluid through the conduit 39 which communicates with the discharge conduit 42 at this time, as is evident from FIG. 17. Of course, when the valve 68 is displaced through 180° from the position shown in FIG. 17 the fluid under pressure will be delivered to the conduit 39 so as to advance the carriage 49 to the left, and at this time the fluid will return through the conduit 40 in the manner described above.

Any suitable releasable detent structure may be provided for releasably retaining each of the valves 66–68 in one or the other of its operating positions. These valves may be turned between their positions in any suitable way such as that illustrated diagrammatically in FIG. 18. Thus, each of the valves may fixedly be connected with a coaxial ratchet 69 which is fixed to each valve and which projects beyond the housing 65 while being turnable with respect to the latter in a fluid-tight manner. The ratchet 69 which is fixed to the valve 66 is shown in FIG. 18, and it is to be understood that the other valves are operated in exactly the same way. A rack 70 has its teeth in engagement with the teeth of each ratchet 69, and the rack 70 which cooperates with the ratchet 69 are fixed to the valve 66 is shown in FIG. 18. The rack 70 is guided for movement to the left and the right, as viewed in FIG. 18, through any suitable guide structure, and the rack is urged toward the teeth of the ratchet 69 by a leaf spring 71, for example. A solenoid 72 is urged by spring 73 to the right, as viewed in FIG. 18, and the armature of the solenoid is pivotally connected at 74 to the rack 70. When the solenoid 72 is energized its armature will shift to the left, as viewed in FIG. 18, advancing the rack 70 to the left, and the stroke of the solenoid is such that the valve 66 will be turned through 180° to its other position of operation. The releasable detent structure as well as the frictional resistance to turning of the valve 66 will maintain it in its operating position while the rack 70 returns to its rest position, this return being brought about by the spring 73 which returns the armature of the solenoid 72 to its rest position when the solenoid is unenergized. As is diagrammatically shown in FIG. 18, the coil of the solenoid is located in a circuit which is closed when the switch 75 is closed, and this switch 75 is urged to its open position by a spring 76. The location of the switch 75 in the machine tool is indicated in FIG. 1, and its electrical connection with the valve-actuating structure is diagrammatically indicated in FIG. 1. An identical switch 76 cooperates

through an identical assembly, as shown in FIG. 18, with the valve 67 to move the latter by 180° each time the switch 76 is closed, and a third switch 77 cooperates also through an assembly identical with that shown in FIG. 18 with the lowermost valve 68 to advance the latter through 180° each time the switch 77 is closed. In the case of the valve 68, however, when the carriage 49 is in its left end position, as viewed in FIG. 1, it will close a switch 53 located at the upper left of the frame 22 in order to actuate the same solenoid which is actuated upon closing of the switch 77 so as to advance the valve 68 through 180°. Thus, in the case of the valves 66 and 67, each of these valves is advanced through 180° each time the switch associated therewith is closed, while in the case of the valve 68, the valve is advanced through 180° alternately by closing of the switches 77 and 53.

The structure of the invention includes an actuating means 50 which closes the switches 75–77 in a predetermined sequence during each operating cycle, and it is this structure for operating the switches 75–77 which forms the present invention.

The drive from the transmission in the gear box 29 constantly rotates a shaft 55 which through a bevel gear transmission constantly rotates an upwardly directed shaft at the right end of the shaft 55, as shown diagrammatically in FIG. 1, and this latter upwardly directed shaft constantly rotates one of a pair of clutch members. These clutch members form part of a one-revolution clutch which is actuated in a manner described below by the return of the carriage 24 to its rest position. When this one-revolution clutch is actuated it will rotate the shaft 51, shown diagrammatically in FIG. 14, through one revolution, and a gear 52 which is fixed to the shaft 51 will also rotate through one revolution and will actuate the structure for advancing the turret 25 through the angle required to locate the next tool in the operating position, the connection between the gear 52 and the turret 25 being shown diagrammatically in FIG. 1. In the illustrated example the turret carries six tools so that it is turned through 60° each time the gear 52 turns through one revolution. Structure for rotating the turret 25 in this way is well-known in the art and does not form part of the present invention.

The switch-actuating means 50 is in the form of a rotary disc which carries switch-actuating cams, and this rotary disc is turned about its axis through the transmission means which is shown in FIGS. 2 and 3 and which is further illustrated in the remaining figures. Referring to FIGS. 2 and 3, it will be seen that the carriage 24 fixedly carries at its underside an elongated rack 80 which moves with the carriage 24. When the carriage 24 moves away from its rest position, it moves in the direction of the arrow 81 shown in FIG. 3, and when it returns toward its rest position it moves in the direction of the arrow 82 shown in FIG. 3. The rack 80 meshes with a gear 83 which is fixed to a shaft 84 supported for rotation by bearings of the frame 22, and the shaft 84 also carries a one-way drive 85 the details of which are shown most clearly in FIG. 6. As may be seen from FIG. 6 the one-way drive 85 includes a gear 86 whose hub is freely turnable with respect to the shaft 84. This hub of the gear 86 is formed with the substantially wedge-shaped recesses 87 which are distributed about the axis of the gear 86, and each of these recesses has a roller 79 located therein. As is apparent from FIG. 6 when the shaft 84 turns in a counterclockwise direction, as viewed in FIG. 6, the rollers 79 will be driven toward the smaller ends of the recesses 87 so as to press against the gear 86 and thus at this time the gear 86 will also turn in a counterclockwise direction, as viewed in FIG. 6. However, when the shaft 84 turns in a clockwise direction with respect to the gear 86, or when the gear 86 turns in a counterclockwise direction with respect to the shaft 84, the rollers 79 will be urged toward the larger ends of the recesses 87, respectively, so that at this time there will be no transmission of a drive from the shaft 84 to the gear 86. In this way a one-way drive is provided. It is emphasized that many different types of one-way drives are known and the particular structure shown in FIG. 6 is illustrated only by way of example. The disc of the actuating means 50 is carried by a coaxial circular plate which has a peripheral flange extending to the left, as viewed in FIG. 2, and terminating in an inwardly directed ring gear 88 which meshes with the gear 86. As may be seen from FIG. 3, when the carriage 24 moves in the direction of the arrow 81 away from its rest position in order to bring a tool into engagement with the work, the rack 80 will turn the gear 83 in a counterclockwise direction, as viewed in FIG. 3, so that the shaft 84 will also turn in a counterclockwise direction at this time, and thus the drive will be transmitted through the one-way drive 85 to the ring gear 88 so that the actuating means 50 is turned in a counterclockwise direction, at this time, as viewed in FIG. 3 and as is indicated by the arrow 89 in FIG. 3.

The transmission means of the invention will not only turn the gear 88 and the actuating means 50 therewith in the direction of the arrow 89 during movement of the carriage 24 in the direction of the arrow 81 shown in FIG. 3, this transmission will also turn the gear 88 and the actuating means 50 in the direction of the arrow 89 during the return movement of the carriage 24 in the direction of the arrow 82. It will be noted that during this return movement the shaft 84 will turn in a clockwise direction, as viewed in FIGS. 3 and 6, so that the drive will not be transmitted at this time through the gear 86 to the gear 88. It will be noted that the shaft 84 also fixedly carries a gear 90, as shown in FIG. 2, and this gear 90 meshes with a gear 91 which is fixed to a shaft 92 which is parallel to the shaft 84 and which is supported by bearings of the frame 22 for rotation about its axis. The shaft 92 fixedly carries a one-way drive 93 identical with the one-way drive 85 shown in FIG. 6. The gear of the one-way drive 93, which corresponds to the gear 86, also meshes with the ring gear 88, and it will be noted that the two one-way drives 85 and 93 are spaced from each other. During the return movement of the carriage 24 in the direction of the arrow 82 the gear 83 will turn in a clockwise direction, as viewed in FIG. 3, so that the drive will not be transmitted through the one-way drive 85 at this time, as was pointed out above. However, it will be noted that at this time the shaft 92 rotates in a counterclockwise direction, as viewed in FIG. 3, due to the drive transmitted to this shaft at this time through the gears 90 and 91. Therefore, the one-way drive 93 will at this time continue the turning of the gear 88 in the direction of the arrow 89 in exactly the manner described above in connection with FIG. 6, so that during the return movement of the carriage 24 the transmission means shown in FIGS. 2 and 3 will continue to turn the gear 88 and the actuating means 50 in the direction of the arrow 89. The manner in which the gears 90 and 91 cooperate to rotate the shafts 84 and 92, respectively, is shown most clearly in FIGS. 4 and 5, FIG. 5 showing in particular the cooperation between the one-way drives 85 and 93 and the ring gear 88. It will be noted that when the gear 88 is driven by the one-way drive 93 this gear 88 will of course turn the gear 86 of the one-way drive 85, and this gear 86 will at this time turn in a counterclockwise direction, and the shaft 84 at this time is turning in a clockwise direction, as viewed in FIG. 6, so that the gear 86 will simply turn freely on the shaft 84 and there will be no transmission of drive between elements 84 and 86. In the same way, when the drive is transmitted to the gear 88 through the one-way drive 85 the gear of the

one-way drive 93 turns in a counterclockwise direction as a result of its rotation by the gear 88, but the shaft 92 at this time rotates in a clockwise direction and of course here again there is no transmission of a drive between the shaft 92 and the gear of the one-way drive 93. In this way the gear 88 and the actuating means 50 will be advanced through certain angular increments in the same direction both during movement of the carriage 24 away from its rest position and during movement of the carriage 24 back to its rest position.

A third one-way drive structure is provided to continue the turning of the gear 88 and the actuating means 50 therewith in the direction of the arrow 89, and this third one-way drive structure is driven from a one-revolution clutch means which is actuated by the carriage 24 when this carriage returns to its rest position, and this latter clutch means will now be described. At the lower part of FIG. 2 is shown the shaft 100 which is constantly rotated during operation of the motor 28 through the drive from the transmission in the gear box 29 and the shaft 55 as well as the bevel-gear transmission at the end of the shaft 55 as was pointed out above in connection with FIG. 1. The shaft 51 which is diagrammatically indicated in FIG. 1 is driven through the one-revolution clutch, and as is apparent from FIG. 2, this shaft 51 is in the form of a hollow tubular shaft into which the shaft 100 extends, and FIG. 2 shows the gear 52 fixed to the hollow shaft 51 and providing a transmission for turning the turret 25, as was described above. The shaft 100 is supported for rotation by any suitable stationary bearing structure and this shaft 100 fixedly carries the lower clutch member 101*a* of the one-revolution clutch 101 shown in FIG. 2. This is in the form of a dog clutch and the lower clutch member 101*a* carries upwardly directed teeth. The upper part 101*b* of the clutch 101 is in the form of a tubular member through which the shaft 100 passes, and the movable clutch member 101*b* is located between the shaft 51 and the rotary clutch member 101*a*. While the clutch member 101*a* is free to rotate it does not move axially, and the clutch member 101*b* moves axially and of course rotates when the downwardly directed teeth of the clutch member 101*b* mesh with the upwardly directed teeth of the clutch member 101*a*. The hollow shaft 51 fixedly carries at its bottom end downwardly directed teeth which mesh with upwardly directed teeth at the upper end of the clutch member 101*b*, and these teeth at the lower end of shaft 51 and the upper end of clutch member 101*b* are long enough to remain at all times in engagement with each other so that when the clutch member 101*b* is engaged with the clutch member 101*a* the drive will be transmitted to the shaft 51. It will be noted that in the position of the parts shown in FIG. 2 the clutch member 101*b* is raised to its inoperative position where its lower teeth do not engage the teeth of the clutch member 101*a* so that at this time the shaft 51 is stationary and the drive is not transmitted from the shaft 100 to the shaft 51. A coil spring 102 is coiled freely about the shaft 100 and engages at its opposite ends shoulders of the shaft 51 and the clutch member 101*b*, so that this spring 102 urges the clutch member 101*b* downwardly into engagement with the clutch member 101*a*.

As is shown most clearly in FIG. 10, the clutch member 101*b* is formed in its exterior with an arcuate groove 103 having an upper camming edge 104 which is directed downwardly, as viewed in FIG. 10. A pin 106, shown in section in FIG. 10, engages the camming edge 104 so as to retain the clutch member 101*b* in its upper disengaged position in opposition to the spring 102. When the pin 106 is moved out of the groove 103 the spring 102 immediately lowers the clutch member 101*b* into engagement with the clutch member 101*a*, and at this time the clutch member 101*b* will be driven in the direction of the arrow 105 shown in FIG. 10, transmitting the drive to the shaft 51, as described above. Before the clutch member 101*b* has turned through a complete revolution the upper end portion of the camming edge 104 will have moved into alignment with the pin 106 which in a manner described below will now snap into the recess 103. The difference between the elevation of the ends of the camming edge 104 is great enough so that when the clutch member 101*b* is in its lower engaged position the uppermost part of the groove 103 will still be at the elevation of the pin 106 so that when the left end of the groove 103, as viewed in FIG. 10, reaches the pin 106 this pin will immediately enter into the groove 103 and will engage the camming edge 104 so that during the continued turning of the clutch member 101*b* this camming edge 104 will cooperate with the pin 106 to raise the clutch member 101*b* in opposition to the spring 102 until the parts again reach the position shown in FIG. 10 where the clutch member 101*b* is disengaged from the clutch member 101*a*, and in this way the clutch provides only a single revolution in the transmission of the drive from the shaft 100 to the shaft 51.

As is shown in FIGS. 3, 11 and 12, the pin 106 is carried by the free end of a lever 107 which is supported for turning movement about a stationary pin 108. The lever 107 is acted upon by a compression spring 109 which urges the lever 107 to turn in a counterclockwise direction, as viewed in FIGS. 11 and 12, so that in this way the pin 106 is urged against the clutch member 101*b*. The lever 107 pivotally carries at its right end, as viewed in FIG. 11, a lever 110 which is urged by the leaf spring 111, shown in FIG. 20, against a wall 112 of the lever 107. In this way the lever 110 cannot turn in a clockwise direction, as viewed in FIG. 20, beyond the position shown in FIG. 20 with respect to the lever 107, but of course the lever 110 is free to turn in opposition to the leaf spring 111, which is carried by the lever 107, in a counterclockwise direction with respect to the lever 107, as viewed in FIG. 20. This lever 110, which is carried by the lever 107, is located in the path of turning of the free end of a lever 113 which is fixed to the lower end of an elongated rotary shaft 114 supported for turning movement about its axis by any suitable bearings and prevented from moving along its axis. The upper end of the shaft 114 fixedly carries a lever 115 which is pivotally connected at its free end to an elongated push rod 116 the left free end of which, as viewed in FIGS. 3, 11 and 12 is located in the path of movement of the carriage 24, and the position of the push rod 116 is such that it will be engaged by the rear end of the carriage 24 just before this carriage 24 reaches its rest position so that in this way the push rod 116 will be pushed by the carriage 24 from the position shown in FIG. 11 to the position shown in FIG. 12. The push rod 116 extends freely through an elongated bore formed in the frame 22, and the push rod 116 is free to tilt through the slight extent necessary to provide the turning of the lever 115 between the positions thereof shown in FIGS. 11 and 12. A spring 117 is coiled about the push rod 116, engages a collar 118 thereon, and this spring engages at its right end, as viewed in FIGS. 11 and 12, a collar threadedly carried by the frame and surrounding the push rod 116 with clearance sufficient to allow movement of the push rod between the positions shown in FIGS. 11 and 12, and thus the spring 117 maintains the push rod 116 in engagement with the rear end of the carriage 24 when the latter moves to the right, as viewed in FIG. 11, beyond the position shown in FIG. 11. A shoulder of the frame 22 engages the collar 118 at its left end, as shown in FIG. 11, so as to limit movement of the push rod 116 by the spring 117 to the left, as viewed in FIG. 11, to the position indicated in FIG. 11.

Therefore, just before the carriage 24 reaches its end position while moving in the direction of the arrow 82 of FIG. 3, the carriage will move the push rod 116 to the right from the position of FIG. 11 to that of FIG. 12, and in this way the shaft 114 and the levers 113 and 115

will all turn in a counterclockwise direction from the position of FIG. 11 to that of FIG. 12, and as a result the free end of the lever 113 will engage the element 110 and will turn the lever 107 in opposition to the spring 109 through an angle sufficient to displace the pin 106 out of the recess 103 so that the spring 102 will immediately lower the clutch member 101*b* into engagement with the clutch member 101*a*, and although the lever 107 is immediately released to the spring 109 the groove 103 will have been displaced out of alignment with the pin 106 and the single revolution provided by this clutch will take place. The configuration of the free end of the lever 110 and of the free end or tip of the lever 113 is such that the lever 113 rides off the lever 110 just before the lever 113 reaches the position shown in FIG. 12, and course when the parts have the position shown in FIG. 12 the one-way clutch 101 is operating. When the carriage 24 again moves away from its rest position the spring 117 will return the shaft 114 and the levers 113 and 115 as well as the push rod 116 to the position indicated in FIG. 11, and at this time the lever 113 will again engage the lever 110 but will simply turn it momentarily in opposition to the spring 111 (FIG. 20), and as soon as the tip of the lever 113 rides off the tip of the lever 110 the spring 111 will return the lever 110 to the position shown in FIG. 20.

As is shown in FIGS. 2, 3 and 9, a bell crank 120 is supported for turning movement about an axis parallel to the axis of turning of the lever 107, and this bell crank is urged by a spring 121 to turn in a clockwise direction, as viewed in FIG. 9. The hollow shaft 51 is provided at its exterior with a recess which receives the pin 122 carried by the bell crank 120 when the shaft 51 is in its rest position, so that in this way a releasable detent structure is provided for precisely locating the shaft 51 in a position exactly displaced by 360° from its previous position. When the clutch 101 is engaged the drive of the shaft 51 will displace it with respect to the pin 122 and the lever 120 will at this time be turned in opposition to the spring 121, and as soon as the detent recess of the shaft 51 again approaches its initial position the spring 121 will urge the lever 120 back to the position shown in FIG. 9 where the pin 122 cooperates with this recess to precisely determine the position of the shaft 51.

As may be seen from FIG. 2, the shaft 51 fixedly carries at its upper end a bevel gear 125 which meshes with a bevel gear 126 which is fixed to a shaft 127 supported for rotation about its axis by bearings carried by the frame 22, and the shaft 127 serves to drive the third one-way drive which advances the gear 88 and the actuating means 50 therewith, as referred to above. The structure of this third one-way drive is shown most clearly in FIGS. 13–16. This third one-way drive includes a rotary gear 130 which is freely turnable on the shaft 127 and which meshes with the ring gear 88 as shown most clearly in FIG. 13. The portion of the shaft 127 which is surrounded by the hub of the gear 130 is formed with an arcuate cutout 131 which receives a motion-transmitting member 132 the configuration of which is clearly shown in FIG. 13. A member 133 is guided in a bore of the shaft 127 for radial movement with respect to the axis thereof, and a spring 134 acts on the member 133 to urge it away from the axis of the shaft 127, this spring 134 also being located in a bore of the shaft 127, as indicated in FIG. 13. The member 133 is thus maintained in engagement with the motion-transmitting member 132 so as to urge the right end thereof, as viewed in FIG. 13, at all times away from the axis of the shaft 127. The left end of the motion-transmitting member 132, as viewed in FIG. 13, engages the left end of the cutout 131, so that when the shaft 127 turns in a clockwise direction, as viewed in FIG. 13, upon receiving its drive from the one-revolution clutch assembly described above, the motion-transmitting member 132 will necessarily turn with the shaft 127, and this shaft 127 turns only in a clockwise direction, as viewed in FIG. 13, through a single revolution as a result of the drive derived from the one-revolution clutch assembly. The inner surface 135 of the hub of the gear 130 is curved in the manner indicated in FIG. 13 so as to be provided with a shoulder 136, and it will be noted that in the position of the parts shown in FIG. 13 the motion-transmitting member 132 engages the shoulder 136.

The parts are shown in FIG. 13 in the position they take immediately after the one-revolution clutch has turned the shaft 127 through one revolution, the gearing 125, 126 being such that when the shaft 51 turns through one revolution the shaft 127 also turns through one revolution. Thus, FIG. 13 shows the position which the parts take when the carriage 24 is in its rest position just prior to moving away from its rest position in order to carry out an operation on the workpiece.

During movement of the carriage 24 away from its rest position toward the workpiece in order to bring a tool into engagement with the latter so as to perform an operation thereon, the ring gear 88 will turn in the direction of the arrow 89 shown in FIG. 14 through a certain angle such as the angle 137 indicated in FIG. 14, and thus the shoulder 137 will turn away from the motion-transmitting member 132, and at the end of the movement of the carriage 24 away from its rest position the one-way drive assembly of FIG. 13 will have assumed the position shown in FIG. 14. The angle 137 is shown only by way of example and will vary with different operations. During the return movement of the carriage 24 to its rest position the gear 88 will of course continue to turn in the direction of the arrow 89, as a result of the transmission means described above, and thus the gear 130 will turn through an additional angle 138, for example, as shown in FIG. 15. Thus, the angle 138 indicated in FIG. 15 indicates the angle through which the gear 130 is turned during the return movement of the carriage 24 until the latter reaches its end position. Thus, the shoulder 136 will have advanced with respect to the motion-transmitting member 132 up to the position indicated in FIG. 15, which again is only by way of example since the angular distances 137 and 138, which will always be equal to each other, will be different for different operations because the carriage 124 will move through different distances away from and back toward its rest position in order to carry out different operations.

As was indicated above, when the carriage 24 returns to its rest position it releases the one-revolution clutch so that the shaft 51 will automatically turn through one revolution, and thus when the gear 130 reaches the position indicated in FIG. 15 the one-revolution clutch will be released for operation and will now turn the shaft 127 from the position thereof indicated in FIGS. 13–15 through a single revolution in a clockwise direction, as viewed in FIGS. 13–15, so that now the shaft 127 turns and the motion-transmitting member moves into engagement with the shoulder 136 and engages the latter so as to positively drive the gear 130 in a clockwise direction through whatever angle is required to complete the turning of the gear 130 through 360°. This angle is shown at 139 in FIG. 16, but of course this remaining angular distance required for a complete revolution of the gear 130 will be different with different operations. Thus, with this construction irrespective of the particular angular position of the gear 88 upon return of the carriage 24 to its rest position after performing a certain operation, the stucture will automatically advance the gear 88 up to a predetermined initial position before the next operation starts and thus it is possible to locate the gear 88, and of course the actuating means 50 therewith, at predetermined starting positions for each of the several operations irrespective of variations in these operations.

It should be noted that the arrows 89 in FIGS. 13–15 are reversed with respect to the arrow 89 in FIG. 3. The reason for this is that the section for FIGS. 13–15 is

taken toward the left in FIG. 2 while the section for FIG. 3 as well as for FIGS. 4–6 is taken looking to the right in FIG. 2. When the gear **88** is driven by the gear **130** this gear 88 will of course be turned by the gear **130** in the direction of the arrow 89 shown in FIG. 3, and as may be seen from FIG. 6 the gear **86** of the one-way drive 85 and the corresponding gear of the one-way drive 93 will turn in a counterclockwise direction, as viewed in FIG. 6, the larger ends of the recesses **87** approaching the members 88 so that there is no drive between the shafts and the gears of the one-way drives **85** and **93**, so that at this time these latter gears simply turn freely on their shafts.

The details of the actuating means **50** are shown most clearly in FIGS. 7 and 8. The actuating means is in the form of a plate **140** which is coaxially fixed to the gear **88** for rotary movement therewith, and the plate **140** carries the plurality of cams or switch-actuating members **141**. A stationary shaft **142** is carried by a stationary frame member **143** and serves to support the gear **88** for rotary movement so that in this way the plate **140** is also supported for rotary movement. The circular plate **140** is formed with concentric circular T-grooves **144, 145, 146**, and the several switch-actuating members **141** are arranged along these circular grooves **144–146**. Each member **141** may be in the form of a nut, for example, threadedly carried by a T-bolt which is slidable along the groove **144, 145**, or **146** in which it is located, and after the element **141** is located at a selected location by the operator it is simply tightened on the bolt so as to be fixed in this way in the selected angular position on the disc **140**. One possible arrangement of a plurality of the switch-actuating members **141** is illustrated in FIG. 7, and they are identifiable by Roman numerals for reference purposes in connection with the operation, as will be apparent from the description below. The several switches **75–77** are located respectively at the same radial distances from the axis of the shaft **142** as the several circular grooves **144–146**, respectively, so that in this way the elements **141** which are arranged along the groove **144** will actuate the switch **75**, the elements **141** which are arranged along the groove **145** will actuate the switch **76**, and the element **141** arranged along the groove **146** will actuate the switch **77**.

The manner in which a machine tool may be operated through a typical cycle of operations with the structure of the invention is apparent from FIG. 7. Inasmuch as the turret **25** carries six tools, there will be six operations performed on each workpiece **32** in order to complete a cycle of operations. The gear **88** and the disc **140** therewith will turn through one revolution in order to complete the six operations of a given cycle. Each of these operations will therefore extend through 60°, and in FIG. 7 is shown the several angular distances **150*a*–150*f*** through which the actuating means **50** turns in order to carry out a complete revolution during six operations each of which takes place during one of these angular distances of 60°. The first operation takes place during turning of the actuating means **50** in the direction of the arrow **89** of FIG. 7 through the angular distance **150*a***. The switch-actuating member I on the horizontal center line to the left of the center of the actuating means shown in FIG. 7 has just engaged the switch **75** so as to close the circuit of the solenoid which will turn the valve **66** through 180° from the position thereof shown in FIG. 17, so that the fluid under pressure will now flow along the conduit **35** shown in FIG. 1 to the left side of the piston in the cylinder of the carriage **24** and thus advance this carriage to the left away from its rest position shown in FIG. 1. In accordance with the particular operation to be performed by the first tool the switch-actuating member II shown in the sector **150*a*** in FIG. 7 will be located at a predetermined angular distance from the switch-actuating member I of the sector **150*a***, and when the switch-actuating member II reaches the switch **75** this switch will again be closed so that the valve **66** will again be turned through 180° and will thus again have the position shown in FIG. 17 where the fluid under pressure now flows along the conduit **36** to the right side of the piston in the carriage **24** and thus the carriage **24** will now automatically be returned to its rest position. The switch-actuating member II for any given operation will always be angularly spaced from the switch-actuating member I by less than 30°, which is to say be less than one half of the angular distance through which the actuating means **50** is required to turn during one operation, so that when the carriage **24** returns to its rest position the next switch-actuating member for the next following operation has not yet reached the switch **75**. However, the return of the carriage **24** to its rest position releases the one-revolution clutch structure described above so that the one-way drive **130** will now be actuated so as to complete the turning of the gear **88** and the actuating means **50** therewith through whatever remaining angle is required to bring the switch-actuating member I of the next operation **150*b*** up to the switch **75**, and in this way even though each of the operations requires movement of the carriage **24** through haphazard distance nevertheless the switch-actuating members I which initiates the several operations are located at equal angular distances from each other. The second operation **150*b*** may, for example, require less movement of the carriage **24** away from its rest position, and it will be noted that the switch-actuating member II of the second operation **150*b*** is located closer to the switch-actuating member I thereof than was the case with the first operation **150*a***. Thus, when the carriage returns to its rest position at the end of the second operation the actuating means **50** will have turned through a lesser angle than was the case with the first operation, but here again the structure shown in FIGS. 13–16 will complete the turning of the switch-actuating means **50** through the angle required to locate the next following switch-actuating member I of the next operation **150*c*** in engagement with the switch **75** so as to actuate the latter. In this way the carriage **24** will be automatically moved back and forth and the several switch-actuating members I which initiate the several operations are all located at equal angular distances from each other.

It is precisely in this latter feature that a particular advantage of the present invention resides. Because the several switch-actuating members I can be located at equal angular distances with respect to each other, if it is necessary to make an adjustment in any one of the several operations, only this one operation need be adjusted and the remaining operations can remain in their already adjusted positions. For example, if it should be found that the carriage should move further away from its rest position during the second operation shown in the angle **150*b*** of FIG. 7, then the operator need only move the switch-actuating member II of the sector **150*b*** to a greater angular distance away from the switch-actuating members I thereof, which would be in a counterclockwise direction, as viewed in FIG. 7, and it will be noted that this adjustment can be made without in any way influencing the remaining adjustments for the remaining operations. Of course, if all of the switch-actuating members were arranged one right after the other so that the space between any pair of successive switch-actuating members I were exactly divided in half by the alternate switch-actuating members II shown in FIG. 7, then of course if any one of the members II had to be adjusted it would be necessary to carry out adjustments of all of the succeeding switch-actuating members. However, with the structure of the invention such a train of adjustments is never required since it is possible to adjust any one single operation independently of all of the others as a result of the feature of the structure shown in FIGS. 13–16 according to which the structure of the invention brings the actuating means **50** at all times to

predetermined starting positions for each of the operations.

The operations will continue in the above-described manner through the fifth operation 150*e* indicated in FIG. 7. When the sixth and final operation 150*f* takes place, then additional switch-actuating members III—V cooperate with the switches 76 and 77. Thus, it will be seen that before the switch-actuating member II of the last operation 150*f* reaches the switch 75, a switch-actuating member III will have actuated the switch 76. This will result, in the manner described above, in turning of the valve 67 shown in FIG. 17 through 180° so that the fluid under pressure is now delivered through the conduit 38 to the lower side of the piston in the carriage 27 and thus the carriage 27 is lowered so that the cut-off tool 48 will approach and engage the workpiece 32 so as to sever it from the bar 34. Before the cut-off operation is completed the switch-actuating member II of the last operation 150*f* reaches the switch 75 so that the valve 66 is again turned and the hydraulic structure automatically returns the carriage 24 to its rest position, and the cutting-off operations continue thereafter until the switch-actuating member IV engages the switch 76 so as to return the valve 67 to the position shown in FIG. 17 where the fluid under pressure will flow along the conduit 37 to the upper side of the piston in the carriage 27 so as to raise the latter away from the axis of the bar 34. Thus, it will be seen that according to the arrangement of the switch-actuating members I—IV of the last operation 150*f* shown in FIG. 7, the downward movement of the cutting-off tool 48 will have been initiated just before the carriage reaches the end of its movement away from its rest position, and during the return of the carriage 24 toward its rest position the return of the cutting-off tool to its rest position is commenced. After the switch-actuating member IV has closed and moved beyond the switch 76 so that the latter again immediately opens, as was described above in connection with FIG. 18, the switch-actuating member V will close the switch 77 so that the valve 68 of FIG. 17 will now be turned through 180° and the fluid under pressure will now flow through the conduit 39 to the left side of the piston in the carriage 49 and thus advance the carriage 49 to the left, as viewed in FIG. 1, so that the work-advancing assembly 41 shifts to the left along the work 34 which does not move axially at this time. When the carriage 49 reaches the end of its movement to the left, as viewed in FIG. 1, it will close the switch 53 which will thus again cause the turning of the valve 68 back to the position shown in FIG. 17 so that the fluid under pressure now flows along the conduit 40 to the right side of the piston which is in the carriage 49 so as to advance the carriage 49 to the right, as viewed in FIG. 1, and thus the work-advancing unit 41 will now grip the bar 34 and advance the latter to the right, as viewed in FIG. 1, so as to locate the next workpiece in position, and immediately upon location of the next workpiece in position the switch-actuating member I of the first operation 150*a* again reaches the position indicated in FIG. 7 so that the cycle of operations is now repeated on the next workpiece.

Thus, it will be seen that with the structure of the invention not only is an exceedingly simple, adjustable actuating means provided making it feasible to work on jobs each of which includes only a small number of workpieces, but in addition the adjustability can be carried out in such a way that when any one operation is adjusted it is not necessary to make adjustments for the remaining operations, so that the adjustment for any one operation can be carried out in an extremely simple quick manner without disturbing the remaining operations because of the feature of bringing the actuating means at all times to predetermined starting positions for the several operations, respectively.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of machine tools differing from the types described above.

While the invention has been illustrated and described as embodied in automatic machine tools, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a machine tool capable of automatically performing a series of operations on a workpiece, in combination, carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position; actuating means for actuating at least part of the controls of the machine tool, said actuating means being movable along a given path and having along said path a plurality of equidistantly spaced starting positions respectively corresponding to the location of said carriage means in said rest position thereof at the beginning of each of the series of operations; transmission means transmitting movement of said carriage means to said actuating means in the same direction from each of said starting positions thereof toward the next following starting position during movement of the carriage means away from and back to its rest position, said actuating means being spaced at the end of each operation at a haphazard distance from the next following starting position depending upon the particular operation; and moving means cooperating with said actuating means for moving the latter at the end of each operation through the remaining distance up to the next following starting position irrespective of the size of said remaining distance.

2. In a machine tool capable of automatically performing a series of operations on a workpiece, in combination, carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position; actuating means for actuating at least part of the controls of the machine tool, said actuating means being movable along a given path and having along said path a plurality of equidistantly spaced starting positions respectively corresponding to the location of said carriage means in said rest position thereof at the beginning of each of the series of operations; and transmisison means transmitting movement of said carriage means to said actuating means in the same direction from each of said starting positions thereof toward the next following starting position during movement of said carriage means away from and back to its rest position.

3. In a machine tool capable of automatically performing a series of operations on a workpiece, in combination, carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position; rotary actuating means for actuating at least part of the controls of the machine tool, said rotary actuating means being turnable about a given axis and having a plurality of starting positions spaced from each other by equal angular distances about said axis and respectively corresponding to the location of said carriage means in said rest position thereof at the beginning of each of the series of operations; transmission means transmitting movement of said carriage means

to said actuating means for turning the latter in the same direction about said axis from each of said starting positions thereof toward the next following starting position during movement of said carriage means away from and back to its rest position, said actuating means being spaced at the end of each operation at a haphazard angular distance from the next following starting position depending upon the particular operation; and moving means cooperating with said actuating means for turning the latter at the end of each operating position through the remaining angular distance up to the next following starting position irrespective of the size of said remaining angular distance.

4. In a machine tool capable of automatically performing a series of operations on a workpiece, in combination, carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position; rotary actuating means for actuating at least part of the controls of the machine tool, said rotary actuating means being turnable about a given axis and having a plurality of starting positions spaced from each other by equal angular distances about said axis and respectively corresponding to the location of said carriage means in said rest position thereof at the beginning of each of the series of operations; transmission means transmitting movement of said carriage means to said actuating means for turning the latter in the same direction about said axis from each of said starting positions thereof toward the next following starting position during movement of said carriage means away from and back to its rest position, said actuating means being spaced at the end of each operation at a haphazard angular distance from the next following starting position depending upon the particular operation, the angular distance from each starting position of said actuating means to the next following starting position being equal to 360° divided by the number of operations which constitute said series of operations; and moving means cooperating with said actuating means for turning the latter at the end of each operating position through the remaining angular distance up to the next following starting position irrespective of the size of said remaining angular distance.

5. In a machine tool as recited in claim 3, said transmission means including a rack fixed to said carriage means for movement therewith, a first gear meshing with said rack, a second gear fixed to said actuating means coaxially therewith, first one-way drive means cooperating with said first and second gears for turning the latter and said actuating means therewith in one direction when said carriage moves in one direction, and second one-way drive means cooperating with said first and second gears for turning the latter and said actuating means therewith also in said one direction when said carriage means moves in an opposite direction.

6. In a machine tool capable of automatically performing a series of operations on a workpiece, in combination, carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position; rotary actuating means for actuating at least part of the controls of the machine tool, said rotary actuating means being turnable about a given axis and having a plurality of starting positions equidistantly spaced from each other about said axis and respectively corresponding to the location of said carriage means in said rest position thereof at the beginning of each of the series of operations; transmission means transmitting movement of said carriage means to said actuating means for turning the latter in the same direction angularly from each of said starting positions thereof toward the next following starting position during movement of said carriage means away from and back to its rest position, said actuating means being spaced at the end of each operation at a haphazard angular distance from the next following starting position depending upon the particular operation; clutch means turnable through a single revolution for moving said actuating means from one starting position to the next following starting position, said clutch means including a driven clutch member cooperating with said actuating means to be turned by the latter and a driving clutch member turnable through a complete revolution and while turning through said complete revolution engaging said driven clutch member and turning the latter through the remaining part of the complete revolution to locate the actuating means in the next following starting position; and means cooperating with said driving clutch member for rotating the latter through a complete revolution at the end of each operation.

7. In a machine tool capable of automatically performing a series of operations on a workpiece, in combination, carriage means adapted to carry a plurality of tools used in performing the series of operations, respectively, and movable during each operation away from and back to a rest position; rotary actuating means for actuating at least part of the controls of the machine tool, said rotary actuating means being turnable about a given axis and having a plurality of starting positions equidistantly spaced from each other about said axis and respectively corresponding to the location of said carriage means in said rest position thereof at the beginning of each of the series of operations; transmission means transmitting movement of said carriage means to said actuating means for turning the latter in the same direction angularly from each of said starting positions thereof toward the next following starting position during movement of said carriage means away from and back to its rest position, said actuating means being spaced at the end of each operation at a haphazard angular distance from the next following starting position depending upon the particular operation; clutch means turnable through a single revolution for moving said actuating means from one starting position to the next following starting position, said clutch means including a driven clutch member cooperating with said actuating means to be turned by the latter and a driving clutch member turnable through a complete revolution and while turning through said complete revolution engaging said driven clutch member and turning the latter through the remaining part of the complete revolution to locate the actuating means in the next following starting position; and means cooperating with said driving clutch member for rotating the latter through a complete revolution at the end of each operation, said means cooperating with said driving clutch member being part of the drive of the machine tool itself and including a clutch for interconnecting the drive of the machine tool with said driving clutch member.

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