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(54) METHOD AND APPARATUS FOR THE PRODUCTION OF MACHINED WORKPIECES ON MULTI-STATION MACHINES TOOLS

(71) We, EUGEN BADER, a German national, of 14 Saline, Rottweil, Germany do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The invention relates to a method for the production of workpieces machined on the peripheral surface on multi-station machine tools, wherein rod stock is introduced into a clamping device of the machine tool and held fast, a rod section being cut off at a distance from the clamping device, and the free end protruding from the clamping device machined.

The invention further relates to a multi-station machine tool for carrying out the method, having a turret or turntable which is stepwise indexable, a plurality of clamping devices mounted at circumferential intervals on the turntable, for clamping rod stock from which the machined workpieces are to be produced, a charging or loading station, a plurality of working stations distributed around the periphery of the turntable, to which the rod stock clamped fast in the clamping devices can be brought in sequence by the movement of the turret, and a cutter device at the loading station for the rod stock.

On such automatic machines a rod section is cut off and clamped fast in the clamping device, the length of which section corresponds to the length of the desired workpiece. The clamping devices as a rule are firmly connected with the turret so that as a rule work is carried out on automatic machines with the workpiece stationary and turning tools in rotation. Ordinarily the turret is arranged horizontally and the clamping devices are directed radially so that there is sufficient space for the arrangement of the machining units around the turret. However machines are also known (German Published Specification No. 21 02 150) where the turret can move about a horizontal axis of rotation and the clamping devices are orientated axially in relation to this axis of rotation.

One advantage of the method for the production of turned parts on these machines consists in that according to choice it is possible to work rod stock or so-called ring stock (coiled rod or wire material) as the starting material.

It is disadvantageous that on the known machines a turning operation on workpieces is possible only on the parts which protrude from the clamping device. At the clamping portion itself no turning work can be executed. Thus the production of workpieces on such machines is limited as a rule to those parts where the whole peripheral surface does not have to be machined, that is to those parts where there is still a sufficiently large zone left free for clamping. In order to overcome this disadvantage, machines have been constructed in small numbers where the workpiece is firstly turned at one end, then taken out of the clamping device and clamped afresh in a new clamp adapted to the turned diameter, and turned further. This method has the disadvantage that considerable extra expense is necessary for the clamping devices and the workpiece reversing device. Moreover a station is occupied for reversing which otherwise could be used for machining. Furthermore it is disadvantageous that the central axis of the first clamp is practically always offset in relation to the central axis of the second clamp. Moreover with this method the workpieces must often be clamped by such small surfaces that there is danger of the material being distorted by compression at the clamped surface, especially if heaving material removal takes place in the second clamped position. This leads to corresponding waste.

Workpieces which are to be turned over the whole circumference in one clamped position can hitherto be produced only on single-spindle and multi-spindle automatic rod machines. As known, these rotate the workpiece. The rod stock is loaded into the spindle drum and advanced by sections through the clamping device in each case, especially a pair of clamping jaws, of the spindle drum so far that it protrudes with its

free end by at least one feed length, corresponding to the final workpiece length plus the width of the severing or parting off tool, from the clamping device. At this free end the clamped-fast rod stock is machined to the desired shape. The feed of the rod stock is carried out in various ways. In some cases the rod is grasped on the peripheral surface at the rear end by a retaining gripper and pushed by sections through the clamping jaws, the ejection of the remainder piece taking place to the rear through the retaining gripper. Otherwise a feed gripper is arranged before the clamping gripper of the spindle drum. The rod stock is pushed with a push rod through this feed gripper and the clamping gripper, and the feed gripper takes over the further feed movement of the rod by sections. The rod remainder is expelled forward, namely by the next succeeding new rod. In the case of both types of construction the finished workpiece is cut from the rod stock by means of a cutting tool. In the case of the single spindle automatic machine only one workpiece is produced during each machine cycle, the tools coming into operation in succession. In automatic multi-spindle machines several tools on several spindles are in action at the same time, which is economical in the case of high production figures.

However the single and multi-spindle automatic machines have the following disadvantages in comparison with the automatic turret machines:–

Expensive spindle halting if operations other than turning are to be executed, for example milling, transverse drilling, transverse thread cutting, riveting, crimping, fitting. These operations can be carried out only with the spindle stationary;

Expensive equipment, if work has to be carried out on the workpiece in several directions;

Noise nuisance resulting from rotation of the material in guides, especially with long lengths of material having a large diameter;

In the case of automatic multi-spindle machines, very expensive rod-loading devices, if these work fully automatically; and

In the case of automatic multi-spindle machines with spindles aligned axially of the axis of rotation of the spindle drum, only a narrow tool space is available, so that tool changing and adjustment are correspondingly difficult.

The invention is based upon the problem of providing a method and an apparatus of the initially mentioned kind so that rod pieces machined on their entire peripheral surface can be produced on multi-station turret machines in one single clamping action. Thus the essential advantage of the automatic multi-spindle machines as regards machining possible over the whole length of the workpiece is to be achieved, but while retaining the essential advantages of the turret machines, namely the possibilities:–

of carrying out the whole of the machining with the workpiece stationary, so that all the connected advantages such as simple execution of machining surfaces eccentric to the workpiece axis, lower noise nuisance, simpler rod loading devices, are obtained,

in the case of clamping devices aligned radially of the axis of rotation of the turret, of being able to arrange the machining stations more favourably in the radial direction,

of being able to machine coiled stock material.

According to the invention there is provided a method for the production of machined workpieces from rod stock on multi-station machines having at least one loading station and a plurality of subsequent working stations spaced around the periphery of a turntable on which are mounted a corresponding plurality of spaced clamping devices, and a machining unit at each of the working stations, said method comprising the steps of feeding a section of rod stock comprising a multiple of desired machining lengths plus a residual clamping section into a clamping device at said loading station, clamping said section of rod stock at the loading station, severing at the loading station the clamped section from the remainder of the rod stock at a distance from the clamping device corresponding to one machining length so that a length corresponding to a machining length protrudes beyond the clamping device at the loading station, indexing said turntable in successive steps through one revolution and machining the protruding section at said working stations, including severing the machined section at a working station, unclamping and moving the remainder of said section at one station so that a length corresponding to a machining length protrudes beyond the clamping device at said one station, reclamping the remainder of said section at said one station, repeating said steps during further indexing of the turntable until only said residual clamping section remains in the clamping device at a working station, and finally unclamping and moving said clamping section out of the clamping device at this working station.

Further according to the invention we provide a multi-station machine for the production of machined workpieces from rod stock, comprising a turntable having a axis and being indexable about this axis between a plurality of stations circumferentially displaced about said turntable and including a loading station and a plurality of working stations, a plurality of clamping devices

mounted circumferentially spaced from each other on said turntable, one per station, and respectively aligned therewith after each indexing of said turntable, means for opening and closing the clamping device which after indexing of the turntable is at said loading station, means for feeding rod stock into the clamping device at said loading station while the clamping device at said loading station is open, severing means at the loading station for severing a rod section from said rod stock, while the clamping device at said loading station is closed, so that a desired machining length protrudes radially outwardly from said clamping device at said loading station, a plurality of radially inwardly directed guide means on said turntable, one for each of said clamping devices, for guiding the severed rod section, a plurality of machining units respectively arranged at said work stations for machining the machining length protruding outwardly from the respective clamping device, said machining units including an additional severing device for severing a machined workpiece from said rod section at a station preceding said loading station, and means at one of said stations following said station with said additional severing device for moving the remainder of said rod section in radially outward direction so that a machining length protrudes again from the clamping device of said following station.

Furthermore by the use of this method further advantages over those referred to above are achieved which make the production of machined parts on machines still more attractive. These advantages are for example the possibility to provide a greater number of machining stations, without detriment to the accessibility of the tool space, that is to say the division of the operations can be made still more effective than in the case of the multi-spindle machine.

The economical use of material is suprisingly increased. While in the known automatic single and multi-sprindle machines the remainder piece must be at least of the length of the clamping zones of the clamping gripper and the retaining gripper of the rod loader or of the clamping gripper and feed gripper or the length of all three grippers, the remainder pieces according to the method in accordance with the invention are as a whole surprisingly small, since the remainder piece of each section needs to be only so long that it suffices for the clamping of one individual machining length section (the last). It is essential here that on automatic machines the severing of the stationary workpiece can take place with a saw blade which can be substantially thinner than the width of the cutting tool used in known automatic multi-spindle machines, for the cutting tool for reasons of strength cannot be made as narrow as a saw blade. With the present invention a rod having a total length for example of 3-4 m may be cut (according to the size and nature of the turret machine) for example into 5-20 pieces of approximately 200-800 mm. It could be assumed that in the case of 5-20 pieces, of which one remaining piece is left over in each case, being necessary for the clamping of the last worked piece, as a whole a higher proportion of remainder pieces occurs than in the case of the single or multi-spindle automatic machine. However that is not the case, since in the manner as explained for cutting away with a cutting tool more material is cut than in the case of cutting with a saw blade. As a rule the saw blade can be made about half as wide as the cutting tool. In the case of the tool width of 2 mm accordingly the saw blade can be 1 mm in width, that is if 15 workpieces are manufactured from a rod section, then for the clamping of the last machine length 14 mm are available as clamping length, without less parts being produced from this rod piece than in the case of manufacture of the same part on an automatic multi-spindle machine with cutting off by a cutting tool. In the present invention the short remaining pieces are integral pieces, so that for example in the case of expensive non-ferrous metal a higher material re-sale price can be obtained than in the case of metal swarf resulting from machining.

It is possible to introduce the rod stock – as in the multi-spindle machine – into the clamping device from the side opposite to the working side. In further development of the invention however the rod stock is pushed into the clamping device of the turret from the working side, radially inward in the case of clamping devices directed radially of the axis of the turret, and the cut-off section is moved out of the clamping device by sections according to the respective machining length in the opposite direction, i.e. radially outward in the case of clamping devices directed radially of the axis of rotation of the turret.

Further details and advantages of the invention appear from the following description of examples of embodiment as represented diagrammatically in the accompanying drawings, in which:

Figure 1 shows a plan view of an automatic machine according to the invention,

Figure 2 shows a partial elevation in the direction of the arrow II in Figure 1,

Figure 3 shows a lateral elevation, partially in section along the line III-III in Figure 1,

Figure 4 shows a vertical partial section along the line IV-IV in Figure 1,

Figure 5 shows a vertical partial section along the line V-V in Figure 1,

Figures 5*a-f* show in diagrammatic representation the working operations at the various stations, namely in lateral elevation in the direction of the arrows V*a-f* in Figure 5,

Figure 6 shows a modified clamping device in vertical section analogous to the sectional plane according to Figure 3,

Figure 7 shows a modified conveyor device for the rod section,

Figure 8 shows the head of this conveyor device in enlarged representation, partially in section, together with adjoining parts of the machine,

Figures 9*a-c* show in diagrammatic representation analogously with Figures 5*a-f* a further type of embodiment of the clamping device in each case, namely in Figures 9*b* and *c* with tool reverser and,

Figure 10 shows a partial elevation in the direction of the arrow X in Figure 9*c*.

The machine as illustrated has a turret 1 stepwise indexable about a vertical rotation axis 1*a*, around which there are arranged uniformly spaced from each other in the circumferential direction a charging or loading station S*t*1 and a plurality of machining or working stations S*t*2-S*t*6 each with machining unit 2-6. According to the number of the stations the turret 1 has six clamping devices 7-12 distributed uniformly in the circumferential direction for rod stock from which the workpieces are to be produced. The rod stock clamped fast in the respective clamping device 7-12 is indexed to the individual stations S*t*1-S*t*6 by the turret movement.

At the charging station S*t*1 a rod loader 13 is arranged which conveys the rod stock W into the respective clamping devices 7-12 of the turret 1. This loader has a drive device 14 with a plunger 15 which presses upon the rear end of the respective rod W. Through a lug 16 the plunger 15 is connected with a drive chain 17 the drive 18 of which is merely diagrammatically indicated. The rod loader has guides 19 for the rod stock W.

With each clamping device 7-12 on the side remote from the machining units 2-6 there is associated a radially extending guide 20 in the form of a semi-circular channel of such length that it is suitable as guide for a rod stock section 21-26 comprising a portion which is a multiple of the machining length and a clamping portion. The guides 20 extend radially of the turret rotation axis 1*a* and end close to this axis. On this rotation axis there is arranged a replaceable stop piece 27 common to all the guides. Beneath the turret 1 at the charging station S*t*1 there is a drive apparatus 28 for actuating the respective clamping device 7-12 in known manner.

Moreover at the charging station S*t*1 there is a vertically raisable stop 29 which is actuated by a piston drive (shown schematically) and cooperates through a lug 30 projecting laterally from the stop 29 with a limit switch or feeler 31.

At the charging station S*t*1 there is further arranged a conveyor device 32 by which the rod section 21-26 can be moved by amounts corresponding to the machining length in each case out of the respective clamping device 7-12. This conveyor device 32 is a drive device having a cylinder 33, a piston 34 axially movable therein with piston rod 35 on the outer end of which there is a drive lug 36 which acts upon the rod multiple section 21-26 at the end face remote from the machining side, that is radially from the interior outwards. On the lug 36 there is located a limit switch 37 which together with two further limit switches or feelers 38, 39 controls the movements of the conveyor device 32 in the manner described below. For this purpose the feelers 37, 38, 39 are connected to a control device 40 which, on the one hand, is in control connection 41 with a compressed air source 42 connected through conduits 43 and 44 with the cylinder 33 of the conveyor device 32, and on the other hand, is in control connection 45 with a control device 46 which is connected through a lead 47 with a limit switch 48 cooperating with the lug 16 of the drive device 14 of the rod loader 13 and controls the drive 18 of the road loader 13 through a lead 49.

Furthermore at the charging station S*t*1 there is arranged a saw 50 with saw blade 51. This saw 50 is movable transversely of the rod stock W in the direction of the arrow 52*a* (Figure 4) by a cylinder/piston drive system 52.

At the last machining station S*t*6 a second severing device 53 with a saw blade 54 is arranged by which the machined workpiece can be severed from the remainder of the rod multiple section 21-26 in each case clamped fast in the respective clamping device 12.

The clamping devices 7-12 clamp the respective rod sections 21-26 by means of two jaws 55, 56 (Figure 5) which work centrally against one another in the direction of the arrows 57. The material W′ protruding forwards out of the clamping device 7-12 corresponds to the workpiece length except for the width of the subsequent saw cut and a small tolerance, and can be machined freely in stages at the stations S*t*2-S*t*6.

In departure from known machines, where at the station S*t*1 the rod stock W is advanced by one workpiece length, clamped and severed, the method according to the invention works in a manner in which a longer section 21 of the rod stock W is advanced at the charging station S*t*1 almost to the centre of the turret, to the stop piece

27, and then clamped by the clamping device 7. From this rod stock piece 21, that is the piece cut off by the saw blade 5' from the rod stock W, as many final workpieces can be produced as there are workpiece lengths plus saw cut widths in the entire rod length of the piece 21 – plus a remainder clamping piece. This remainder clamping piece has a length sufficient for the clamping of the final machining length section.

The stop piece 27 is exchangeable and dimensioned so that the remainder clamping piece becomes smaller than one machining length section, so that after the finishing of the last complete workpiece on renewed advance by the lug 36 it can drop down between the stop 29 and the clamping device 7. The stop piece 27 is changed according to the workpiece length.

To explain the operations it is assumed that the clamping devices 7, 8, 9, 10, 11 and 12 are empty. It is also assumed that the clamping devices 7-12 always move from one station to the next, for example in Figure 1 the clamping device 8 moves between stations St2 and St3. The supply conduit 44 to the cylinder 33 of the conveyor device 32 is fed with compressed air. The engaging lug 36 is thus at its maximum extended position, close to the rotation axis 1*a* of the turret 1. On the starting of the machine the turret 1 rotates into the position shown in Figure 1 and is locked in a known manner. Directly after the locking the stop 29 is driven upwards in the direction of the arrow 29*a*. In the upper position the switch 31 cooperating with the lug 30 gives a control pulse for the opening of the clamping device 7 and pressure charging of the supply conduit 43 of the cylinder 33. The lug 36 which is firmly connected with the piston rod 35 moves in the direction of the arrow 35*a* towards its retracted position 36' shown in dot-and-dash lines in Figure 3. If the lug 36 can arrive at all in this position, this signifies that the clamping device 7 is empty, for the short remainder piece remaining in the clamp drops down between the clamping device 7 and the stop 29 on advance of the lug 36. Then a feed movement is initiated in the rod loader 13 through the feeler 39. The stop 29 is retracted to allow the entry of the rod stock. The rod stock W is pushed through the guides 19 until it strikes upon the central stop piece 27. The lug 36 is in this case pushed again into its extended radially inner position by the rod stock. The conduits 43, 44 are rendered pressureless simultaneously with the loading operation of the rod loader 13, so that the piston rod 34 is not loaded at either side and the lug 36 can be entrained without resistance. After the lug 36 reaches the feeler 38 the latter gives a control pulse for a feed control, for example to the cylinder/piston drive system 52 of the saw 50, and to the clamping device 7 which initially is located at the station St1. By this control device the clamping device is closed and the stop 29 is driven back into the lower position represented in Figure 3, so that the saw blade 51 can sever the rod stock W. After the severing operation and the return of the saw 50, the latter initiates a control pulse by engaging a limit switch (not shown) for the further indexing of the turret 1 in the direction of the arrow 1*b*, so that the next clamping device can be loaded with rod stock W so that all six clamping devices are loaded in sequence.

After the loading of the first rod 21, sawing off and further indexing of the turret 1, the first machining can be commenced at the station St2 with the unit 2. If one of the machining operations on station St2-St6 lasts longer than the loading and sawing off, then further indexing is effected by an interlocking circuit of known construction only when the unit last having completed its machining initiates the further indexing step, with an appropriate pulse. Thus both pulses must be present before a turret step can take place. In order to avoid impacts, the piston 34 of the conveyor device 32 is provided with known damping means in its forward and rear positions.

The procedure was described above for absence of rod pieces 21-26. If however a rod piece is present, the lug 36 on its way from the radially inner position to the radially outer position 36' strikes the end of the rod piece at some point and pushes the latter, with clamping device at station St1 opened, against the stop 29 situated in the upper position, so that at the following stations the rod zone W' advanced afresh can be machined. So that the lug 36 does not strike at full speed upon the rod piece, the latter is detected with the leading feeler 37 connected firmly with the lug 36. By changing over a corresponding valve the return speed of the piston 34 is reduced so that the rod section W' is pressed lightly upon the stop 29 and can be clamped in the clamping device 7 by means of the clamping drive apparatus 28. During all these operations the channel 20 supports the respective rod piece 21-26.

The feed control of the machining units 2, 3, 4, 5 and 6 is actuated in known manner after each indexing step, irrespective of whether a loading operation takes place simultaneously with the individual working operations or not. In order to prevent the feeler 38 from giving the pulse for clamping and sawing to the station St1 on every advance of the lug 36, the pulse is processed further only if a pulse from the feeler 39 has preceded.

The two cycles, in the one case machining with charging operation and in the other

machining alone – can proceed at two different times. As a rule the charging operation and the sawing off of the rod pieces will last longer than the machining, so that according to how many workpieces can be produced from a rod piece, a larger number of short operations can be followed by six longer operations.

Since it is not guaranteed that the rods fed by the rod loader are of equal length, it must be expected that on the one or the other occasion a shorter rod piece will remain over. This would then in fact strike upon the central stop piece 27, but would no longer be grasped by the clamping device at station *St*1. In order to avoid this, in the position of the plunger 15 with lug 16 as illustrated in Figure 3 a pulse is instigated by the feeler 48 which instantaneously stops the feed drive of the plunger 15 by means of the drive chain 17. The stop position of the plunger 15 is selected so that this residual rod stock W remains stationary about 3 mm before the saw blade 51, so that only these 3 mm are severed.

In Figures 5*a-f* the production steps at the individual stations of the turret are shown:–

Station *St*1: Open clamping device 7, advance material W′ in direction of arrow to stop 29;

Station *St*2: Machine externally;

Station *St*3: Knurling;

Station *St*4: Drilling;

Station *St*5: Machine internally;

Station *St*6: Sawing off by means of the saw blade 54 of the severing device 53.

In the case of workpieces which require a smaller number of machining operations, during indexing of the turret through 360° two workpieces or even two or three different workpieces, if the material diameter is the same, can be produced at the same time. Only a second or third conveyor device 32, but without rod loader 13, is necessary, for example at the position 32*a* in Figure 1. In the case of a 10-station machine for example three different workpieces can be produced as follows:–

Station 1: Load	first workpiece
Station 2: Shape	
Station 3: Drill, saw off	
Station 4: Re-clamp material	second workpiece
Station 5: Shape	
Station 6: Cut thread	
Station 7: Drill, saw off	
Station 8: Re-clamp material	third workpiece
Station 9: Shape	
Station 10: Saw off	

In the modified embodiment according to Figure 6 the respective clamping device 7-12 for the respective rod piece 21-26 is formed as collet clamping device 7*a*. Such a clamping device in each case has a collet 59 which is actuated by means of a piston 60 and a thrust piece 61. In the case of this collet clamping the material cannot be advanced from the rear with the lug 36 in the manner as shown in Figures 1-3, but must be drawn from the front out of the collet 59 with the apparatus 62 as illustrated in Figures 7 and 8. The extraction takes place at the charging station *St*1. The finished workpiece is cut off by means of the saw blade 54 one station ahead of station *St*1. The gripping apparatus 62 makes an advancing movement towards the device 7*a* once every rotation of the turret. The gripper fingers 63, 64 are closed by the piston 65 so that the rod residue protruding from the collet 59 is grasped. By the rearward movement of the gripper 62 by one workpiece length plus severing tool width the material is entrained with the collet opened. After clamping by the collet and opening of the gripper fingers 63, 64 the turret 1 can index one step further. When the rod piece is completely consumed and the remaining clamping piece has dropped away downwards, the gripper fingers 63, 64 at the next step can carry out a greater travel, so that then by means of a lug 66 connected with the piston will pass a feeler 67 whereby a control pulse is given to the rod loader 13 for the loading of a new rod piece. For this purpose the feeler 67 is in control connection through a lead 68 with the drive 18 of the rod loader 13 (analogous with the control connection 48 in Figure 3). In the case of this embodiment according to Figures 6-8 a full tube 20*a* instead of a semi-circular channel can be used as guide 20 for the respective rod section 21-26, as shown in dot-and-dash lines in Figure 6.

At the charging station then the charging operation takes place analogously as described with reference to Figures 1-3: the rod stock W is pushed through the apparatus 62 forward into the collet 59 until it strikes upon the central stop piece 27 of the turret. Then the saw 50 is actuated by a control pulse, so that the material can be severed with the saw blade 51.

The present invention can be adapted to machine workpieces at both ends. This cannot be carried out in one operation on known single-spindle or multi-spindle automatic machines where the second machining operation is carried out on another machine. In a further development of the present invention the machine workpiece is grasped during severing from the clamped remaining portion of the rod section, reversed after severing, introduced into a second clamping device on the turret, clamped fast there and worked further on the previously severed end face, while the remainder in each case of the rod multiple section remains in the respective first clamping device of the turret. With slight extra

expense in the formation of the clamping device and with a tool reverser of ordinary construction type it thus becomes possible to carry out finishing work from the second end in the same passage.

For carrying out this further developed method there serves the modified embodiment according to Figures 9*a-c* and Figure 10. For functionally similar parts the same references are used here. The respective clamping device 7-12 for the respective rod piece 21-26 is provided with a second clamping device 69 and with the severing device with the saw blade 54 for the machined workpiece W" there is associated a reversing device 70 by which the workpiece can be grasped before severing from the clamped-fast respective residue of the rod multiple section 21-26, reversed after severing and introduced into the position W ''' in the second clamping device 69 in each case.

The second clamping device 69 is arranged parallel above the respective first clamping device 7-12 and has common clamping jaws 71, 72 therewith having clamping profiles 73 for the rod multiple section 21-26 and clamping profiles 74 for the reversed workpiece W'''. The clamping profiles 73, 74 are in each case prismatic. The lower clamping profile 73 for the rod multiple section 21-26 is larger than the upper clamping profile 74 for the reversed workpiece W''', so that during the clamping fast of this reversed workpiece it holds the respective residue of the rod section 21-26 only loosely.

The reversing device 70 consists in principle of a shaft 76 which is rotatable about a horizontal axis 75 and displaceable to and fro in the direction of the arrow 75*a*, with a crank arm 77 which has at a radial distance from the rotation axis 75 an extension 78 extending parallel with the axis 75. At its free end a gripper 79 is arranged radially inwards towards the rotation axis 75 and is rotatable in the direction of the arrow 80*a* about an axis 80 at right angles to the axis 75. Mechanical drive means or energy supply leads can extend within the parts 76, 77 and 78.

During the severing with the saw blade 54 (Figure 9*a*) the workpiece W" is already gripped by the gripper 79 (Figure 9*b*), immediately after sawing through it is reversed through 180° about the vertical axis 80 and at the same time brought into the upper second clamping device 69 by a rotation through 180° about the horizontal axis 75. Then the clamping jaws 71, 72 are closed so that the workpiece is clamped fast in the position W''' in the upper clamping device 69. The gripper 79 can then be brought back again into the initial position.

During the machining of the workpiece W''' reversed through 180° and clamped in the upper clamping device 69, the rod multiple section 21-26 is entrained lying in the lower clamping device 7-12 and the guide 20, loosely, that is unclamped. Only when the second end face machining is terminated, that is the upwardly situated workpiece W''' is ejected, is the rod piece 21-26 advanced again for fresh machining.

Workpieces, of which the severing and the transference from the lower to the upper clamping device would incur too long a time in comparison with other operations, can be pre-sawn except for about one-fifth of the diameter to be severed, one station prior to transference.

The second clamping device 69 has such a length L in the radial direction that the workpiece W''' can be received and clamped substantially by its whole length therein. Machining over the whole length of the workpiece in the lower clamp can be carried out, as long as the workpiece is still part of the rod section 21-26. After reversing essentially only the previously severed end face is to be worked. That is to say the workpiece W''' can be clamped over almost its whole length in the second clamping device 69. With equally high clamping pressure thus the danger of compression distortion of already turned faces is substantially less than in the case of the initially described known reversing method.

The surprisingly low loss of material in the carrying out of the method according to the invention appears from a comparison of the following examples, starting in each case from material rods having a total length of 4 m:–

a) *Material waste in the case of automatic single and multi-spindle machines,* caused by loss in cutting and by the residual piece which can no longer be machined:–

Example 1:

Material diameter:	14 mm
Workpiece length:	20 mm
Cutting tool width:	2 mm
Remainder piece using a loading magazine:	app. 80 mm (say 85 mm)

Number of workpieces
$= (4000 - 85) \div (20+2)$
$= 178$ *pieces*

Example 2:

Material diameter:	22 mm
Workpiece length:	48 mm
Cutting tool width:	3 mm
Remainder piece:	app. 80 mm (or 124 mm)

Number of workpieces
$= (4000 - 124) \div (48 + 3)$
$= 76$ *pieces*

b) *Material waste in the method according to the invention,* caused by loss in the sawing of a rod into pieces and the subse-

quent sawing of workpieces from these pieces:

Example 1:

Number of rod pieces

Possibility A: 16 pieces @250 mm

Possibility B: 16 pieces @242 mm
1 remainder piece 104 mm
if 24 mm are deducted for
15 × 1.6 mm saw width

Number of workpieces

Workpiece length: 20 mm

Saw width: 1 mm

In the case of A: 250 ÷ 21 = 11 pieces
Remainder 18.9 mm

In the case of B: 242 ÷ 21 = 11 pieces
Remainder 11 mm

This remainder is sufficient for the clamping of the last part.

From the remainder piece there can still be produced 104 ÷ 21 = 4 pieces.

Remainder 20 mm for clamping the last part. Thus in all

16 × 11 + 4 = *180 workpieces* can be produced. Thus despite division into rod pieces, two workpieces more than in the case of the single or multi-spindle automatic machine.

With a workpiece length of about 10 mm, with the method according to the invention approximately 20 workpieces more can be produced from a rod 4 m in length than in the case of the known automatic lathes.

Example 2:

Number of rod part pieces with 265 mm length

4000 ÷ 265 = 15 rod pieces
with a saw width of 1.6 mm.

Number of workpieces

265 ÷ (48 + 1.5) = 5 rod pieces

Remainder for clamping the last workpiece = 17.4 mm

Total producible workpieces

15 × 5 = *75 workpieces*

That is in all 1 part less than the known method.

As regards the waste, it is possible to work according to the invention the more advantageously, the shorter are the workpieces.

Within the scope of the invention modifications are still possible by the application of technically equivalent means. It would be a more expensive and to that extent less favourable but nonetheless possible modification, to cut rod part pieces to length from workpiece rod stock completely separately from the machine and only then to introduce them into the clamping devices of the turret and clamp them fast. Moreover machines are possible in which the clamping devices are not exactly radially directed, but directed for example obliquely or even axially. Then the charging station and the individually machine stations are correspondingly differently arranged. In the case of thin rod stock, intersecting arrangements of guides 20 lying one above the other are possible, so that then the rod sections 21-26 can be as long as corresponds to the diameter of the turret plus a machining length.

WHAT WE CLAIM IS:

1. A method for the production of machined workpieces from rod stock on multi-station machines having at least one loading station and a plurality of subsequent working stations spaced around the periphery of a turntable on which are mounted a corresponding plurality of spaced clamping devices, and a machining unit at each of the working stations, said method comprising the steps of feeding a section of rod stock comprising a multiple of desired machining lengths plus a residual clamping section into a clamping device at said loading station, clamping said section of rod stock at the loading station, severing at the loading station the clamped section from the remainder of the rod stock at a distance from the clamping device corresponding to one machining length so that a length corresponding to a machining length protrudes beyond the clamping device at the loading station, indexing said turntable in successive steps through one revolution and machining the protruding section at said working stations, including severing the machined section at a working station, unclamping and moving the remainder of said section at one station so that a length corresponding to a machining length protrudes beyond the clamping device at said one station, reclamping the remainder of said section at said one station, repeating said steps during further indexing of the turntable until only said residual clamping section remains in the clamping device at a working station, and finally unclamping and moving said clamping section out of the clamping device at this working station.

2. A method as claimed in claim 1, wherein said step of feeding said section of rod stock into said clamping device at said loading station comprises pushing said section in radially inward direction into said clamping device.

3. A method as claimed in claim 1 or 2, wherein said step of moving the remainder of said section of rod stock at said one station so that a length corresponding to a machining length protrudes again beyond the clamping device at said one station comprises the step of pushing the remainder of said section in radially outward direction beyond the clamping device at said one station.

4. A method as claimed in claim 1, 2 or 3, wherein the length of said section of rod stock is substantially equal to the radius of the turntable.

5. A method as claimed in any one of claims 1 to 4, wherein the length of said

section of rod stock is at least five times the machining length plus said clamping section.

6. A method as claimed in any one of claims 1 to 5, wherein the severing step at said loading station and at a working station comprises cutting said section with a saw blade.

7. A multi-station machine for the production of machined workpieces from rod stock, comprises a turntable having an axis and being indexable about this axis between a plurality of stations circumferentially displaced about said turntable and including a loading station and a plurality of working stations, a plurality of clamping devices mounted circumferentially spaced from each other on said turntable, one per station, and respectively aligned therewith after each indexing of said turntable, means for opening and closing the clamping device which after indexing of the turntable is at said loading station, means for feeding rod stock into the clamping device at said loading station while the clamping device at said loading station is open, severing means at the loading station for severing a rod section from said rod stock, while the clamping device at said loading station is closed, so that a desired machining length protrudes radially outwardly from said clamping device at said loading station, a plurality of radially inwardly directed guide means on said turntable, one for each of said clamping devices, for guiding the severed rod section, a plurality of machining units respectively arranged at said work stations for machining the machining length protruding outwardly from the respective clamping device, said machining units including an additional severing device for severing a machined workpiece from said rod section at a station preceding said loading station, and means at one of said stations following said station with said additional severing device for moving the remainder of said rod section in radially outward direction so that a machining length protrudes again from the clamping device of said following station.

8. A method for the production of machined workpieces from rod stock on multi-station machines as claimed in claim 1 and substantially as described herein.

9. A multi-station machine substantially as described herein with reference to the accompanying drawings.

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1590111 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1

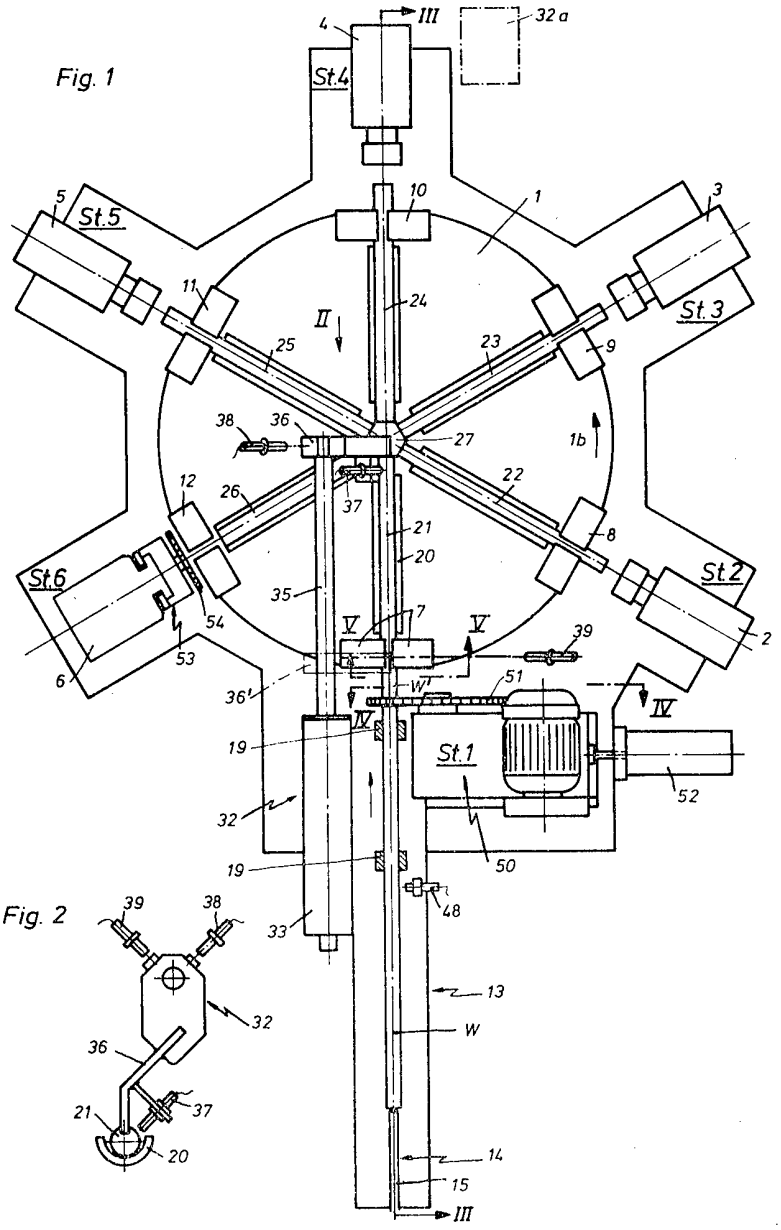

Fig. 2

1590111 COMPLETE SPECIFICATION
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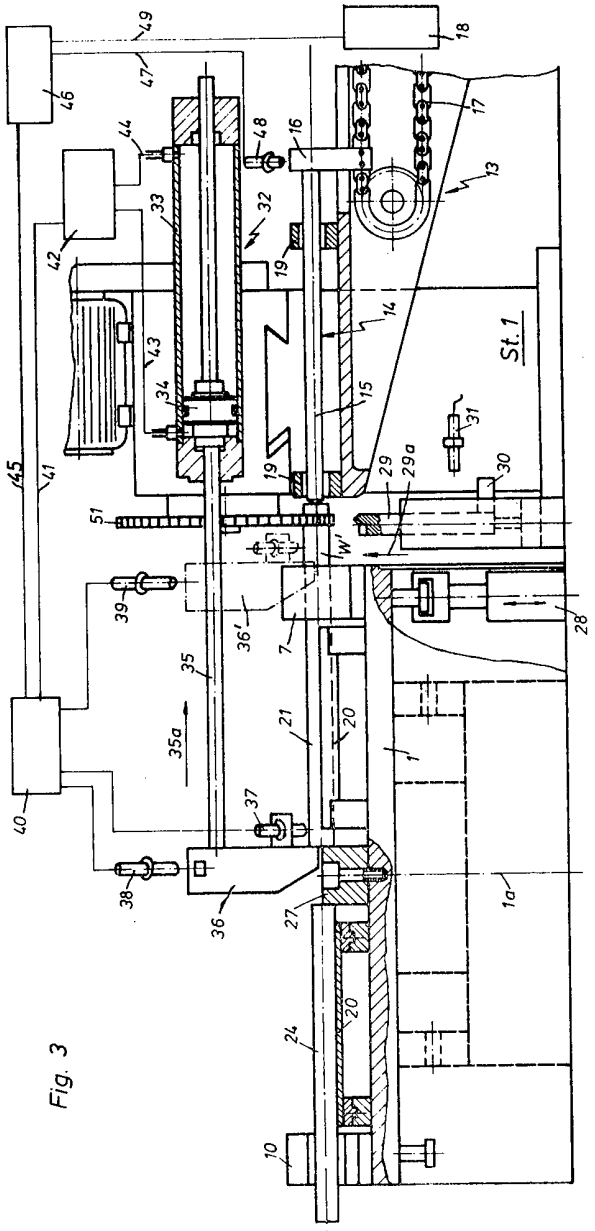

Fig. 3

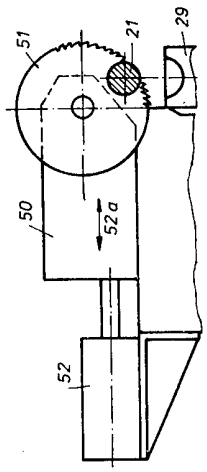

Fig. 4

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Sheet 3

Fig. 5a

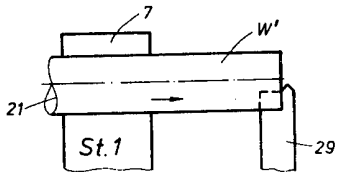

Fig. 5b

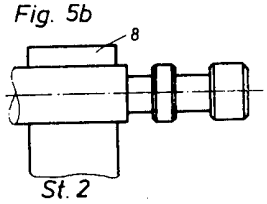

Fig. 5c

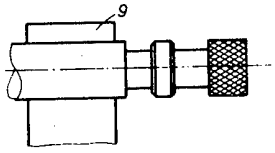

Fig. 5d

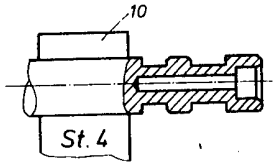

Fig. 5e

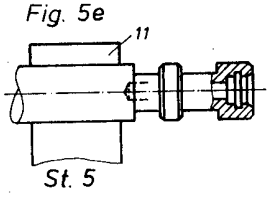

Fig. 5f

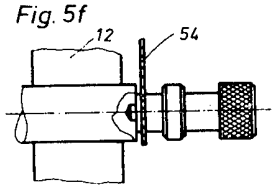

Fig. 5

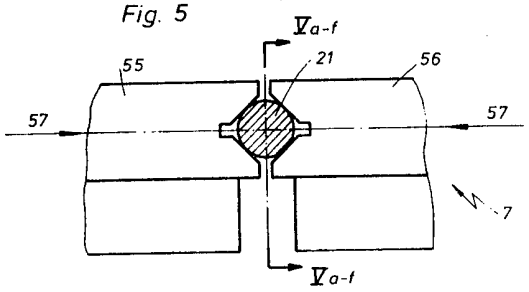

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Fig. 6

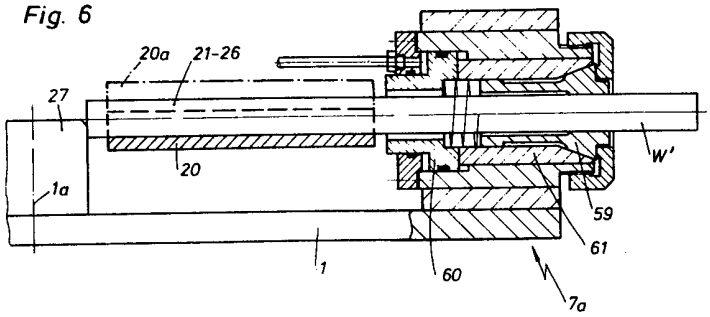

Fig. 8

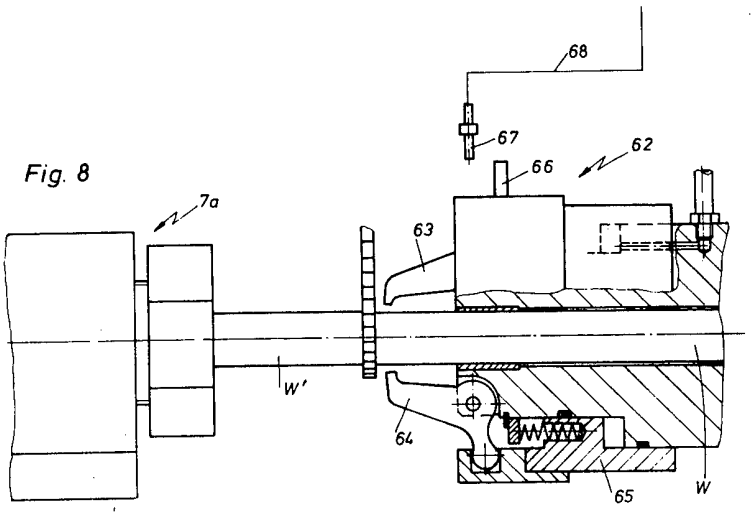

Fig. 7

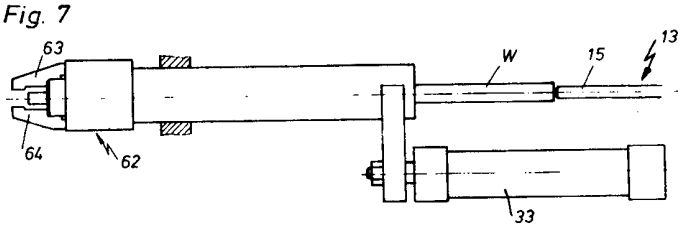

Fig. 9a

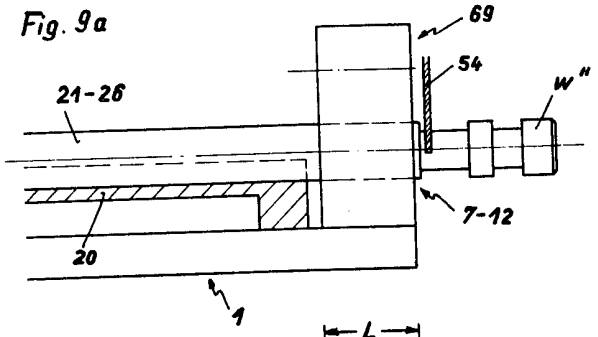

Fig. 9b

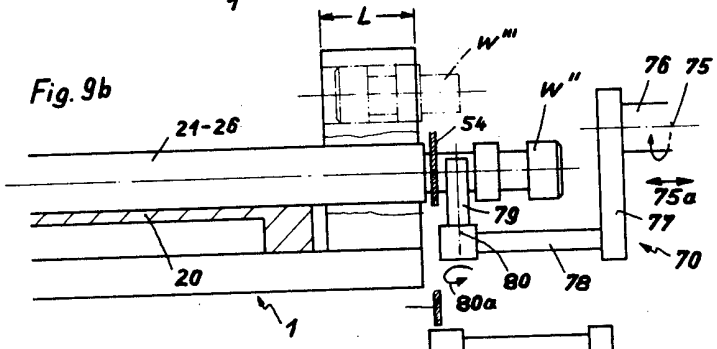

Fig. 9c

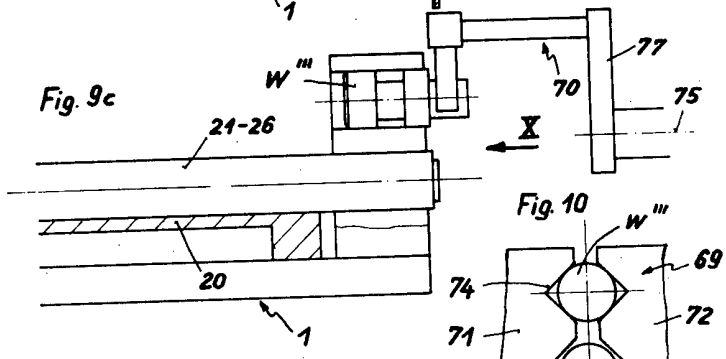

Fig. 10