May 28, 1957 B. KRALOWETZ 2,793,548

MACHINE FOR HIGH-SPEED FORGING AXIAL-SYMMETRICAL WORKPIECES

Filed Feb. 6, 1951 6 Sheets-Sheet 1

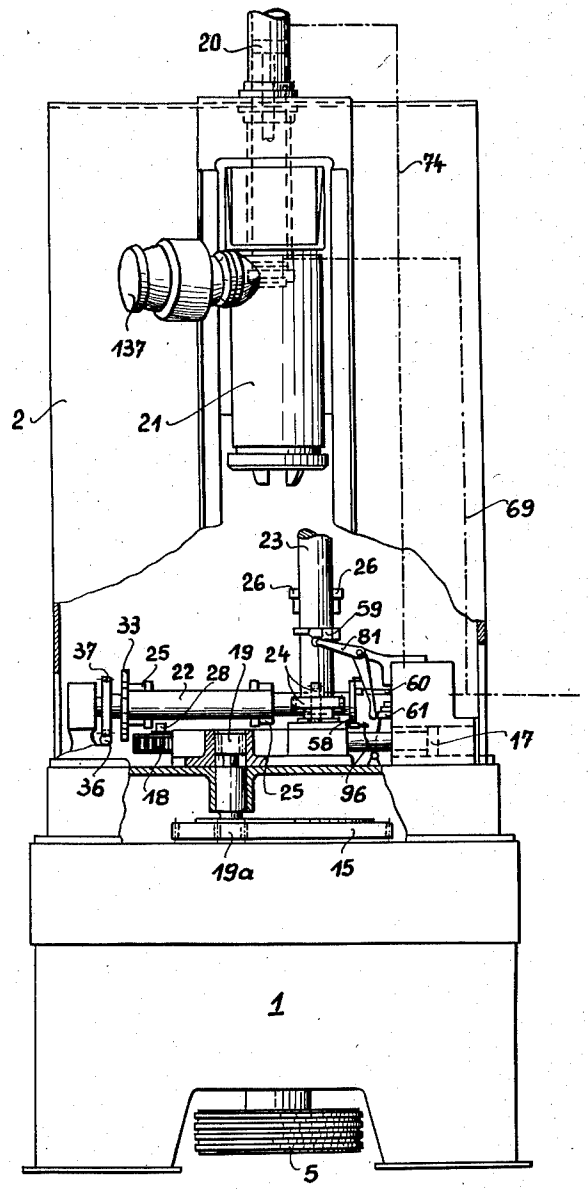


Fig.1

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Fig. 2

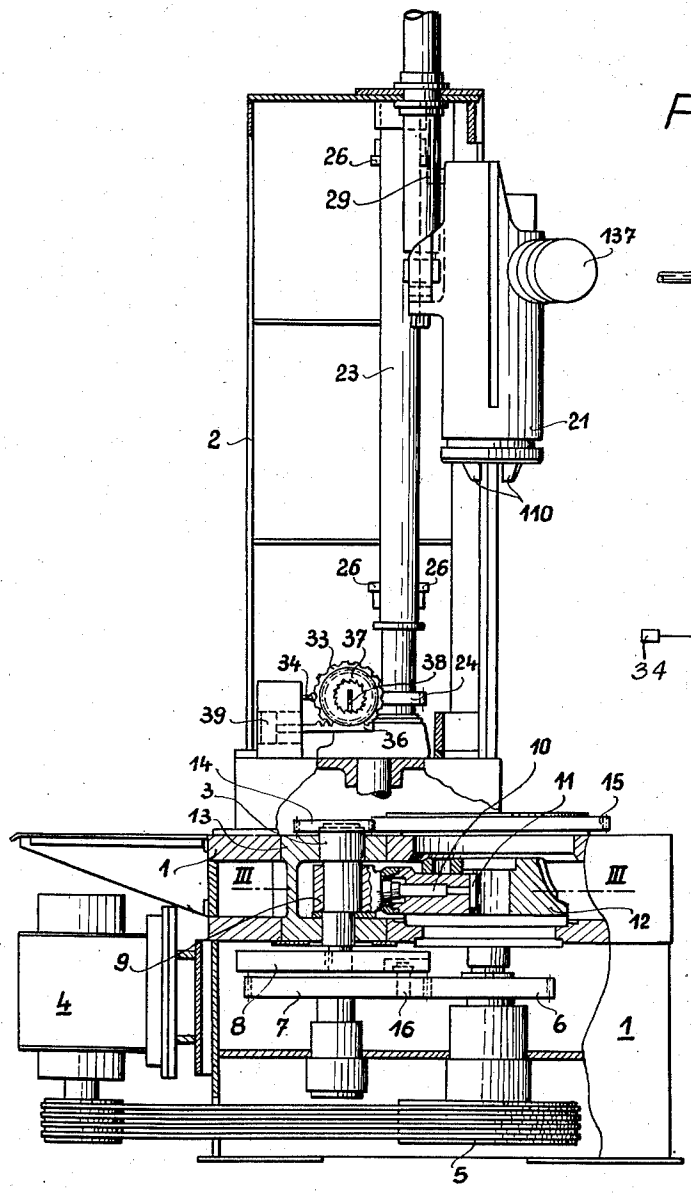


Fig. 5

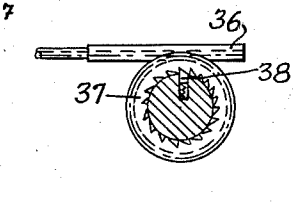
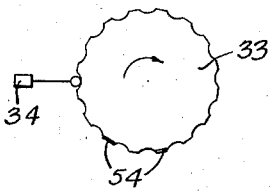


Fig. 6



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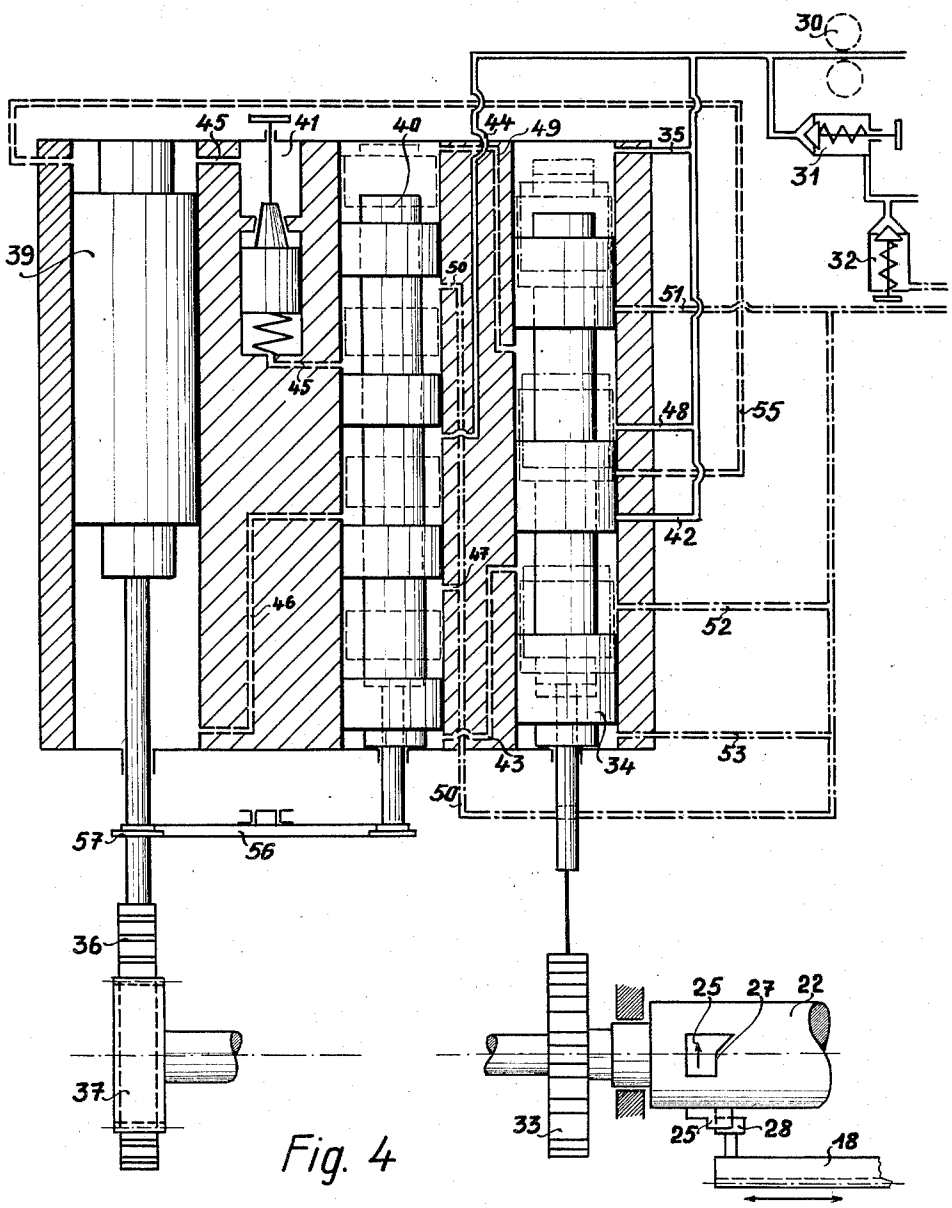


Fig. 4

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Fig.3

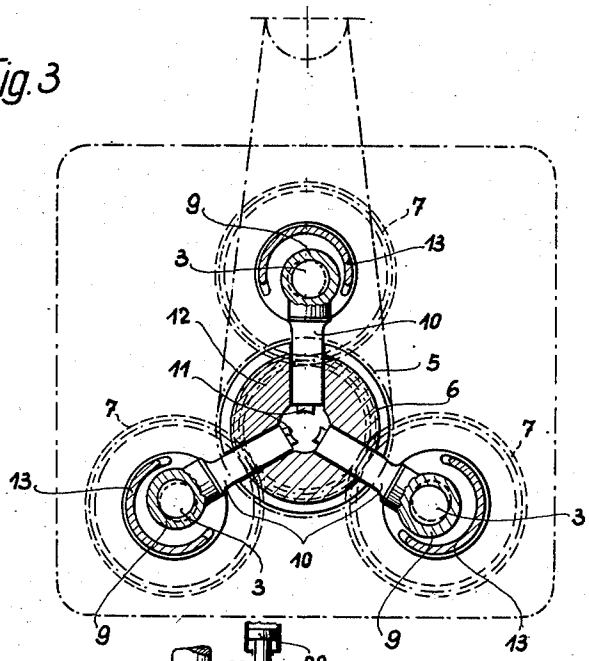


Fig.8

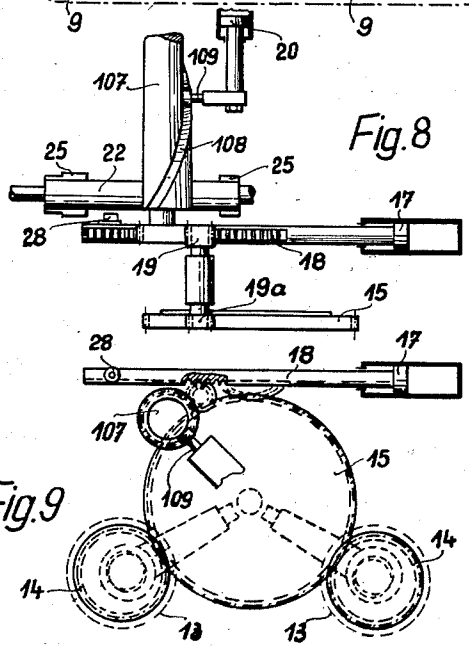


Fig.9

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MACHINE FOR HIGH-SPEED FORGING AXIAL-SYMMETRICAL WORKPIECES

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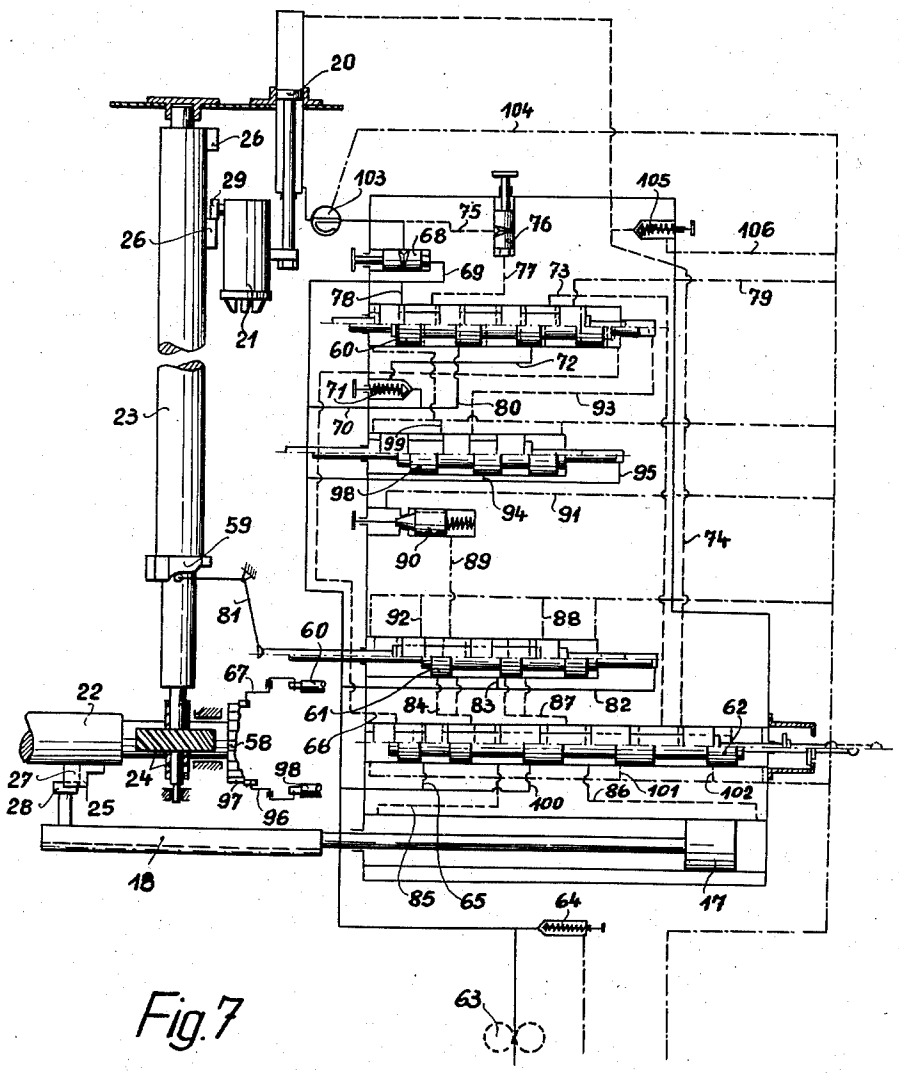


Fig. 7

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MACHINE FOR HIGH-SPEED FORGING AXIAL-SYMMETRICAL WORKPIECES

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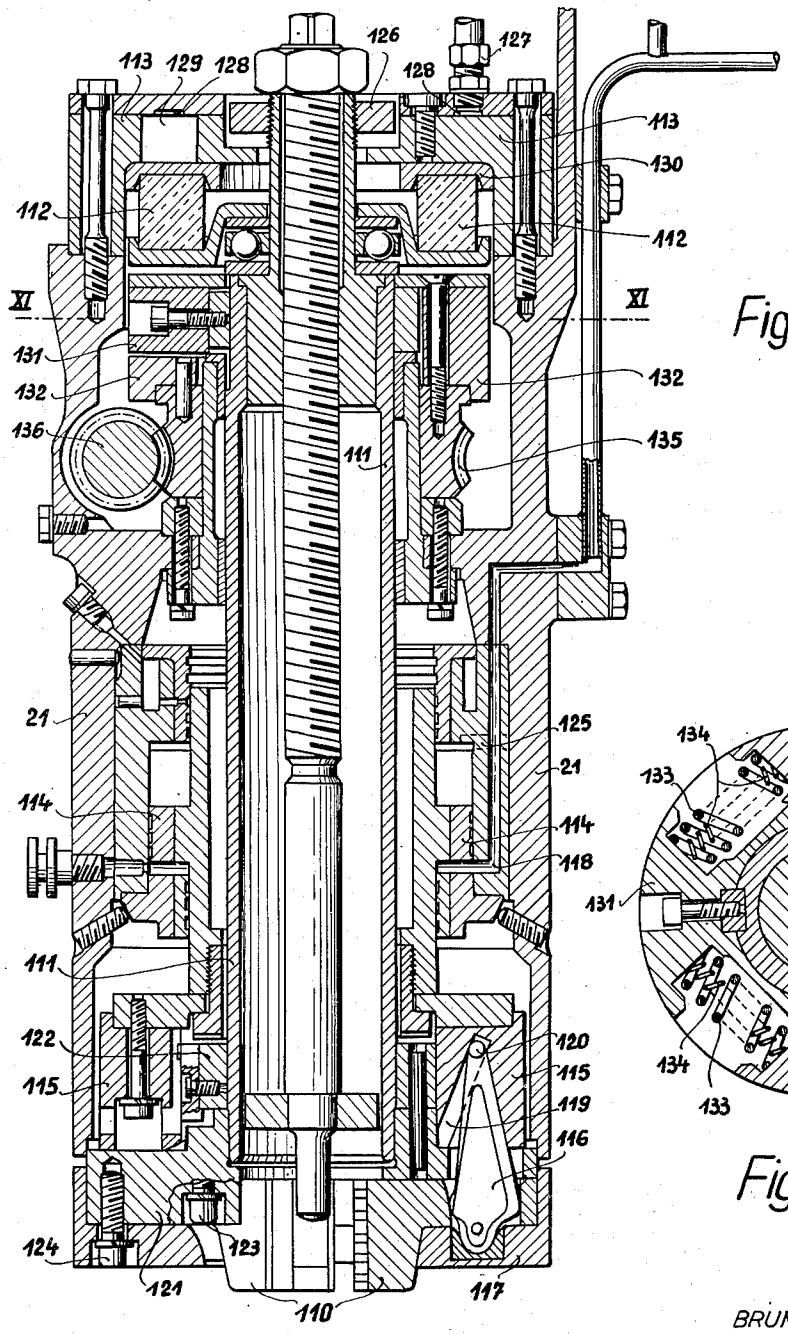


Fig. 10

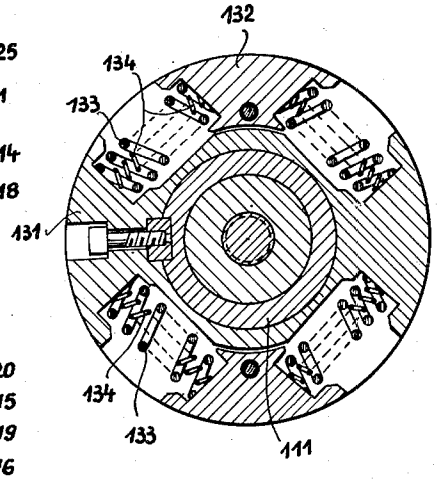


Fig. 11

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2,793,548

MACHINE FOR HIGH-SPEED FORGING AXIAL-SYMMETRICAL WORKPIECES

Bruno Kralowetz, Steyr, Austria, assignor to August Saxer, Thalwil, Switzerland

Application February 6, 1951, Serial No. 209,599

Claims priority, application Austria, February 9, 1950

17 Claims. (Cl. 78—20)

This invention relates to a forging machine for high-speed forging axial symmetrical workpieces.

Forging machines for axial symmetrical workpieces are known, in which machines several hammer tools, which are evenly distributed over the periphery of the workpiece, are driven by means of eccentrics, which in turn are adjustable by means of eccentric bearing bushings to effect a depth setting of the tools. The workpiece is thus given a rotary and an axial motion and its total deformation necessary is subdivided into a multitude of small individual deformations, the hammer tools beating in rapid succession. Whereas in the swaging hammer and in the upsetting machine the deformation is effected by a few operations or by one, respectively, requiring large forces, the subdivision of the deforming work results in a substantial reduction of the forces required. Thus it is possible to perform large total deformation jobs with relatively small machine weights. Moreover, since the eccentric shafts of the tools run in synchronism, all hammer blows and deformations are effected at the same time and a transmission of forces into the machine base is precluded.

For the control of such forging machines, that is, for the automatic adaptation of the feed of the workpiece and the depth setting of the tools relative to each other, in accordance with the predetermined shape of the workpiece, templates have been used previously, from which during the axial movement of the workpiece the depth setting of the hammer tools as required in each case has been derived. Corresponding to the nature of a template control, in general, it is possible to produce in this manner only workpieces of cylindrical, conical, or flatly curved shape, that is, of a shape in which there is a gradual transition from one cross-sectional magnitude to the other, whereas the forging of shoulders, and collars, or the forging-in of grooves is impossible, unless the axial feed of the workpiece is discontinued and the tool setting effected separately, the automatic control being disconnected.

Because the workpiece is given generally a continuous rotary motion and a continuous axial feed, but is held fast by the hammer tools at the moment of the blow, reaction forces are set up, on the one hand, which are directed against the gripping head which carries the workpiece, and which make themselves felt by shaking of the machine frame, or at least, by the generation of much noise. On the other hand the workpiece is helically deformed or twisted. For this reason it has been tried to brake or interrupt in particular the rotary motion of the work in dependence and derivation of the striking motion of the hammers; this has so far required, however, a very complicated transmission system.

It is the object of the invention to avoid these disadvantages and to provide a machine for high-speed forging axial symmetrical workpieces in which machine the forging operation is controlled fully automatically and which enables the manufacture of flowing axial sectional shapes achievable by means of templates, as well as of sharp

shoulders, collars, or grooves, the change-over of the control from one workpiece shape to another being effected easily and quickly, similarly as in automatic lathes, and the gripping head for the workpiece resiliently cushioning the axial reaction forces and causing the workpiece to stand still at each hammer blow, without transmission device from the tool eccentrics, in spite of a continuous rotary drive of the workpiece. It is another object of this invention to avoid all those idle strokes which are not necessitated by the forging operation as such and a further advantage resides in that all motions and control operations can be performed at two different speeds, the machine automatically adjusting itself for high-speed operation.

It is another object of the invention to provide a control system for the automatic control of two movements in dependence of either of them, more particularly for the control of the axial movement of the workpiece and of the movement for setting the penetration of the forging tools in a forging machine of the type described.

This is achieved according to the invention by the provision of hydraulically pressed working pistons for the setting of the hammer tools and for the workpiece movement, respectively, the control of which pistons consists of a system of piston control slides operable by two control rollers, which are adjusted in dependence of each other at the end of the respective piston movement. In the case of template control the hammer setting is in each case derived from the workpiece motion, but the control of the workpiece motion by the tool setting motion is impossible. As contrasted therewith, the use of hydraulically pressed pistons for both motions, in conjunction with a common control slide system, and the dependence of the adjusting movement of the control rollers serving for operating the system of slides, which control rollers are acted upon each by one of the two pistons, respectively, does not only achieve the automatic performance of the control cycle, but enables for the first time the control of both motions, as desired, from both sides, and thus the forging of shoulders.

Other features of this invention reside in a special arrangement and construction of the control system and of an adjusting slide system for adjusting the control rollers, as well as in the construction of a gripping head for the workpiece, which head meets fully the requirements of the forging operations involved by the control system. The advantages will be explained and illustrated with reference to an example.

The invention is shown by way of example in the accompanying drawings,

Figs. 1 and 2 showing the overall arrangement of a high-speed forging machine in an elevation and side view, respectively, the most essential units being shown by partial sections.

Fig. 3 is a horizontal section through the eccentrics and the connecting-rod guide, along the line III—III of Fig. 2.

Fig. 4 is a top plan view showing diagrammatically the system of adjusting slides for adjusting the control rollers in two positions, one of which is indicated in solid, the other in dash lines.

Fig. 5 is a side view showing diagrammatically a ratchet arrangement, as a detail.

Fig. 6 is a side view showing as a detail a notched wheel provided on the shaft of one of the control rollers.

Fig. 7 is a diagrammatic representation of the hydraulic control of the two working pistons, with two piston control slide valves, a starting slide valve and a shut-off slide valve, each of which slide valves is shown in two positions, one of which is indicated in solid, the other in dash lines.

Figs. 7*a*, 7*b* and 7*c* show as details the two piston con-

trol slide valves and the starting slide valve, respectively, in positions other than those of Fig. 7. In Figs. 7*a* and 7*c*, respectively, one of the piston control slide valves and the starting slide valve are shown in two positions, one of which is indicated in solid, the other in dash lines. Fig. 7*b* shows the other piston control slide valve in a third position.

Figs. 8 and 9 are a diagrammatic elevation and top plan view, respectively, showing the arrangement of an additional template cylinder.

Fig. 10 is an enlarged axial section showing a gripping head for the workpiece, and

Fig. 11 is a cross section taken along the line XI—XI of Fig. 10.

Three eccentric shafts **3** are mounted in the forging table **1** of the machine frame **2**. The shafts **3** are driven by a motor **4**, which is flanged to the forging table, through grooved pulley **5**, gear **6**, and gears **7**, through the intermediary of flywheels **8**. The eccentrics **9**, constituting drive means, are connected with connecting rods **10**, which constitute carriers for the exchangeable hammer tools **11**, and move the latter intermittently against the work. This motion is effected for all connecting rods at the same time from and towards the work. The connecting rods are guided in the corresponding radial channels of a disk body **12**, which is mounted in the forging table so as to be freely rotatable about the axis of the workpiece, and which freely follows the oscillating motion of the connecting rods without drive. For setting the depth of the tools in accordance with the workpiece diameter called for in each case, the eccentric shafts **3** are eccentrically journalled in bushings **13**, which are rotatable or adjustable, respectively, in the forging table through the gears **14** and a common central gear **15**. When the bearing bushings **13** are being turned, the distance of the eccentric shafts **3** from the central axis of the workpiece is altered and thus also the stroke position of the tools, the displacement of the axis of the flywheel **8** relative to the gear **7** being compensated by the play of the coupling pin **16** between the two.

The depth setting of the tools, that is, the turning of the bearing bushings **13**, is effected through a hydraulically pressed piston **17**, which is horizontally mounted in the machine frame and rigidly connected with a rack **18**. The rack is in mesh with an intermediate pinion **19**, which through a pinion **19***a* mounted on the same shaft with it turns the central gear **15**. Likewise a hydraulically pressed piston **20**, which slidingly moves in a corresponding vertical cylinder at the machine frame, is provided for the workpiece motion. This piston **20** is rigidly connected with the gripping head **21** for the workpiece, which head can be slidably moved in the frame. Both pistons are controlled through a system of slides, which is operable by two control rollers **22**, **23**, which are adjusted in dependence of each other at the end of the respective piston movement.

The two control rollers **22**, **23** are rotatably journalled and coupled with each other for joint rotation by a pair of helical gears **24**. Moreover, the control rollers are provided with pairs of end stops **25**, **26**, in a circumferential distribution which corresponds to the angular measure of the turning of the control rollers. These pairs of end stops can each be adjusted along a generatrix and are provided with an oblique engaging surface **27**. Moreover, the end stops act through roller-type followers **28** and **29** on the working pistons **17**, **20** moved in parallelism with the respective rollers. On the other hand, however, the end stops limit the movement of the respective working piston and, since the two rollers are movable in dependence on each other, the workpiece diameters set on the horizontal roller **22** by means of the stops **25** positively correspond with the related forging lengths determined on the vertical roller **23** by means of the stops **26**.

On the engagement of the follower **28** or **29**, of the respective working piston which has been moved, with one of the roller stops **25** or **26**, the corresponding control roller, and with it also the second roller, are turned through a small distance, owing to the oblique engaging surface **27**. Thus it is apparent that stops **25**, **26** arranged on control rollers **22**, **23** in the path of the pistons **17** and **20** associated therewith and limiting the movement of said pistons form part of shift means for rotating said control rollers in response to predetermined movement of either of said pistons. This short turning of the rollers is utilized for transmitting an impulse to a separate hydraulic system of adjusting slides, which only subsequently performs the actual rotary adjustment of the control rollers. This has the advantage that the adjustment of the control rollers takes place always completely and exactly, independently of the control of the working pistons, as is essential for clean forging work, and that the working pistons are relieved from this adjusting work.

Each rotary adjustment of the rollers amounts to $\frac{1}{16}$ of their circumference, and as a consequence there are also 16 pairs of end stops on each roller. In Figs. 4 and 7 only two stops, or a pair, have been shown, on an enlarged scale, for improved clearness. Moreover, all oil lines which are continuously under pressure are shown as solid lines, in said drawings, all unpressurized return lines as dash-and-dot lines, and all those lines which, constituting "control lines" carry flowing oil under pressure only at certain times, as dash lines.

According to Fig. 4 the separate system of adjusting slides for adjusting the control rollers is supplied by a gear pump **30** with oil under a gauge pressure of 10 atmospheres, which oil also, after being reduced to approximately 3 atmospheres gauge pressure by means of a reducing valve **31**, serves for lubricating the eccentric bearings and other essential lubricating points of the machine. In addition, a relief valve **32** is provided.

To enable the transmission of the control impulse to the system of adjusting slides by the short turning of the control roller at the end of the respective working-piston movement, the shaft of the horizontal control roller **22** carries a notched wheel **33**, against which bears a slide **34**, which is permanently urged against the wheel by the pressure line **35**. Moreover, an adjusting piston **39** is provided, which adjusts the control roller only in one direction, through a rack **36** with gear **37** and ratchet **38**, and to which pressure is applied either from one or the other side, depending on the position of the slide **34**, which depends on the angular position of the notched wheel **33**.

An intermediate slide **40** is arranged between the notched-wheel slide **34** and the adjusting piston **39**, which intermediate slide, depending on the position of the notched-wheel slide, is under pressure in one or the other direction and thereby provides the pressure-line connection through an adjustable throttle **41** for pressurizing the control piston in the direction of movement for adjusting the control rollers, or, unthrottled, for the return movement of the adjusting piston, and at the same time opens the oil return line from the piston side which is not under pressure, as the case may be.

During the short turning of the control roller at the end of each piston movement, the notched wheel is turned to some extent too, so that the slide **34** comes into its upper (with reference to the drawing) position, shown in full lines in the left-hand half of the drawing. Thereby the pressure line **42** is connected with the control line **43** and the oil under pressure moves the intermediate slide **40** upwardly (with reference to the drawing) into the position shown in the left-hand half of the drawing. Now oil under pressure can flow from the line **44** through the control line **45** and the throttle **41** and move the adjusting piston **39** downwardly (with reference to the drawing). The adjusting piston turns the gear **37** through the rack **36** and thus through the ratchet **38** and the horizontal control roller **22**, through $\frac{1}{16}$ of its circum-

ference. The oil at the other side of the piston returns into an oil reservoir (not shown) through the lines 46, 47. The throttle 41 fitted in the line 45 serves for controlling the rate of flow and thus for controlling the adjusting speed, as is necessary for adjusting a retardation of the forging operation, e. g., for forging up collars.

As soon as the turning of the control rollers has been completed, the slide 34, being constantly pressed through the line 35 against the notched wheel 33, falls into the next notch to come into the position shown in solid lines in the right-hand half of the drawing. In this position it opens the passage for the oil under pressure out of the line 48 into the line 49, whereby the intermediate slide 40 is moved into the position shown in the right-hand half of the drawing. Thereby the oil under pressure is enabled to apply pressure to, from the line 44 through the control line 46, the piston 39 from below (with reference to the drawing) and to move it upwardly, the control rollers not being turned along because the ratchet 38 releases this motion. The oil on the other piston side flows back to the oil reservoir through the line 45, the throttle 41, now opening against the force of the spring, and the line 50. The return lines 51 and 52 permit of the return flow of oil which is displaced by the movement of the intermediate slide 40, whereas the line 53 is a leakage oil line of the notched-wheel slide.

Thus it is apparent that the ratchet wheel 33 constitutes means responsive to the engagement of pistons 17, 20 with stops 25, 26 to transmit a control impulse upon such engagement, that piston 29, rack 36, gear 37 and pawl 38 form a hydraulically operable system connected to control rollers 22, 23 to rotate the same and thus change the position of stops 25, 26 relative to the paths of pistons 17, 20, and that slide valves 34 and 40 form second slide valve means responsive to ratchet wheel 33 and in controlling relation with the hydraulically operable system 39, 36, 37, 38 to operate the same upon such control impulse in such a manner as to move the next successive pair of stops 25, 26 on each roller 22, 23 into the path of the respective pistons 17 and 20. It is further apparent that the ratchet wheel slide valve 34 is in continuous engagement with ratchet wheel 33 to be moved thereby into either of two control positions, in each of which it causes the admission of pressure to one side of shift piston 39.

Further it has been shown and described that line 44, control line 45, throttle 41, and lines 46, 47 form a second hydraulic system operable to apply pressure to one side of shift piston 39 in a forward direction for operating control rollers 22, 23 through the intermediary of the piston rod of piston 39, rack 36 and pinion 37, and to apply pressure to the other side of shift piston 39 in a reverse direction to cause the return of said piston, whereas the rollers do not follow said return movement because pinion 37 is connected to the shaft of roller 22 for rotation therewith in only one direction, by means of pawl 38.

It has also been shown that the intermediate slide valve 40 is in controlling relation to said second hydraulic system and movable into either of two control positions, in one of which it admits to shift piston 39 in said forward direction through throttle 41, and in the other of which it admits to and from shift piston in said reverse direction.

Further it has been shown that pressure line 42, control line 43, lines 48 and 49, and return lines 51 and 52 form a third hydraulic system operable to apply pressure to either side of intermediate slide valve 40 to move it into either of said control positions.

It may be desired to save idle control time by precluding the delays in the sequence of the several hammer setting and workpiece movements, respectively, which delays are caused by the throttle 41. For this purpose the invention provides further that the notched-wheel slide 34 is slidable into a third control position, by means of mountings 54 fixable to the lands of the notched wheel 33, in which position it provides an unthrottled pressure-line connection for applying pressure to the adjusting piston 39 in the direction for adjusting the control rollers. This third position is shown in dash lines in the left-hand half of the drawing and it can be seen that in this position the pressure line 42 is connected with a control line 55, for directly applying pressure to the adjusting piston 39.

If the adjusting movements follow each other in rapid succession, the piston 39 may receive the impulse for a new adjusting movement before it has reached its upper (with reference to the drawing) initial position for the adjusting movement. To avoid this the invention provides means for locking the intermediate slide 40 in its position in which it provides the pressure-line connection 44, 46 for returning the adjusting piston 39. This locking means comes into effect automatically and is put out of effect automatically by the adjusting piston as the latter reaches its initial position. The locking means comprises a resilient lever 56, which holds the intermediate slide in its lower (with reference to the drawing) position until the piston 39, by means of a releaser 57 fixed to its piston rod, turns the lever 56 and thus releases the slide.

As has been mentioned hereinbefore, the setting of the stroke positions of the hammer tools to the workpiece diameter prescribed in each case, and the axial workpiece movements, in accordance with the desired shape of the workpiece, are performed by means of the hydraulically pressed working pistons 17 and 20, which are controlled by a system of slides, which is fully automatically operated by the control rollers.

For this purpose, a disk 58, 59, with exchangeable or adjustable engaging pieces projecting by different extents, is provided on the shaft of each control roller, respectively. By each of said disks a slide 60, 61 for controlling the two working pistons, which slides are pressed against the engaging pieces, is adjusted by different distances, which depend on the height of the engaging pieces, during the movement of the control rollers. Each engaging disk operates that slide which controls the working piston which is parallel to the other control roller. Thus the diameters and lengths of the workpiece are determined by the adjustment of the end stops on the two control rollers, and the manner and sequence of the two working-piston movements is determined by a corresponding selection of the engaging pieces on the disks, on which pieces the several positions of the control slides depend, so that after these settings the machine will forge automatically.

A starting slide 62 held in a central position (shown in solid lines in Fig. 7) by spring force and in this position providing the connection of lines for the respective preset automatic control of the working pistons, connects in its one (left-hand) position (shown in dash lines in Fig. 7a), a pressure line for applying pressure to the slide 60, which controls the piston 20 for moving the workpiece, in the direction towards the corresponding engaging disk 58, for initiating the cycle of operations. In its other (right-hand) end position (shown in Fig. 7c) the starting slide effects, as an emergency control, the application of pressure to the piston 17 for setting the hammers, in the direction of opening the hammers, and, if desired, the application of pressure to the piston 20 in the direction leading off the hammers. Thus the sequence of operations is intiated by pressing the control slide 60 for the piston 20 toward its corresponding engaging disk 58, and the sequence and nature of the further operations depends on the effective engaging piece of said disk.

According to Fig. 7 another gear pump 63 is provided, which supplies the oil for this hydraulic system under a pressure of approximately 30 to 35 atmospheres gauge pressure. A relief valve 64 enables the return flow of surplus oil under pressure into the oil reservoir (not shown).

When the starting slide 62 is moved by hand from its

normal, central position into its left-hand end position, oil under pressure flows out of the line **65** through the control line **66**, and moves the slide **60** to the left until the latter comes to bear, through the intermediary of a toggle lever **67**, against the engaging disk **58**. This slide **60** serves for controlling the piston **20**, the piston-rod side of which is constantly oil-pressurized through a direct line **69** leading over an adjustable throttle **68**, and is slidable, according to the invention, into any of four positions, by means of corresponding engaging pieces on the disk **58**. In its left-hand position, shown in dash lines (Fig. 7), it opens the passage of oil out of the pressure line **70** through a throttle **71**, pressure line **72**, into the control line **73**, which conducts the oil through the starting slide **62**, which by the spring force always returns to its central position, into the control line **74** and from there to the upper side of the piston **20**. As has been said, the piston **20** is always under pressure from below. The effective top piston surface, however, exceeding the size of the lower one (piston-rod side), the piston will move downwardly when pressure is applied at the same time from above, and carry along the gripping head **21** down to the respective lower stop **29** on the control roller **23**. The oil at the underside of the piston is thus pressed back into the oil-under pressure line through the throttle **68**. A speed control is possible by the adjustment of this throttle.

When the slide **60** is in its position farthest to the left, shown in solid lines, the connection of lines (Fig. 7*a*) for oil-pressurizing the piston **20** remains unchanged. However, a passage for the oil is opened through the control line **75**, an additional adjustable throttle **76**, and the line **77**, back to the pressure line **78**. Thus the cross sections of flow and the speed of the downward movement of the gripping head are increased (high-speed motion). Thus it is possible to vary the speed of the gripping head by the use of only two engaging pieces of different height.

When the slide **60** comes into its right-hand position, shown in solid lines in Fig. 7, the pressure line **72** is shut and the control line **73** connected with the return line **79**. Thus the top side of the piston is not oil pressurized and the piston **20** together with the gripping head, will move upwardly owing to the continued oil pressure from below, oil under pressure flowing toward the piston out of the line **69** through the throttle **68**. In the position of the slide farthest to the right, shown in dash lines in Fig. 7*a*, oil under pressure is also free to flow out of the line **80** into the control line **77** and farther on through the throttle **76** and the line **75** into the cylinder space below the piston **20**, for increasing the upward speed of the gripping head.

When a hammer setting movement is to take place after an upward or downward movement of the gripping head or workpiece, respectively, this is effected by corresponding engaging pieces on the disk **59**, which operates the control slide **61** through a double lever **81**. This slide, which is permanently pressed by the pressure line **82** against the engaging disk **59**, can assume three positions, according to the invention. In its right-hand position, shown in solid lines in Fig. 7, the oil-under-pressure line **83** is connected with the control line **84**, which communicates over the starting slide **62**, which, as has been mentioned hereinbefore, is returned to its central position by the spring, with the control line **85**, whereby the piston **17** is under pressure from the left and moves to the right. The piston carries the rack **18** along, which, through the intermediary of the intermediate pinions **19**, **19***a* and of the central gear **15**, turns the bearing bushings **13** and thus opens the hammers. The oil from the right-hand side of the piston is passed to the return line **88** through the control line **86**, starting slide **62** (central position), and control line **87** (slide **61** in right-hand position).

When the slide **61** is in its left-hand position, shown in dash lines in Fig. 7, oil under pressure flows out of **83** into the control line **87** and over the starting slide (central position) into the control line **86**, and applies pressure to the piston **17** from the right. The piston moves to the left and closes the hammers through the intermediary of the rack, intermediate pinions, and eccentric bushings. The oil at the left-hand side of the piston **17** flows through the control line **85**, starting slide **62**, control line **84**, slide **61**, line **89**, and adjustable throttle **90**, into the return line **91**. The throttle **90** enables the control of the setting movement of the hammers by a reduction in the cross section of flow, which is of significance particularly during groove forging.

To save idle time, that is, to enable the setting of the hammers at higher speed in the sequence of control motions in cases where this is required for other than grooving work, the slide **61** can be moved into the position shown farthest to the left, in Fig. 7*b*, by abutment members of corresponding height on the engaging disk **59**. In this position the control line **84** is connected with the return line **92**, which bypasses the throttle **90** and conducts the oil from the left-hand side of the piston directly into the oil reservoir.

The slide **60** for controlling the piston **20** for moving the workpiece must, on the one hand, during the automatic motion be constantly pressed to the left against the corresponding engaging disk **58**, and on the other hand, at the end of a period of operation, remain in its right-hand position (for the upward movement of the workpiece or gripping head, respectively), because only in that case the aforedescribed initiation of a new period of operation is possible by means of the starting slide and the connection of lines **65—66**. The permanent oil-pressurization of the slide **60** from the right is effected through the lines **93**, **94** (the connection of lines **65—66** is interrupted in the normal position of the starting slide) and this connection must be interrupted at the end of a period of operation. For this purpose a shut-off slide **98** is provided, according to the invention, which slide owing to the application of a constant oil pressure through the line **95** is permanently pressed through the intermediary of a toggle lever **96** against the engaging disk **58** and is automatically operable by means of an additional engaging piece **97**. When this shut-off slide is moved to the right by the engaging piece **97**, the line **93** is connected to the return line **99**, the pressure line **94** is shut off and the slide **60** remains at a standstill. When, after the next start, the control rollers have been turned through $\frac{1}{16}$ of their circumference, the slide **98** will move off the engaging piece **97**, to the left, and connect the oil-under-pressure line **94** with the control line **93**, whereby the control slide **60** is again constantly under pressure from the right and remains pressed against the engaging pieces of the disk **58**.

When the starting slide is moved into the position shown farthest to the right (in dash lines), for emergency control, the following results:

Oil flows from the oil-under-pressure line **100** into the control line **85** and applies pressure to the piston **17** from the left; the control line **86** is connected at the same time through the line **101** with the return system. The piston **17** is thus moved to the right and opens the hammers. Moreover, the control line **74** is connected with the return line **102** so that the application of pressure to the piston **20** from above, if any, discontinues and the gripping head moves upwardly.

In setting the machine it may be desirable to move the gripping head **21** into the desired position and to hold it fast. Since on the starting of the hydraulic system the gripping head always moves upwardly owing to the constant application of pressure to the piston **20** from below, a manually adjustable three-way cock **103** is fitted in the direct pressure line for the permanent application of pressure to the piston, which three-way cock, depending on its position, either permits of the normal passage of oil, or shuts off the pressure line en-

tirely (standstill of piston) or connects this side of the piston through a line **104** with the return system (piston sinks down).

The throttle **71** fitted into the pressure line **70, 72** for applying pressure to the piston from above (direction toward the hammers), serves for reducing the pressure acting on the piston from above to such a value that the gripping head moves upwardly and downwardly at the same speed, provided that the throttles **68** and **76** are adjusted alike. This adjustment must be provided for to compensate for the influence of the weight of the gripping head and the difference in the piston faces of the piston **20**. To maintain at a constant value the pressure reduced by the throttle **71**, a relief valve **105** is provided which permits of the flow of oil under surplus pressure through the return line **106**. The return lines not designated in Fig. 7 are leakage oil lines of the several slides.

Thus it has been shown that lines **72, 73, 74**, throttle **68**, lines **69, 75, 77, 78**, throttle **76** and line **79** constitute a fourth hydraulic system operable to apply pressure to the first piston **20** in a forward direction toward and in a reverse direction from the forging tools.

Further it has been shown that lines **83, 89, 91**, first unthrottled line **86, 87, 88**, third adjustable throttle **90**, second unthrottled line **84, 85, 92**, constitute a fifth hydraulic system operable to apply pressure to the second piston **17** in the closing direction corresponding to a deeper and in an opening direction corresponding to a smaller penetration of the forging tools, and that first and second slide valves **60** and **61** are provided in controlling relation with said fourth and fifth hydraulic systems respectively, which second slide valve **61** is movable into any of three control positions in the first of which it admits to second piston **17** in said opening direction and admits from said piston **17** through said first unthrottled line and in the second and third of said positions admits to said piston in the closing direction and admits from said piston in the closing direction through said third throttle, whereas in the third of said positions it admits additionally from said second piston **17** through said second unthrottled line.

Moreover, it has been shown that lines **66** and **82** form parts of sixth and seventh hydraulic systems, respectively, which are operable to urge said first and second slide valves **60** and **61**, respectively, into engagement with the abutment members on disks **58, 59**.

Further it has been shown that starting slide valve **62** is arranged in controlling relation with said fifth, sixth and seventh hydraulic systems and movable between two end positions in the first of which it admits to second piston **17** in the opening direction and in the second of which it admits to first slide valve **60** to urge it into engagement with the abutment members of disk **59**, and that the starting slide valve **62** is in controlling relation with the fourth hydraulic system (lines **74, 73, 79**) to admit from first piston **20** in said reverse direction. Besides, it is apparent from Fig. 7 that starting slide valve **62** has connected thereto an axially movable control rod **151** loaded by a spring **150**, which constitutes resilient means in equilibrium when starting slide valve **62** is in second slide valves **60, 61** to permit them to be urged against the second slide valves **60, 61** to urge them against the abutment members on disks **58, 59**.

Besides, it has been shown that throttle **68** is a first adjustable throttle and throttle **76** is a second adjustable throttle admitting to first piston **20** in said reverse direction and that first slide valve **60** is movable into any of four positions in the first and second of which it admits to first piston **20** in said forward direction to overcome the pressure admitted thereto in the reverse direction to the side of the piston to which the piston rod is connected, and in the third and fourth of which positions it closes the admission to said first piston in the forward direction, whereas in the second and fourth of said positions it admits from said piston in the forward direction and to said piston in the reverse direction, respectively, through said second throttle **76**.

In addition it has been explained that the shut-off slide valve **98** is in controlling relation with said sixth hydraulic system and in engagement with the abutment members on disk **58**, and that one of the abutment members on disk **58** is longer than the others and adapted to move said shut-off slide valve into an effective position in which it shuts off said sixth hydraulic system from slide valve **60** and admits from slide valve **60**.

It has further been made clear that disks **58, 59** constitute slide valve adjusting members for slide valves **60, 61**, which adjusting members are operatively connected to control rollers **22, 23** and operable thereby to adjust each of slide valves **60** and **61** independently of the other to admit to the first piston **20** in either of said forward and reverse directions and to admit to said second piston **17** in either of said closing or opening directions independently of the direction of admission to the respective other piston.

Whereas the previously described control system permits of the perfect forging of shoulders or collars, etc., it does not permit of the manufacture of conical workpieces or of workpieces of similar flowing axial sectional shapes. However, in order to enable the forging of all essential workpiece shapes encountered in practice, and to achieve a truly universal forging machine, a template cylinder **107** is provided according to the invention, which cylinder is in mesh with the intermediate pinion **19** for turning the central gear **15** and can be disconnected, if desired (Fig. 8 and Fig. 9). During the movement of the gripping head, the template cylinder, arranged parallel to the control roller **23**, is turned, by a roller-type follower **109** guided on its curve template **108** and connected with the gripping head, against the hydraulic pressure acting on the rack **18**, and thus effects, through the intermediate pinions **19** and **19*a***, central gear **15**, gears **14** and bushing **13**, the respective hammer setting which corresponds to the template shape and is dependent on the feed of the workpiece. The initiation and discontinuance or reversal of the movement of the gripping head and of the hammer setting movement, however, are effected by the system of slides.

The automatic control of the machine permits of any desired sequence of hammer setting movements and gripping head movements or axial workpiece movements, respectively, in both directions, so that actually all workpieces of practical significance can be forged. To avoid idle strokes and thus a retardation of the entire forging operation, however, it requires both a "pressing" and a "pulling" forging (workpiece feed downwardly toward the hammers and upwardly off the hammers, respectively). This requirement necessitates the construction of a special gripping head, which is equally suitable for both directions of feed.

As has been mentioned hereinbefore, the continuous feed motion of the workpiece, effected by the hydraulic pressure acting on the piston **20**, is stopped on each blow of the three hammer tools. During pressing forging, this results in each case in an axial thrust against the gripping head, which thrust is intensified by the stretching of the workpiece, and during pulling forging it signifies an increase in the hazard that the workpiece will be torn out of the gripping jaws. These reaction forces are now resiliently cushioned by the construction of the gripping head according to the invention.

A sleeve **111**, carrying the gripping jaws **110**, is rotatably mounted in the gripping head casting **21** (Figs. 10 and 11), which is guided at the machine frame **2** and connected with the piston **20**. This sleeve bears axially over the intermediary of a rubber buffer (ring) **112** on the casing cover **113** and is pressed by means of an air-pressurized piston **114**, which is displaceable relative of the sleeve, against said cover into the clamping position of the jaws. The piston **114** is connected with an annular

body 115, provided with radial cuttings-out or grooves, respectively, in which levers 116 are slidably movable, which are pivotally mounted with their other end in a lower cap 117 and exercise radial pressure on the gripping jaws 110. When air pressure is applied to the piston 114 from below, through the line 118, the annular body 115 is upwardly displaced together with the piston and the levers 116 are turned by means of their lateral pins 120, which are guided in the oblique groove 119 of the annular body, toward the center, whereby the jaws 110 are forced against the workpiece introduced between them. All levers provide for a favorable transmission of forces so that the workpiece is held with sufficient force. When the piston is urged in this manner, the sleeve 111 is pressed upwardly against the rubber buffer through the levers 116, cap 117, and intermediate rings 121 and 122. The intermediate ring 122 is shrunk on the sleeve 111. The ring 121 is firmly connected to the ring 122 by means of the screws 123, and the cap 117 to the ring 121 by the screws 124, whereas the annular body 115, having grooves for the tightening levers, and with it the piston 114, follow only the turning movement of the sleeve 111 through the intermediary of the intermediate ring 122.

When pressure applied to the piston 114 through the line 125 from above (non-clampingly), the piston 114 and with it the annular body 115, and finally also the sleeve 111, are displaced downwardly until the sleeve comes to bear on the casing cover 113 by means of an abutting disk 126. Now the gripping jaws are opened by impact as a result of an outward turning of the levers 116 as they slide in the grooves of the annular body 115, which is suddenly moved downwardly. This opening by impact, for separating the workpiece, is necessary because the jaws tend to bite into the workpiece.

Thus when the workpiece is gripped (clamping position), the sleeve 111, with the gripping jaws, is held in its position in which it bears against the rubber buffer 112, by the application of pressure to the piston 114 from below (line 118), so that the impacts occurring during pressing forging can be taken up or cushioned, respectively, by the buffer, and are not transmitted to the machine frame or the piston 20, etc. On the other hand, however, during pulling forging, the pneumatic pressure on the piston 114, which pressure must not be reduced owing to the required gripping pressure of the jaws, would prevent a resilient yielding of the sleeve against smaller axial tensile forces set up, so that these reaction forces would now have to be taken up by the machine or the danger of the workpiece being torn out of the jaws would be present. To avoid this, an additional compressed-air line 127 is provided, which through an annular groove 128 and bores 129 in the casing cover 113 permits the application of pressure to the sleeve 111 and of the top end abutting ring 130 in the pulling-out direction. Thereby the force acting on the sleeve from the piston 114, against its pulling out in an axial direction, is reduced by a force acting in the opposite direction (application of pressure to the top end face of the sleeve, the effective area of which face is smaller than that of the piston 114) without reducing the gripping jaw pressure, so that a yielding of the sleeve is achieved even in the case of small tensile forces, and the danger of the workpiece being torn out is removed.

Finally, two claw disks 131, 132, with springs 133, 134 arranged between the interlocking claws, are provided for turning the sleeve in the gripping jaw casing. The disk 131 is keyed on the sleeve 111, whereas the other one is connected with a worm gear 135 and driven through a worm 136 by a motor 137, which is flanged to the gripping-jaw casing. In this manner the automatic holding of the sleeve and workpiece at rest at the moment of the hammer blow is achieved by the cushioning and the periodic arrest of the workpiece on each hammer blow.

As a matter of course, forging is also possible when the rotary motion of the workpiece is discontinued (motor 137 disconnected) and thus the manufacture of edged workpieces or of workpieces having straight-lined grooves.

From the foregoing description and from the drawings it is apparent that the gripping head comprises gripping jaws 110 radially movable and axially fixed in the rotatable sleeve 111, drive means 137 operatively connected to sleeve 111 to rotate the same relative to the casing 21, buffer means 112 between the top end of sleeve 111 and top stop 113 of the casing, pressure applying means operatively connected to sleeve 111 and operable to exercise thereon a resilient upward force relative to casing 21, through parts 115, 116, 117, 124, 121, 123, 122, connecting means 115, 116 interconnected between said pressure applying means 114 and gripping jaws 110 for transmitting a radially inwardly directed component of force from said pressure applying means to said gripping jaws, second pressure applying means 127 operatively connected to sleeve 111 to apply thereon a downwardly directed force, and operatively disconnected from connecting means 115, 116, and buffer means 133, 134 interposed between drive means 137 and sleeve 111 to provide a resilient drive connection therebetween.

It is also apparent that motor 4 constitutes tool driving means operatively connected through pulley 5, gears 6 and 7, shafts 3, eccentrics 9, and connecting rods 10 to forging tools 11 to operate them so as to perform blows on the work at regular intervals and that buffer means, 133, 134 are springs of such dimensions and resiliency as to offset fully the torque of said drive means 137 and thus interrupt the rotation of the work at the time of such blows.

What I claim is:

1. A control system for the automatic control of two movements in dependence of either of them, which comprises, in combination, two hydraulic pistons each of which is operable to perform one of said movements, a hydraulic system operable to apply pressure to said pistons, slide valve means in controlling relation to said hydraulic system, a pair of control rollers connected for interdependent rotation and in controlling relation with said slide valve means, each of said control rollers being arranged to cooperate with one of said pistons, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising stops arranged on each of said control rollers in the path of the piston arranged to cooperate therewith and limiting the movement of said piston.

2. A control system for the automatic control of two movements in dependence of either of them, which comprises, in combination, two hydraulic pistons each of which is operable to perform one of said movements, a hydraulic system operable to apply pressure to said pistons, slide valve means in controlling relation to said hydraulic system, a pair of control rollers connected for interdependent rotation and in controlling relation with said slide valve means, each of said control rollers being arranged to cooperate with one of said pistons, stops arranged on each of said control rollers in the path of the piston arranged to cooperate therewith and limiting the movement of said piston, means responsive to an engagement of said pistons with said stops to transmit a control impulse upon such engagement, a hydraulically operable system operatively connected to said control rollers to rotate the same and thus to change the position of said stops relative to the paths of said pistons, and second slide valve means responsive to said responsive means and in controlling relation to said hydraulically operable system to operate the same upon such control impulse.

3. A control system for the automatic control of two movements in dependence of either of them, which comprises, in combination, two hydraulic pistons each of which is operable to perform one of said movements and has an engaging roller rigidly connected thereto, a hy-

draulic system operable to apply pressure to said pistons, slide valve means in controlling relation to said hydraulic system, a pair of axially fixed control rollers in controlling relation with said slide valve means, said control rollers being connected for interdependent rotation and arranged to cooperate each with one of said pistons, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising a plurality of pairs of end stops axially adjustably mounted on each of said control rollers, the stops of each pair having an oblique engaging surface each which faces the oblique engaging surface of the other stop of the pair, said control rollers being rotatable to move said pairs of end stops successively into the path of the engaging rollers of said pistons for limiting the movement thereof by the engagement of said engaging rollers with said oblique engaging surfaces, whereby a rotary control impulse is imparted to said control rollers, a hydraulically operable system operatively connected to said control rollers to rotate the same, and second slide valve means in controlling relation to said hydraulically operable system and responsive to said control rollers to rotate upon predetermined rotary control impulses said hydraulically operable system to rotate said control rollers sufficiently for moving the next successive pair of stops on each control roller into the path of the respective piston.

4. A control system for the automatic control of two movements in dependence of either of them, which comprises, in combination, two hydraulic pistons each of which is operable to perform one of said movements, a hydraulic system operable to apply pressure to said pistons, slide valve means in controlling relation to said hydraulic system, a pair of control rollers connected for interdependent rotation and in controlling relation to said slide valve means, each of said control rollers being arranged to cooperate with one of said pistons, stops having an oblique engaging surface arranged on each of said control rollers in the path of the piston arranged to cooperate therewith and limiting the movement of said piston and adapted to impart a rotary control impulse to said rollers upon engagement of said pistons with said engaging surfaces, a shaft carrying one of said rollers and a ratchet wheel, a pinion connected to said shaft for rotation therewith in only one direction, a shift piston having a piston rod carrying a rack in mesh with said pinion, a second hydraulic system operable to apply pressure to either side of said shift piston, and a ratchet wheel slide valve in controlling relation with said second hydraulic system and in continuous engagement with said ratchet wheel to be moved thereby into any of two control positions, in each of which it causes the admission to one side of said shift piston.

5. A control system as set forth in claim 4, which comprises an adjustable throttle and in which said shift piston is movable in a forward direction to rotate said pinion in the direction in which it is connected for rotation with said shaft, and in a reverse direction, whereas said ratchet wheel slide valve is in controlling relation with said second hydraulic system through the intermediary of an intermediate slide valve in controlling relation to said second hydraulic system and movable into either of two control positions in one of which it admits to said shift piston in said forward direction through said adjustable throttle and in the other of which it admits to said shift piston in said reverse direction, and of a third hydraulic system operable to apply pressure to either side of said intermediate slide valve to move it to either of said control positions and controlled by said ratchet wheel slide valve in dependence of the position to which the latter is moved by said ratchet wheel, and locking means are arranged to interlock automatically with the intermediate slide valve in its position in which it admits to the shift piston in the reverse direction, said locking means in said interlocking position extending in the path of said shift piston at the end of its return movement to be moved out of said interlocking position by the returning shift piston.

6. A control system as set forth in claim 4, in which said shift piston is movable in a forward direction to rotate said pinion in the direction in which it is connected wth said shaft, and a in a reverse direction, and which comprises an adjustable throttle connected in said second hydraulic system to the side of the shift piston admitting in said forward direction, an unthrottled pressure line connected to the same side of said shift piston, and a tooth extension member mounted on said ratchet wheel and adapted to displace said ratchet wheel slide to a third control position, in which it admits to said shift piston through said unthrottled pressure line.

7. A conrol system for the automatic control of two movements in dependence of either of them, which comprises, in combination, two hydraulic pistons, each of which is operable to perform one of said movements, a pair of control rollers connected for interdependent rotation and arranged to cooperate each with one of said pistons, two shafts each of which carries one of said rollers and a disk having a plurality of adjustable abutment members projecting by different distances, two hydraulic systems each of which is operable to apply pressure to one of said pistons, two slide valves each of which is in controlling relation to one of said two hydraulic systems and in engagement with the abutment members on one of said disks, said slide valves being movable into any of several control positions in dependence of the distance of projection of the abutment members with which they are in engagement, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising stops arranged on each of said control rollers in the path of the piston associated therewith and limiting the movement of said piston.

8. An automatic control system for a forging machine which comprises a gripping head for holding the workpiece and for turning and axially moving the same, forging tools arranged around the axis of said gripping head and movable radially relative to said axis, eccentrics in driving relation with said forging tools to move them into the workpiece, and rotary eccentric bearing bushings in controlling relationship to said eccentrics to adjust the penetration of said forging tools into the workpiece, said control system comprising, in combination, a first hydraulic piston operatively connected to said gripping head to move it in its axial direction, a second hydraulic piston operatively connected to said eccentric bearing bushings to adjust the penetration of said forging tools, a pair of control rollers connected for interdependent rotation and associated each with one of said pistons, two shafts each of which carries one of said rollers and a disk having a plurality of adjustable abutment members projecting by different distances, a fourth hydraulic system operable to apply pressure to the first piston in a forward direction toward and in a reverse direction from the forging tools, a fifth hydraulic system operable to apply pressure to the second piston in a closing direction corresponding to a deeper and in an opening direction corresponding to a smaller penetration of the forging tools, first and second slide valves in controlling relation with said fourth and fifth hydraulic systems, respectively, sixth and seventh hydraulic systems operable to urge said first and second slide valves, respectively, each into engagement with the abutment members on one of said disks, said slide valves being movable into any of several control positions in dependence of the distance of projection of the abutment members with which they are in engagement, a starting slide valve in controlling relation with said fifth, sixth and seventh hydraulic systems and movable between two end positions in the first of which it admits to said second piston in the opening direction and in the other of which it admits to said first slide valve to urge it into engagement

with said abutment members on the respective disk, resilient means connected to said starting slide valve and in equilibrium when said starting slide valve is in a mid-position in which it admits from said first and second slide valves to permit them to be urged against the abutment members on said respective disks, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising pairs of stops arranged on said control rollers at mutually opposite ends of the path of the pistons associated therewith and limiting the movement of said pistons.

9. A control system as set forth in claim 8, in which the starting slide valve is in controlling relation to the fourth hydraulic system to admit in said first position from said first piston in said reverse direction.

10. A control system as set forth in claim 8, which comprises a piston rod connected between the gripping head and the side of the first piston admitting in the reverse direction, a first adjustable throttle admitting to said piston in said reverse direction, and a second adjustable throttle, and in which said first slide valve is movable into any of four control positions in dependence of the distance of projection of the abutment member with which it is in engagement, and in the first and second of said positions admits to said first piston in said forward direction to overcome the pressure admitted thereto through said first throttle, and in the third and fourth of said positions closes the admission to said first piston in the forward direction, whereas in the second and fourth of said positions it admits from said first piston in the forward direction and to said first piston in the reverse direction, respectively, through said second throttle.

11. A control system as set forth in claim 8, in which said fifth hydraulic system comprises a third adjustable throttle, first and second unthrottled lines, and in which said second slide valve is movable into any of three control positions in dependence of the distance of projection of the abutment member with which it is in engagement, and in the first of said positions admits to said second piston in said opening direction and admits from said second piston through said first unthrottled line, and in the second and third of said positions admits to said second piston in the closing direction and admits from said second piston through said third throttle, whereas in the third of said positions it admits additionally from said second piston through said second unthrottled line.

12. A control system as set forth in claim 8, which comprises a piston rod connected between the gripping head and the side of the first piston admitting in the reverse direction, a first adjustable throttle admitting to said piston in said reverse direction, a second adjustable throttle, a manually adjustable three-way cock in series with said first adjustable throttle, a pressure line, and a return line, said three-way cock in one position admitting to said first piston from said pressure line, in a second position admitting from said first piston to said return line, and in a third position shutting off said first piston from said pressure and return lines, and in which said first slide valve is movable into any of four control positions in dependence of the distance of projection of the abutment member with which it is in engagement, and in the first and second of said positions admits to said first piston in said forward direction to overcome the pressure admitted thereto through said first throttle, and in the third and fourth of said positions closes the admission to said first piston in the forward direction, whereas in the second and fourth of said positions it admits from said first piston in the forward direction and to said first piston in the reverse direction, respectively, through said second throttle.

13. A control system for the automatic control of two movements in dependence of either of them, which comprises, in combination, two hydraulic pistons, each of which is associated with one of said movements, a pair of control rollers connected for interdependent rotation and associated each with one of said pistons, two shafts each of which carries one of said rollers and a disk having a plurality of adjustable abutment members projecting by different distances, two hydraulic systems each of which is operable to apply pressure to one of said pistons, two slide valves, each of which is in controlling relation with one of said hydraulic systems, two additional hydraulic systems operable to urge said first and second slide valves, respectively, each into engagement with the abutment members on one of said disks, said slide valves being movable into any of several control positions in dependence of the distance of projection of the abutment members with which they are in engagement, a shut-off slide valve in controlling relation with said hydraulic system operable thus to urge said first slide valve and in engagement with the abutment members on one of said disks, one of the abutment members on said last-mentioned disk being longer than the others and adapted to move said shut-off slide valve to an effective position in which it shuts off said last-mentioned hydraulic system from said first slide valve and admits fluid from said first slide valve, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising stops arranged on each of said control rollers in the path of the piston associated therewith and limiting the movement of said piston.

14. An automatic control system for a forging machine which comprises a gripping head for holding the workpiece and for turning and axially moving the same, forging tools arranged around the axis of said gripping head and movable radially relative to said axis, eccentrics in driving relation to said forging tools to move them into the workpiece, and rotary eccentric bearing bushings in controlling relationship to said eccentrics to adjust the penetration of said forging tools into the workpiece, said control system comprising, in combination, a first hydraulic piston operatively connected to said gripping head to move it in its axial direction, a common central gear operatively connected to the eccentric bearing bushings to rotate the same, a rack, an intermediate pinion in mesh with said rack and operatively connected to said central gear, a second hydraulic piston rigidly connected to said rack, a template cylinder in mesh with said intermediate pinion, a curve template on said template cylinder, a roller follower rigidly connected with the gripping head and in engagement with said curve template to rotate the template cylinder and thus set the penetration of said forging tools through the intermediary of said template cylinder, intermediate pinion and central gear in dependence of the shape of said template and the axial movement of the gripping head, and means for initiating, stopping, and reversing the movement of both pistons, said last-mentioned means comprising a hydraulic system operable to apply pressure to said pistons, slide valve means in controlling relation to said hydraulic system, a pair of control rollers connected for interdepent rotation and in controlling relation with said slide valve means, each of said control rollers being associated with one of said pistons, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising pairs of stops arranged on said control rollers at mutually opposite ends of the path of the pistons associated therewith and limiting the movement of said pistons.

15. An automatic control system for a forging machine which comprises a gripping head for holding the workpiece and for turning and axially moving the same, forging tools arranged around the axis of said gripping head and movable radially relative to said axis, eccentrics in driving relation to said forging tools to move them into the workpiece, and rotary eccentric bearing bushings in controlling relation to said eccentrics to adjust the penetration of said forging tools into the workpiece, said con-

trol system comprising, in combination, a first hydraulic piston operatively connected to said gripping head to move it in its axial direction, a second hydraulic piston operatively connected to said eccentric bearing bushings to adjust the penetration of said forging tools, a pair of control rollers connected for interdependent rotation and associated each with one of said pistons, a fourth hydraulic system operable to apply pressure to the first piston in a forward direction toward and in a reverse direction from the forging tools, a fifth hydraulic system operable to apply pressure to the second piston in a closing direction corresponding to a deeper and in an opening direction corresponding to a smaller penetration of the forging tools, first and second slide valves in controlling relation with said fourth and fifth hydraulic systems, respectively, a slide valve adjusting member for each of said slide valves, said slide valve adjusting members being operatively connected to said control rollers and operable thereby to adjust the respective slide valve independently of the other to admit to said first piston in either of said forward and reverse directions and to admit to said second piston in either of said closing and opening directions independently of the direction of admission to the respective other piston, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising pairs of stops arranged on said control rollers at mutually opposite ends of the path of the pistons associated therewith and limiting the movement of said pistons.

16. A forging machine for the rapid forging of axially symmetric workpieces, which comprises, in combination, a gripping head for holding the workpiece and for turning and axially moving the workpiece, said gripping head comprising a casing having a top stop, a sleeve rotatably mounted in said casing and carrying gripping jaws axially fixed and connected for rotation with said sleeve and radially movably mounted therein, drive means operatively connected to said sleeve to rotate the same relative to said casing, buffer means between the top end of the sleeve and said top stop, pressure applying means operatively connected to said sleeve and operable to exercise thereon a resilient upward force relative to the casing, connecting means connecting said pressure applying means with said gripping jaws for transmitting a radially inwardly directed component of force from said pressure applying means to the gripping jaws, second pressure applying means operatively connected to said sleeve for applying thereon a downwardly directed force relative to said casing and operatively disconnected from said connecting means, and buffer means interposed between said drive means and sleeve to provide a resilient drive connection therebetween, said machine further comprising forging tools arranged below said gripping head around the axis thereof and movable radially relative to said axis, eccentrics in driving relation to said forging tools to move them into the workpiece, rotary eccentric bearing bushings in controlling relation to said eccentrics to adjust the penetration of said forging tools into the workpiece, and an automatic control system which comprises a first hydraulic piston operatively connected to said gripping head to move it in its axial direction, a second hydraulic piston operatively connected to said eccentric bearing bushings to adjust the penetration of said forging tools, a pair of control rollers connected for interdependent rotation and associated each with one of said pistons, a fourth hydraulic system operable to apply pressure to the first piston in a forward direction toward and in a reverse direction from the forging tools, a fifth hydraulic system operable to apply pressure to the second piston in a closing direction corresponding to a deeper and in an opening direction corresponding to a smaller penetration of the forging tools, first and second slide valves in controlling relation with said fourth and fifth hydraulic systems, respectively, a slide valve adjusting member for each of said slide valves, said slide valve adjusting members being operatively connected to said control rollers and operable thereby to adjust the respective slide valve independently of the other to admit to said first piston in either of said forward and reverse directions and to admit to said second piston in either of said closing and opening directions independently of the direction of admission to the respective other piston, and shift means for rotating said control rollers in response to predetermined movement of either of said pistons, said shift means comprising pairs of stops arranged on said control rollers at mutually opposite ends of the path of the pistons associated therewith and limiting the movement of said pistons.

17. A forging machine as set forth in claim 16, which comprises tool driving means operatively connected through said eccentrics to said forging tools to operate them to perform blows on the work at regular intervals of time, and in which said buffer means interposed between said drive means and sleeve are springs of such dimensions and resiliency as to offset fully the torque of said drive means and thus to interrupt the rotation of the work at the time of such blows.

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