

Jan. 15, 1963

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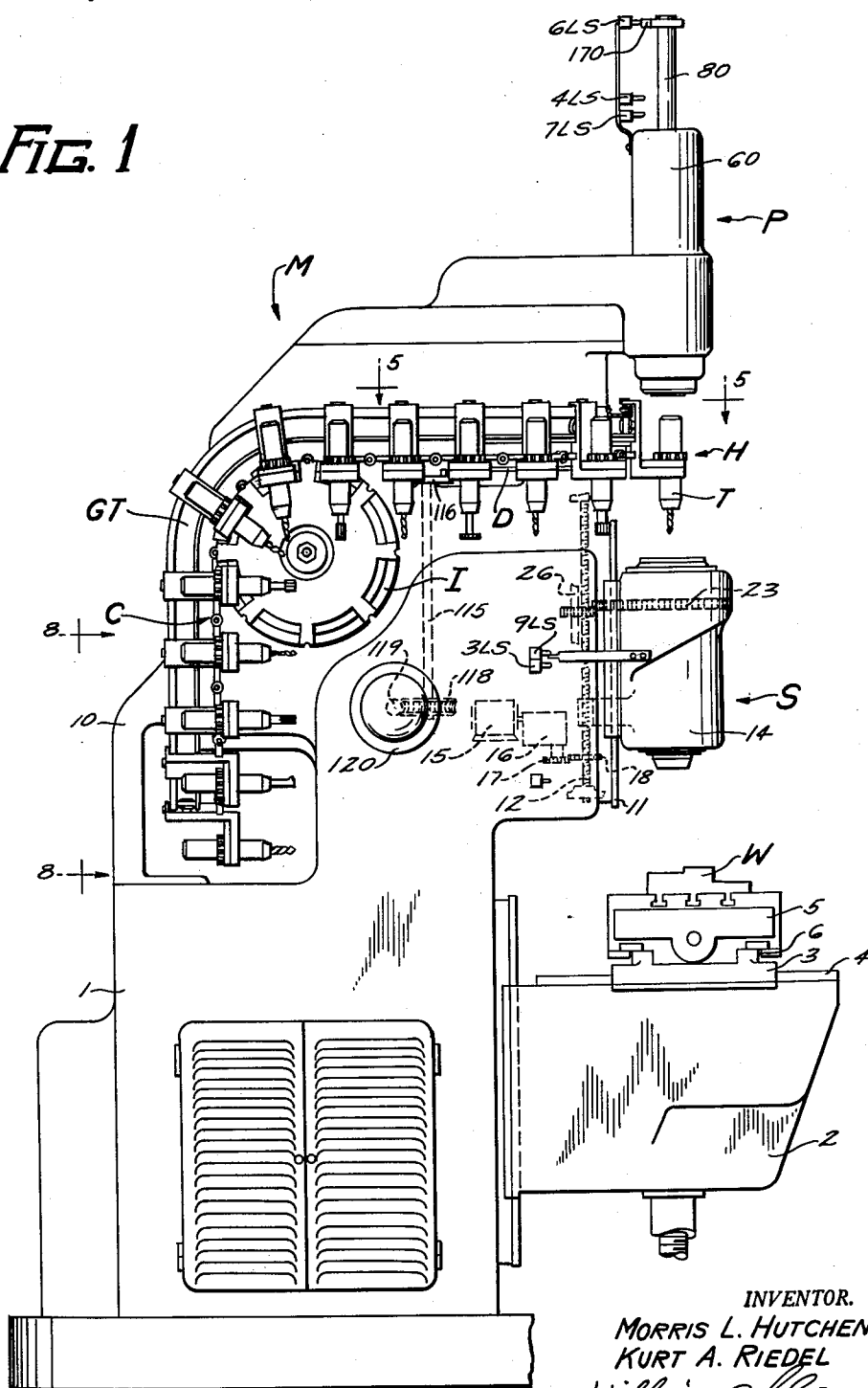
3,073,024

METAL WORKING MACHINE

Filed July 24, 1961

7 Sheets-Sheet 1

FIG. 1



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FIG. 3

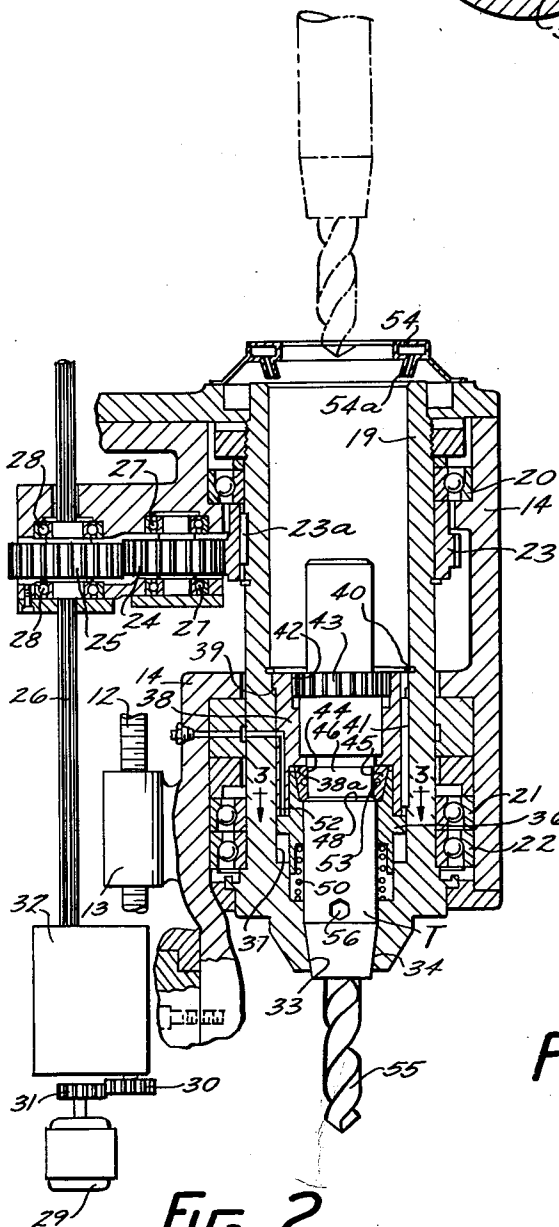
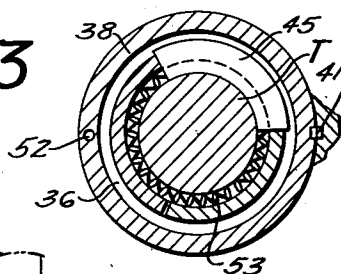


FIG. 2

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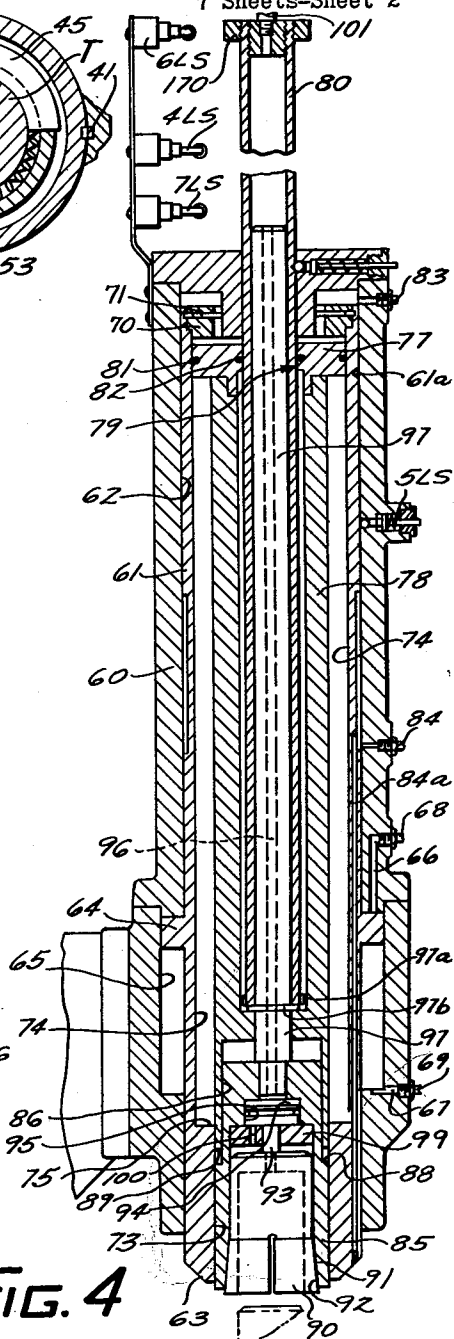


FIG. 4

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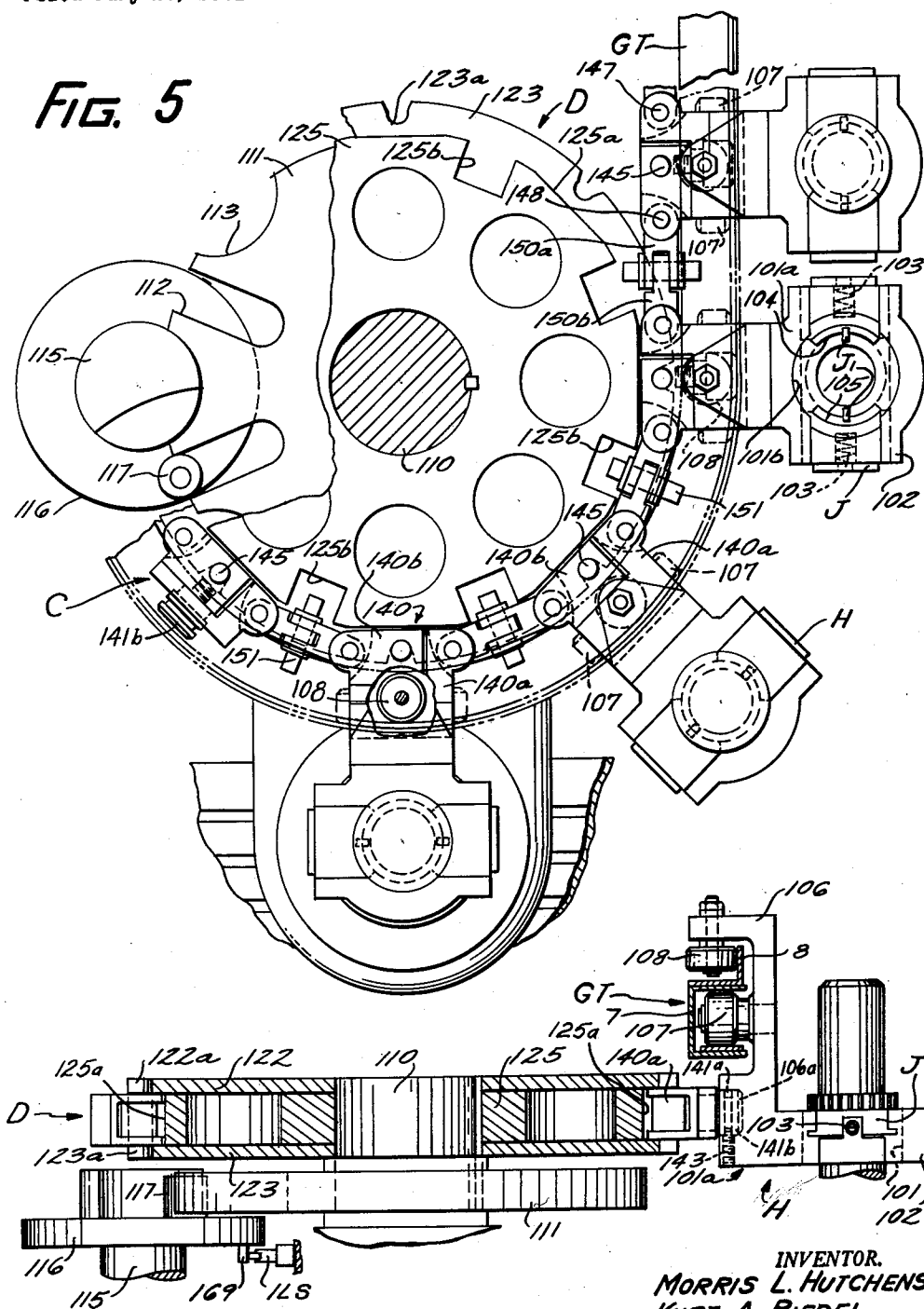
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FIG. 7

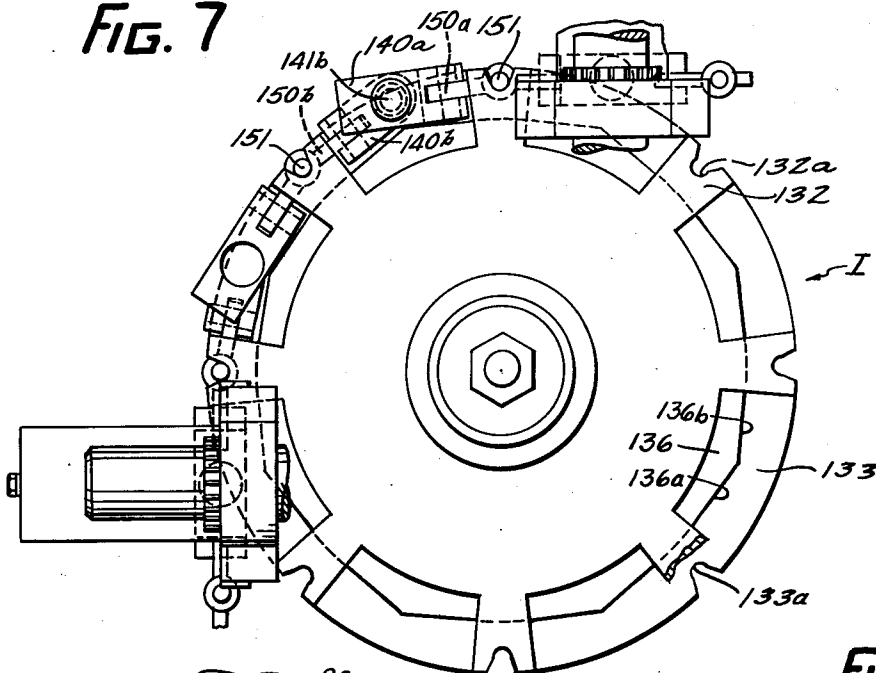


FIG. 8

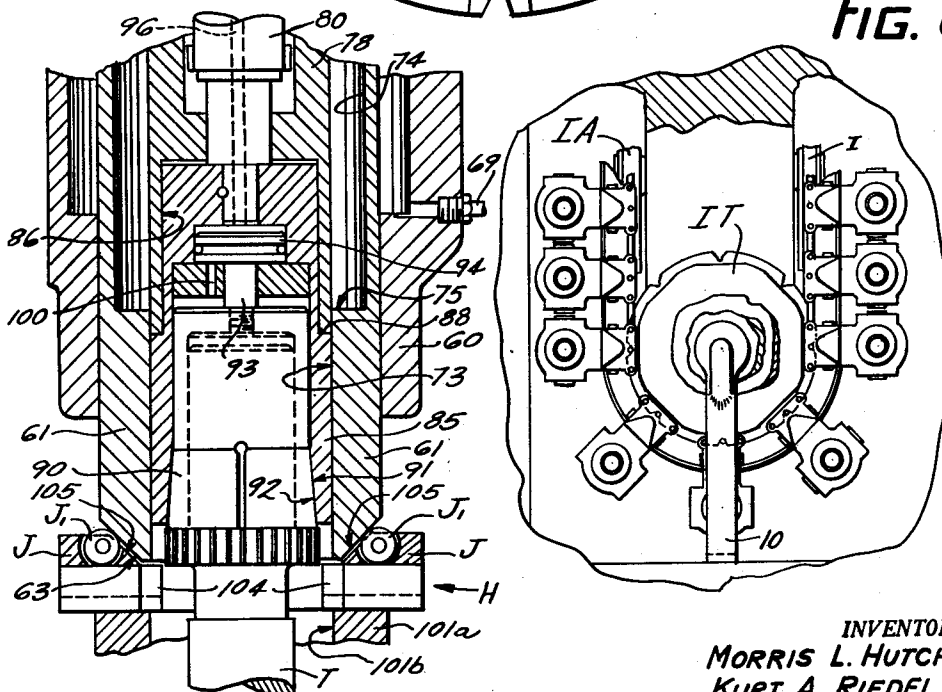


FIG. 9

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7 Sheets-Sheet 6

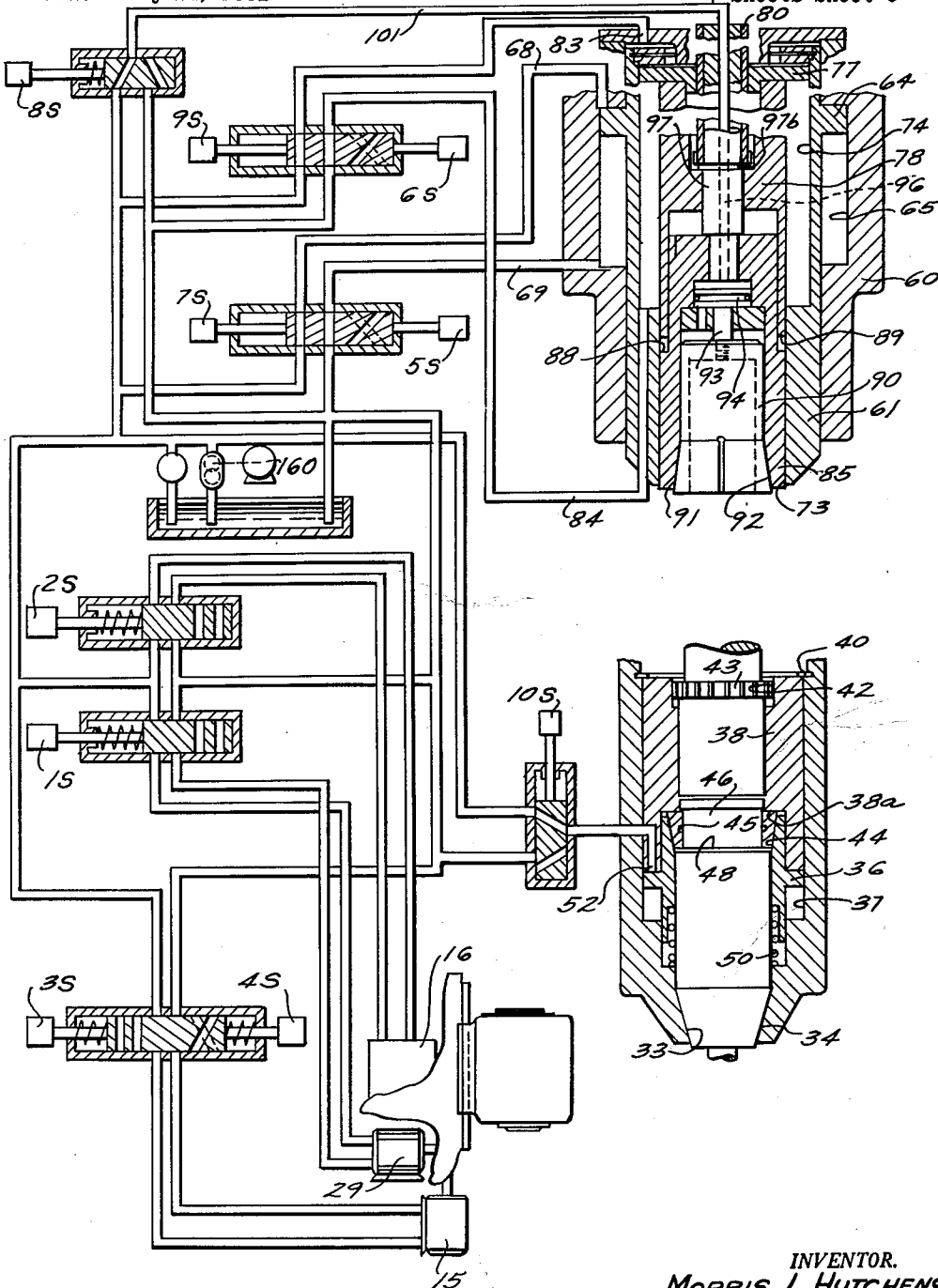


FIG. 11.

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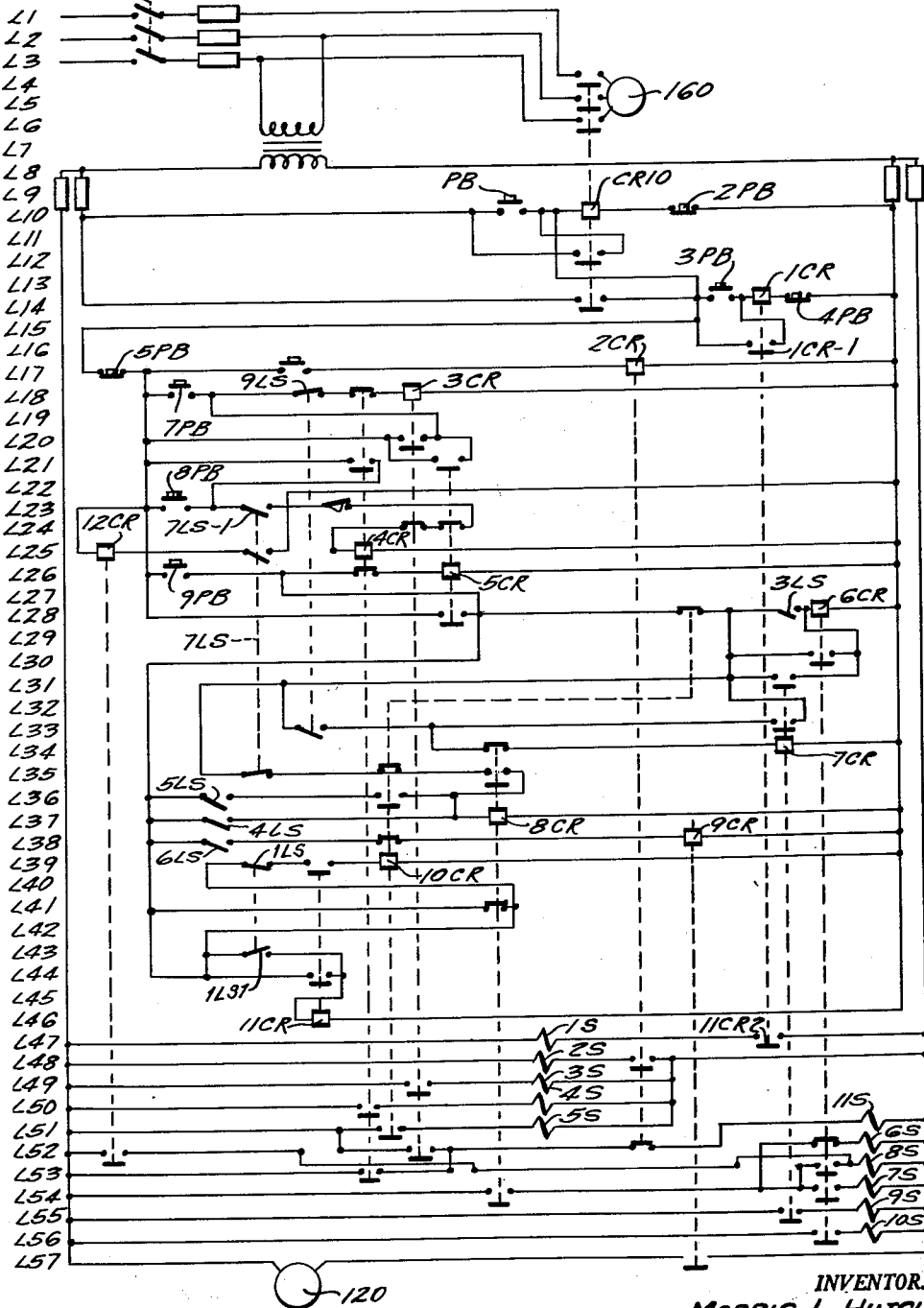


FIG. 12.

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3,073,024

METAL WORKING MACHINE

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Filed July 24, 1961, Ser. No. 134,555
20 Claims. (Cl. 29—568)

The present invention relates generally to metal working machines utilizing an endless chain for carrying a plurality of tools to and from an area where they are successively used for performing various operations on a workpiece.

One aspect of the present invention relates to a machine of the above type having an arrangement and construction of the various cooperating, component parts which result in a rapid sequence of particularly efficient tool loading and unloading operations.

The present invention also provides an improved conveying chain for storing various tools and for presenting them, one at a time, to the work performing station. The improved chain provides exceptional flexibility whereby it can travel in planes which are mutually perpendicular to one another. Furthermore, the improved chain arrangement provides exceptionally good stability for itself and for the tool carried thereby which is important in being able to quickly, positively, and precisely shift the tool out of its holding chain, insert it into an operating spindle, and subsequently return the tool to its storage position in the chain mechanism.

Another aspect of the present invention provides a tool conveying means having improved tool holders secured along its length. These holders permit a tool positioner which is located on one side of the holder to firmly grasp the tool, pass through the tool holder, and urge the tool out the other side of the holder and into operative engagement with a tool spindle. The arrangement of the component parts and the structure of the tool holder is such that the positioner can pass through the holder to deliver the tool to the spindle, then release the tool and after the tool has performed its operation on the workpiece, the positioner can again grasp the tool and retract itself through the holder, and thereby carry the tool back into the holder where it is again held in the storage position.

Still another aspect of the present invention relates to an improved tool positioner for use with a tool holder of the above type.

Another aspect of the present invention relates to an improved "pass through" tool spindle head into which the tool is inserted from one end, passed through the spindle, and then partially emerges from the opposite end of the spindle for engagement with the workpiece which is located adjacent said opposite end of the spindle. This aspect of the invention also contemplates the use of a novel, hydraulically operated locking means for preventing axial shifting of the tool in the spindle while performing its operation on the workpiece.

These and other objects and advantages of the present invention will appear hereinafter as this disclosure progresses, reference being had to the accompanying drawings, in which:

FIGURE 1 is a side elevational view of a machine embodying the present invention;

FIGURE 2 is a side elevational view, in section, of a portion of the machine as shown in FIGURE 1, namely, the spindle head and drives therefor, the view being on an enlarged scale and with certain parts removed or broken away for clarity of the drawings;

FIGURE 3 is a horizontal, cross-sectional view taken generally along line 3—3 in FIGURE 2 and through the

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collet, the view being on an enlarged scale, certain parts being shown as broken away or removed for clarity;

FIGURE 4 is a sectional, side elevational view of another portion of the machine as shown in FIGURE 1, namely, the tool positioner, the view being on an enlarged scale;

FIGURE 5 is a fragmentary plan view taken generally along line 5—5 in FIGURE 1, but on an enlarged scale, certain parts being shown in section, broken away, or removed for the sake of clarity;

FIGURE 6 is a fragmentary, elevational view of the mechanism shown in FIGURE 5, certain parts being removed, in section, or broken away;

FIGURE 7 is a side elevational view of a portion of the machine as viewed in FIGURE 1, but on an enlarged scale, certain parts being removed, broken away, or in section;

FIGURE 8 is a rear elevational view of a portion of the machine shown in FIGURE 1 and taken generally from line 8—8 in that figure;

FIGURE 9 is an enlarged, sectional, fragmentary elevational view showing the tool grasped by the gripper of the positioner and the outer sleeve of the position acting to urge the jaws of the tool holder apart, ready for the gripper to move downwardly through the jaws;

FIGURE 10 is an enlarged, perspective, and exploded view of a portion of the novel, double pivot axis, tool conveying and storage chain made in accordance with the present invention and shown in certain of the other figures;

FIGURE 11 is a diagram of a hydraulic circuit for operating certain parts of the machine, and

FIGURE 12 is a diagram of an electrical circuit utilized with the present invention.

The present invention finds utility in many different types of machines which perform various operations on a workpiece in rapid succession to one another, but will be shown and described for purposes of illustration only, as used with a particular machine.

During the description of the invention, reference will be made to certain directions of movement, such as, for example, "vertically" or "horizontally" or to positions of the various parts, such as, "above" or "below" but the invention should not be limited to any particular disposition of the parts.

A brief summary at this time of the general organization and operation of the machine and its novel components will facilitate a subsequent and more complete explanation:

General Organization

The milling machine M shown in FIGURE 1 includes a column 1 having a vertically adjustable knee 2 carrying a saddle 3 that is reciprocally adjustable on ways 4 in a transverse direction in the conventional manner. A table 5 is supported on the saddle and is horizontally adjustable on way 6 in a direction normal to the saddle adjustment.

A workpiece W is quickly securable in the well-known manner to the table for having a succession of operations rapidly performed thereon.

The general organization of the machine also includes a spindle head S which is reciprocal in a vertical direction to move a tool downwardly into a working position or upwardly to a tool-changing position.

A tool positioner P is located on that side of the spindle head S opposite from the workpiece W and has an extendible chuck mechanism that can grasp a tool T and be shifted in a direction toward or away from the spindle.

Any one of a plurality of tools T is moved in to a position between the spindle head and tool positioner where it is held for engagement by the positioner. The means for accomplishing this comprises a flexible and end-

less conveying and storage mechanism which takes the form of an endless chain C having a series of improved tool holders H attached at spaced locations along its length.

The tool storage and conveyor chain C has double pivot axes, that is to say, it is flexible in two mutually perpendicular directions which enhances the versatility and flexibility of the entire tool storage, conveying, and positioning functions. As applied to the machine shown in FIGURE 1, the tool T is shown in the vertical position when in the operative station in the machine and the large drive sprocket D is in the horizontal position and chain C is trained around its periphery for travel in a horizontal plane.

The chain is also trained around a pair of idler sprockets I and IA (FIGURE 8) which are vertically positioned in planes at a right angle to the plane containing the drive sprocket, and these idlers are located on opposite sides of the machine from one another. The idler sprockets are identical in construction and serve to guide the chain in vertical planes, and they change the direction of travel of the chain from a horizontal path to a vertical one.

A fourth idler sprocket IT is journaled at the rear of the machine and is positioned in a vertical plane but at a right angle to the planes containing idlers I and IA and is also at a right angle to the plane containing the drive sprocket. Idler IT is a tensioning idler for the chain and is vertically adjustable in its mounting bracket 10.

The four sprockets are of particular construction, as will more fully appear later, so as to provide good stability to the conveyor and tools carried thereby. In addition, a continuous guide track GT is mounted to the machine frame and follows the entire path of the chain. As shown in FIGURE 6, the cross section of this track provides an outwardly facing channel 7 and also a flange 8 extending therefrom, against which certain rollers of the tool holder, to be described later, are supported and guided to give additional rigidity and stability to the tool holders.

The flexible and double pivot conveyor chain carries any one of a plurality of tools successively into the loading position between the spindle head S and tool positioner P, where it is in alignment with the direction and path of movement of the positioner and head. The tool so moved into the loading position is then fed to the spindle head by the positioner P which then releases it. More particularly, the positioner is sequentially extensible and operable to (1) grasp the upper end of the tool, (2) open the opposing jaws J of the holder, (3) push the tool downwardly out of the holder and firmly into the spindle head, and (4) release the tool. The spindle head then causes the tool to rotate and move downwardly into engagement with the workpiece. After the tool has completed its operation on the workpiece, the spindle head reverses its travel, stops rotation of the tool, and the positioner P again engages the tool as the spindle head completes its upward travel. At that time, the positioner retracts, pulling the tool upwardly and when the tool is in the holder, the holder jaws close to grasp the tool. The positioner then releases the tool and moves upwardly and clear of the path of the chain and its holders.

The chain is then indexed to place another tool in the loading position, and the above cycle is then repeated. The entire cycle is rapid and to do so with dependability and without mal-function requires accurate positioning and holding of the tools, and precise timing of operation of the various components.

A more detailed description of the invention will now be made in reference to the drawings in which one of its forms has been illustrated.

Spindle Head and Tool

The spindle head S is generally of open center con-

struction, that is to say, it is unobstructed along its longitudinal center portion. This head is mounted on the front side of column 1 on suitable ways 11 for reciprocation in a vertical direction by conventional means which need no detailed description for purposes of this disclosure. It is believed sufficient to say that a feed screw 12 (FIGURES 1 and 2) is threadably engaged in a projection 13 formed integrally with the housing 14. A reversible motor 15 (FIGURE 1) can rotate the feed screw 12 in either direction through the gear box 16, and the meshing gears 17 and 18. The head is thereby driven in either direction by the motor 15.

A tubular spindle 19 (FIGURES 2 and 12) is journaled in the housing 14 on antifriction bearing assemblies 20, 21, and 22 and can be rotatably driven through the ring gear 23 rigidly secured around its periphery by a key 23a, which gear is in constant mesh with gear 24. Another gear 25 is in constant mesh with gear 24 and has a splined shaft 26 slidable therein for driving rotation therewith. Gears 24 and 25 are suitably journaled in pairs of antifriction bearing units 27 and 28, respectively, mounted in spindle housing. The rotative driving force for the spindle and its tool is furnished by a motor 29 through suitable gears 30, 31, gear box 32, and shaft 26 extending from the gear box.

With the above arrangement, as the spindle head is moved vertically, the gear 25 slides along shaft 26 maintaining its driven relationship therewith in the known manner and causing rotation of the spindle and tool.

At its lower end, the spindle has a tapered opening 33 which forms a wedging seat for a complementary tapered, external nose 34 of the tool T.

A hydraulically operated, tubular piston 36 is reciprocable in the bore 37 of the spindle. A tubular member 38 is held captive in the bore by the shoulder 39 and snap ring 40. A key 41 prevents the member 38 from rotating in the bore and relative to the spindle, and a set of internal teeth 42 around and adjacent the upper end of this member mesh with the external teeth 43 fixed on the periphery of the tool. The member 38 has an internal shoulder 38a for a purpose that will appear later.

In this manner, the tool can be pushed downwardly and directly through the piston 36 and tubular member 38, and the gear teeth 42 and 43 are slid into mesh with one another for driving engagement between the tool and spindle. When the tool is fully in place, the tapered surfaces 33 and 34 are firmly abutted together, and the tool extends from the working end of the spindle for engagement with the workpiece.

Releasable locking means are provided for firmly holding the tool in the working position within the spindle, as follows. The upper end of the piston 36 has a tapered bore 44 which engages the complementary external taper formed around the periphery of a segmental locking ring 45. The segments of this ring encircle and engage a diametrically reduced portion 46 of the tool and prevent the tool from shifting axially upwardly when it engages the work. This axial locking is provided by the ring being inserted tightly around the tool and between the previously mentioned shoulder 38a in member 38, and an external shoulder 48 formed on the tool periphery by the reduced portion 46.

A spring 50 in the spindle urges the piston upwardly and its internal tapered surface 44 against the external tapered surface of the segmental ring to consequently urge the latter inwardly between shoulders 38a and 48. The spring 50 thereby serves to normally bias the piston and ring into their locking positions.

Consequently, the tool is rigidly held at two axially spaced locations, namely, at its tapered nose and also at its reduced diameter portion.

Means are also provided for positively and quickly unlocking the ring and this is accomplished by introducing pressure fluid via passageway 52 extending through

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the spindle and its housing, to thereby shift the piston out of locking engagement with the ring 45. A garter spring 53 located inside the segmental ring then urges it radially outwardly of shoulder 48. The hydraulically operated piston and also the garter spring act to positively release the tool for axial withdrawal from the spindle.

Carried adjacent the upper or tool receiving end of the spindle is a tubular ring 54 having a series of jets 54a directed downwardly therefrom and into the spindle. This cleaning ring forms no part of the present invention, but it serves to direct a blast of compressed air into the spindle for cleaning debris therefrom.

The tools themselves are similar in construction to one another, except for the lowermost portion, such as the drill indicated at 55, which may be inserted in the tool and rigidly held therein by set screws 56, for example.

Tool Positioner

The tool positioner P (FIGURES 1, 4, 9, and 11) includes an elongated and vertically disposed cylindrical housing 60 fixed to the upper front side of the machine. This positioner is located in axial alignment with both that tool located in the loading position and the spindle head.

The positioner also includes an outer sleeve 61 which is reciprocable within the bore 62 of the housing and extends downwardly to terminate in a tapered nose 63. This sleeve has a piston 64 fixed to its periphery which is slidable in the larger cylinder 65 formed in the housing. Hydraulic fluid communicates with cylinder 65 on opposite sides of the piston via the housing passages 66, 67 and their respective conduits 68, 69.

At the upper, inner end of the reciprocable sleeve 61, a stop ring 70 is fixed by means of a snap ring 71. The lower internal end of the sleeve is defined by a bore 73 of smaller diameter than the main bore 74 of the sleeve, thus forming a shoulder 75 between these bores.

Mounted for reciprocation in bore 74 and between the shoulder 75 and stop ring 70 is another piston 77 fixed to an inner, reciprocable sleeve 78. The piston 77 has a central aperture 79 by means of which it is mounted on a third but smaller sleeve 80. Suitable O-rings 81 and 82 provide the conventional sliding seals for the piston 77. The other end of the sleeve 78 is slidable in and guided by the bore 73 of sleeve 61. The sleeve 78 is driven in either direction by pressure fluid introduced at opposite sides of its piston 77 via conduit 83 and via conduit 84 and its associated passageway 84a.

A collet actuator 85 is located and slidable in a bore 86 in the lower end of the sleeve 78. In addition to being slightly slidable relative to the sleeve as limited by shoulders 88, 89, the actuator is also reciprocable together with the sleeve in the bore 73 of the outer sleeve 61.

A spring jaw collet 90 is carried in the actuator and has an external taper 91 at its end which is complementary to and abutable with the internal taper 92 of the actuator.

A collet releasing means is mounted in the actuator for positively and quickly releasing the tool held by the gripping collet, as follows:

A short stem 93 is threaded into the end of the collet and a piston 94 fixed to its free end is located in the counterbore 95 of the actuator and is actuated by fluid pressure admitted through a rifle drilled passage 96 in a shaft 97 from conduit 101 secured to sleeve 80. Shaft 97, in turn, is secured by being press fitted into the top end of the actuator 85.

The downward movement of the actuator 85 is limited by a snap ring 97b secured to shaft 97.

Actuation of the piston forcibly and positively shifts the collet outwardly to thereby release the tool by relieving the gripping pressure between the tapered surfaces 91 and 92.

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The plate 99 serves to retain the piston in counter-bore 95.

A small aperture 100 in plate 99 simply serves to release any fluid from beneath the piston 94 and thereby insure proper and immediate actuation of the piston when fluid is admitted above it, via passage 96.

The sequence of movement of the parts of the positioner will now be briefly referred to, commencing at the beginning of a tool loading operation.

Generally, the inner or second sleeve 78 moves downwardly together with the outer or first sleeve 61 during the initial movement of the positioner in the loading direction, which movement is a relatively short stroke. Then, the shaft 97 moves together with its actuator 85 and sleeve 78 as a unit, although slight relative cushioning movement is permitted between the actuator and sleeve 78.

More specifically, when the positioner movement is to commence, pressure fluid is admitted through conduit 68 to urge the sleeve 61 downwardly which, through its stop ring 70, carries with it the sleeve 78, actuator 85, and shaft 97. As these sleeves move downwardly, the tool is grasped by the collet. During this interval, the collet slides upwardly and is frictionally engaged by the actuator to positively grip the tool. Immediately after the tool is firmly grasped by and bottomed in the collet, continued downward movement causes the tapered nose 63 to engage the jaws J of the tool holder H, urging the jaws apart to a tool release position. This position is shown in FIGURE 9. At this time, sleeve 61 has reached the lower limit of its travel and fluid pressure in passage 83 and behind piston 77 causes sleeve 78 to continue to move downwardly, thereby pushing the tool downwardly as the sleeve 78 passes through the holder jaws. The length of the stroke of sleeve 78 is sufficient to permit it to shove the tool firmly into the spindle, as shown in FIGURE 2. When the sleeve 78 has moved down sufficiently, its piston 77 contacts an abutment 97a fixed to the lower end of sleeve 80, thereby acting to hold sleeve 80 down when fluid pressure is admitted via conduit 101 and to the interior of the top end of sleeve 80. When fluid is so introduced and passes through the drilled passage 96, the tool T is positively released by this fluid pressure actuating on piston 94 which shifts the collet 90 outwardly to release its gripping pressure.

Tool Holder

The tool holder H has a generally L-shaped body 101a when viewed from the side, as in FIGURE 6, and has a pair of oppositely facing and mutually cooperable jaws J, one located on each side of an opening 101b in the body. These jaws are reciprocable in the outwardly extending, tool receiving flange 102 of the holder, and a spring 103 biases each of the jaws toward one another into the tool holding position. The inner or adjacent ends 104 of the jaws are arcuate in form, as shown clearly in FIGURE 5, and act to encircle and firmly engage the annular groove 46 (FIGURE 2) around the tool. These arcuate ends of the jaws also have a beveled or tapered top edge 105 (FIGURE 9) having a plurality of rollers J1 journaled in the jaws and extending slightly above the edge 105. These antifriction rollers are thereby engaged by the tapered nose 63 of the positioner, for opening the jaws by urging them apart.

The tool holder also has another flange 106 containing an aperture 106a (FIGURES 6 and 10) which forms a means in the body 101a by which the holder is pivotally secured to the flexible and endless conveyor chain C. The flange 106 also serves as a mounting for a pair of rollers 107 and another roller 108 disposed for rotation about an axis which is at a right angle to that of rollers 107. Rollers 107 are located in and travel along the outwardly facing channel 7 and act to support the weight of the holder, tool, and a portion of the weight of the

chain. This pair of rollers also acts to provide lateral stability for the holder, that is, they prevent tilting to the left or right, as viewed in FIGURE 9.

Roller 108 bears against the inner side of flange 8 and acts together with the sprocket-supported chain to provide good lateral stability for the holder and tool in the other direction, namely, they prevent tilting from left to right, as viewed in FIGURE 6.

Sprockets for Endless Chain

The sprockets, now to be described, are also constructed to furnish good stability for the chain and holders regardless of their position, and at the same time permit flexibility of the chain in the intended directions.

Referring to FIGURES 1, 5, and 6, the drive sprocket D is fixed to the shaft 110 suitably journaled for rotation in the main frame of the machine M. Also secured to shaft 110, and directly below the sprocket D, is a Geneva drive wheel 111 having the conventional radial slots 112 and arcuate serrations 113 around its periphery. This Geneva drive is conventional and well known, and for purposes of this disclosure it is sufficient to say that the shaft 110 and its sprocket are rotatably driven in increments, that is, the Geneva drive can index each tool holder in the loading position where it is in alignment with the positioner and spindle, as previously described. This intermittent motion provided by the Geneva drive results from the rotation of the main drive shaft 115 and the driving plate 116 fixed thereto. A follower 117 is rotatably mounted on the plate and serves to enter the slots 112 and drive the wheel 111 until the follower 117 again emerges from the slot. As shown in FIGURE 5, and as indicated by the curvilinear arrows, the period of dwell has just terminated and the follower 117 is about to commence the next indexing movement. The power for rotating the drive shaft is through its gear 118 (FIGURE 1), and worm gear 119, and from the electric motor 120 carried in the machine.

Referring again to the drive sprocket D, (FIGURES 5 and 6) it includes a pair of spaced apart plates 122 and 123 (plate 122 has been removed from FIGURE 5 for clarity) arranged in parallelism and having open-ended openings or slots 122a and 123a, respectively, around their periphery. These slots or openings are equally spaced, and those of one plate are in alignment with those in the other plate. These drive openings engage complementary pins, to be described, of the chain C.

In between the plates 122, 123 is a stabilizing or back-up plate 125 of greater thickness but of a smaller diameter than the plates 122, 123.

These three plates are all secured to shaft 110 for rotation therewith as a unit. Plate 125 has a series of flat surfaces 125a formed around its periphery, against which an articulated link, to be described, abuts and is supported and stabilized thereby. It will be noted, by referring to FIGURE 5, that one stabilizing surface 125a is provided adjacent each pair of drive openings 122a and 123a. In between each of the surfaces 125a, the plate 125 also has a rectangular, open-ended opening or recess 125b which is adapted to provide clearance for and receive a pivot pin (to be described) of the chain C.

The idler and tensioning sprocket IT, FIG. 8, is generally of the same construction as the drive sprocket in that it also has a pair of plates 122, 123 and an intermediate plate 125. The sprockets D and IT can be similar in this respect because the endless chain C flexes in the same manner as it travels around either of these sprockets.

The two idler sprockets I and IA (FIGURES 1 and 7) are similar to one another but are necessarily different from sprockets D and IT because the chain flexes in a different direction when travelling around these sprockets. That is to say, the chain uses a different set of its pivotal axes, as will appear, because it is turning in a different direction. Only one of the idler sprockets will be de-

scribed, it being understood that they are similar. These idler sprockets have a pair of spaced plates 132, 133, each with aligned peripheral notches 132a, 133a, respectively, similar to the arrangement for sprocket D, but for engaging a different set of pivot pins (to be described) of the chain. The idler sprockets also each have an intermediate plate 136 having a series of pairs of beveled surfaces 136a and 136b against which two separate parts of the articulated link (to be described) are adapted to be stabilized.

Tool Storage and Conveying Chain

The chain C is comprised of a main link 140 (shown best in FIGURES 5, 6, and 10) which, in turn, has two parts 140a and 140b that are pivotally connected together about a stub shaft 141 threaded into part 140b and on which shaft the parts 140a is rotatable. Part 140a is generally L-shaped while part 140b is generally rectangular and adapted to fit within the part 140a. Part 140b has a rounded end which permits clearance with part 140a when swinging relative thereto about shaft 141.

Complementary means are provided between the holder and the chain for rotatably connecting them together, as follows. Shaft 141 has an enlarged cylindrical end 141b which is rotatable in aperture 106a in the tool holder and is held captive therein by a set screw 143 which extends into an annular groove 141a formed around end 141b.

Thus, the holder H is rotatably mounted on the main link, and the latter is comprised of two parts pivotally connected together.

The main link, more particularly the part 140b thereof, has a drive pin 145 extending from both sides which is engaged in the peripheral notches 122a, 123a of the sprockets D or IT.

Each of the main link parts 140a and 140b has at its bifurcated, free end a pivot pin 147 and 148, respectively, which are positioned at a right angle to the pivot shaft 141 and parallel to drive pin 145.

A connecting or secondary link 150 serves to connect the main links together, and it is pivotally attached at its opposite ends to the respective pins 147 and 148 of adjacent links. Thus, the main links 140 can pivot with respect to one another in one plane, namely, that containing the drive sprocket D. The two parts 140a and 140b of the main links, however, cannot pivot in that plane, nor, in fact, can these parts pivot relative to one another while they are around the drive sprocket.

The secondary link 150 is actually a compound one, being comprised of sections 150a and 150b connected, respectively, to parts 140a and 140b of the main link. Sections 150a and 150b are connected together at their adjacent ends by pin 151 for relative pivotal movement therebetween, and on an axis parallel to that formed by shaft 141 of the main link.

Pins 151 are engaged by the peripheral notches 132a and 133a of the idler sprockets I and IA, for good support of the chain thereby. When these pins are travelling around sprockets D and IT, however, they then simply register in the clearance recesses 125b provided for that purpose.

As seen in FIGURE 5, when the chain is travelling around the drive sprocket D, the two parts 140a and 140b of the main link cannot pivot relative to one another and they lie closely adjacent the stabilizing surface 125a of the central plate 125. This arrangement aids in preventing tilting of the main link and the holder carried thereby.

When the chain is travelling around the idler sprockets I and IA and flexing in another direction, then the parts 140a and 140b of the main link do pivot relative to one another, and they then lie closely adjacent their respective surfaces 136a and 136b of the central plate 136, and are thereby prevented from tilting.

As the chain travels around its sprockets, the rollers form a connection with the guiding and supporting rail GT, more particularly with the channel 7 and flange 8

thereof, to provide good lateral stability in two directions and also act to support the weight of the tool conveying and storage mechanism.

Hydraulic and Electrical Diagrams

FIGURES 11 and 12 illustrate one form of hydraulic and electrical circuitry which are useable with the present invention, and reference will be made thereto in describing one cycle of operation:

To start the machine, the master start switch PB is manually depressed which energizes relay CR10 to start the hydraulic pump motor 160, thus creating fluid pressure in the hydraulic system.

Assume, at the beginning of a cycle, that the spindle head with a tool in it is in the down or workpiece engaging position, and the tool positioner is in the extended position where it had deposited the tool in the spindle. Assume further that the machine had been turned off for some reason, and it is desired to commence operation.

Rotation of the spindle can be started or stopped, when desired, by depressing the switches 3PB or 4PB, respectively. For example, the spindle start switch 3PB is manually depressed to energize the spindle start relay 1CR which is then sealed in and held by its contact bar 1CR-1, and relay 1CR then closes the contact bar 1CR-2 to actuate solenoid 1S. Solenoid 1S then causes operation of the fluid motor 29 (FIGURES 2 and 11) and rotation of the spindle.

The "head up" switch 7PB is then pressed to energize relay 3CR and solenoid 3S is thereby actuated to cause the spindle head to go up. The head can also be caused to raise by depressing the tool change switch 9PB which energizes relay 5CR. In either event, as the spindle head rises, it contacts the limits switch 3LS carried on the main column of the machine (FIGURE 1) which acts to unclamp the tool from the spindle collet by energizing relay 6CR which energizes resiliently returnable solenoid 10S.

Continued upward movement of the spindle head causes it to push the tool into gripping relationship with the collet of the positioner and also opens the limit switch 9LS located on the machine column adjacent switch 3LS, causing upward movement of the spindle head to stop and simultaneously closes line 33 to energize relay coil 7CR which operates solenoid 9S to thereby admit fluid to conduit 84 and pull the inner sleeve 78 and the tool upwardly.

As the sleeve 78 moves upwardly through the tool holder and deposits the tool in the jaws of the holder, the limit switch 4LS mounted on the positioner housing (FIGURE 1) is closed by the dog 170 carried on the inner sleeve 80 which moves with sleeve 78. Actuation of switch 4LS does two things: (1) it causes energization of relay 8CR and solenoid 8S to permit fluid pressure to enter the center sleeve 80 via conduit 101 to thereby release the collet, and (2) it also actuates solenoid 7S to force the outer sleeve 61 upwardly to withdraw it from its contact with the tool holder jaws, thereby permitting the latter to firmly hold the tool.

The tool is now in its storage position in the chain holder where it is securely held by the holder jaws.

When the center sleeve 80 rises to its uppermost position, the dog 170 carried thereby hits limit switch 6LS to thereby energize relay 9CR (and also energizes relay 10CR as will appear) and start tool indexing by electrically energizing the Geneva drive index motor 120.

As the Geneva drive is thus indexing the chain conveyor to align another tool beneath the positioner, the Geneva cam 116 (FIGURE 6) has a dog 169 which opens switch 1LS momentarily, and it also closes the lower bar 1LS-1 of this switch to momentarily energize relay 11CR. As soon as relay 11CR is energized it "seals in" through its normally open contact bar in line 44. The contact bar in line 39 of relay 11CR has also been closed energizing relay 10CR.

Actuation of the switch 1LS sets up a sequencing circuit which: (1) advances the positioner for gripping the next

tool, (2) moves the inner sleeve to position the tool in the spindle, and (3) then releases the collet in the inner sleeve.

When the dog 170 on the positioner had closed limit switch 6LS, relay 10CR was also energized upon completion of the indexing movement which in turn energized solenoid 5S, to permit fluid to enter conduit 68, starting the outer sleeve 61 (and also sleeve 78) moving downwardly.

Initially, the sleeves 61 and 78 move downwardly together to a position shown in FIGURE 9 when the collet carried in the inner sleeve has gripped the tool and the nose of the outer sleeve than has opened the holder jaws J by pushing against the antifriction rollers J1 rotatably mounted on the jaws.

During downward movement of sleeves 61 and 78, the detent 61a (FIGURE 4) closes switch 5LS mounted on the positioner housing, thus energizing relay 8CR and causing energization of solenoid 6S to, in turn, cause the inner sleeve 78 to then move downwardly and independently of the outer sleeve to the lowermost position in the spindle head where it deposits the tool.

The collet in the positioner then releases its grip on the tool due to the dog 170 contacting limit switch 7LS as the inner sleeve reaches its lowermost position because, closing switch 7LS and its contact bar in line 25 causes energization of relay 12CR, actuation of solenoid 8S, and admission of fluid pressure via conduit 101, thereby urging the collet piston 94 to the collet release position.

The spindle head is then lowered to the workpiece by manually depressing the "head down" button 8PB. The head is capable of independent movement in either direction by simply pressing the respective "head up" button 7PB or "head down" button 8PB.

Recapitulation

The general arrangement of the improved machine utilizes a reciprocable spindle, a sequentially but continuously extensible tool positioner that moves in a direction which is in alignment with the direction of movement of the spindle. An endless and double-axis tool storage and conveying chain successively positions the tool holders and their tools in alignment with and in between the spindle and positioner.

Initial movement of the positioner acts to cause its gripper to grip the tool and its continued movement then causes another portion to release the tool from the holder. The gripper of the positioner then continues to move toward the spindle, passing directly through the tool holder, and placing the tool securely in the spindle.

At this time, the tool is released by the gripper, and the spindle grips the tool and moves it into engagement with the workpiece.

After completing its work, the tool is moved back by the spindle into gripping engagement with the gripper of the positioner. Release of the spindle locking ring then causes the tool to be freed from the spindle and moved by the retracting gripper of the positioner back into the holder. As the holder reaches its normal position in the holder, the positioner sleeve, which has acted to open and hold the holder jaws apart, then also retracts, permitting the jaws to again firmly hold the tool.

The pass-through tool holder together with the spindle and positioner relationship results in a rapid and efficient tool transfer arrangement for permitting a plurality of functions to be successively performed on a workpiece.

The conveyor chain provided by the present invention is particularly flexible and together with its guide rail provides a stable and accurate support for holding the tools in the loading position and for conveying and storage thereof.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention:

We claim:

1. A metal working machine comprising, a reciprocable spindle head, a tool positioner adjacent to one end of said head and being extensible and contractible in a direction in alignment with the reciprocatory movement of said head, a tool holder shiftably mounted on said machine for moving a tool between said positioner and head and into alignment with the said direction of movement of said positioner and head, said holder having releaseable means for holding said tool and operable by said positioner, said positioner when being extended acting to (1) grip said aligned tool, (2) engage said releaseable means, (3) move together with said tool through said holder, and (4) then continue to move said tool through one end of said head sufficiently to operatively extend from the other end of said head, said positioner when being retracted acts to withdraw said tool from said head through said one end, move back through said holder and position said tool therein, and then disengage said releaseable means.

2. A metal working machine comprising, a reciprocable spindle head, a tool positioner adjacent to one end of said head and reciprocal in a direction in alignment with the reciprocatory movement of said head, and a flexible and endless tool carrying chain mounted on said machine and having a plurality of releaseable tool holders spaced therealong, said chain being rotatably and indexably mounted for successively positioning each holder and its tool between said positioner and head and into alignment with the said direction of movement of said positioner and head, said holders each having releaseable means for holding its tool and operable by said positioner, said positioner when moving in one of its directions acting to grip said aligned tool, engage said releaseable means, move together with said tool through said holder, and then continue to move said tool through one end of said head sufficiently to operatively extend from the other end of said head, said positioner when moving in its other direction acting to withdraw said tool from said head through said one end, move back through said holder and position said tool therein, and then disengage said releaseable means.

3. A metal working machine comprising, a spindle head mounted for longitudinal reciprocation between working and tool changing positions, said head having a tool loading end and an opposite working end from which a tool can operatively protrude, a tool positioner adjacent to and in alignment with said loading end and having tool gripping means reciprocable relative to said head and in alignment with the reciprocatory path thereof, and tool carrying means mounted on said machine and having a plurality of releaseable tool holders spaced therealong, said carrying means being mounted for moving each holder and its tool into alignment with said path between said positioner and said head, said gripping means being shiftable in one direction to (1) grip said tool, (2) pass through said holder, (3) move said tool through said loading end, and (4) then into said head where it extends from said working end thereof, said gripping means also being shiftable in an opposite direction to withdraw said tool through said loading end and partially through its holder.

4. A metal working machine comprising, a spindle head having a longitudinally open center and mounted on said machine for longitudinal reciprocation between a working position and a tool changing position, said head having a tool loading end and an opposite working end from which a tool can protrude in a working position, a tool positioner mounted on said machine and adjacent said loading end of said head and in alignment therewith, said positioner having a tool gripping means shiftably mounted for reciprocal movement relative to said head and in alignment with the reciprocatory path of said head, and a flexible and endless tool carrying chain mounted on said machine and having a plurality of releaseable tool holders spaced therealong, said chain being rotatably and indexably mounted for successively positioning each holder and its tool in alignment with said path between said positioner

and said head, and gripping means being shiftable in one direction of its said reciprocal movement to grip said tool, pass through said holder, and move said tool through said loading end and into said head where it extends from said working end thereof, said gripping means also being shiftable in the other direction of its reciprocal movement to withdraw said tool through said loading end and then partially through its holder for being held thereby.

5. A metal working machine comprising, a spindle head having a longitudinally open center and mounted on said machine for longitudinal reciprocation between a working position and a tool changing position, said head having a tool loading end and an opposite working end from which a tool can protrude in a working position, a tool positioner mounted on said machine and adjacent said loading end of said head and in alignment therewith, a flexible and endless tool carrying chain rotatably mounted on said machine and having a plurality of releaseable tool holders spaced therealong, said tool holders having releaseable jaws for holding a tool, said positioner having tool gripping means and also a holder jaw actuating sleeve both mounted for reciprocal movement independently of one another and also relative to said head and in alignment with the reciprocatory path of said head, and means on said machine for successively indexing said holders into alignment with said path and between said positioner and head, whereby upon reciprocation said sleeve can actuate said jaws of an aligned holder and said gripping means can grip the tool carried by said holder and pass through the latter to deliver the tool through said head loading end for protrusion through said working end.

6. A storage and conveying chain for a plurality of tools comprising: a series of main links, each of said main links including two parts, a shaft connecting said two parts together for relative pivotal movement in one direction only and having a free end extending outwardly from one side of said main link, means on said free end for pivotal connection to a tool holder, one of said parts having a drive pin extending from opposite sides thereof and at a right angle to said shaft and for engagement with a drive sprocket; and a secondary link connecting each of said main links together, said secondary links being pivotally connected to said main links about pivotal axes which are normal to said shaft and parallel to said drive pin, said secondary links each comprised of two separate sections pivotally connected together about an axis which is parallel to said shaft and normal to said pivotal axes with said main links.

7. A storage and conveying chain for a plurality of tools comprising: a series of main links, each of said main links including a generally rectangular part having a drive pin extending from opposite sides thereof, a generally L-shaped part embracing said rectangular part, a stub shaft secured to said rectangular part and extending in a direction normal to said pin and through said L-shaped part for pivotally mounting said parts together, said shaft extending from one side of said main link and having means on its free end for pivotal attachment of a tool holder, and a secondary link connecting each of said main links together, said secondary links being pivotally connected to said main links about pivotal axes which are normal to said shaft and parallel to said drive pin, said secondary links each comprised of two separate sections pivotally connected together about an axis which is parallel to said shaft and normal to said pivotal axes with said main links.

8. As an article of manufacture, a main link for a tool conveying and storage chain comprising, a generally rectangular part having a drive pin extending from opposite sides thereof, a generally L-shaped part embracing said rectangular part, a stub shaft secured to said rectangular part and extending through said L-shaped part for pivotally mounting said parts together, said shaft extending outwardly of said main link and having means on its free end for pivotal attachment of a tool holder, and means

on each end of said main link for forming a pivotal connection with adjoining links about axes which are normal to said shaft but parallel to said drive pin.

9. A tool holder for use with an endless and flexible tool conveying chain, said holder comprising a body having an opening therethrough, releasable means carried by said body for releasably holding a tool in said opening, means in said body for rotatable attachment to said chain, and guide support means carried by said body for stabilizing and supporting said holder.

10. A tool holder for use with an endless and flexible tool conveying chain, said holder comprising a body having an opening therethrough, spring biased jaws slidably mounted on said body for releasably holding a tool in said opening, means in said body for forming a rotatable attachment with said chain, and a pair of rollers mounted on said body for rotation about mutually perpendicular axes for stabilizing and supporting said holder.

11. A storage and conveying chain having a series of main links, each of said main links including two parts, a shaft connecting said two parts together for relative pivotal movement in one direction only and having a free end extending outwardly from one side of said main link, one of said parts having a drive pin extending from opposite sides thereof and at a right angle to said shaft and for engagement with a drive sprocket; a secondary link between and connecting each of adjacent main links together; a series of tool holders for pivotal attachment along the length of said chain for movement thereby, and complementary means on each holder and on the free end of said shafts for pivotally connecting said holders to said chain.

12. A metal working machine having a tool changing station and comprising, a series of sprockets mounted on said machine for rotation in planes at right angles to one another, means for intermittently driving one of said sprockets, and a tool storage and conveying chain trained around said sprockets and having a plurality of tool holders secured along its length for successively being moved into and out of said station by said chain, said chain having mutually perpendicular pivot axes so as to flex in two directions and travel in said different planes.

13. A metal working machine having a tool changing station and comprising, a series of sprockets mounted on said machine for rotation in planes at right angles to one another, means for intermittently driving one of said sprockets, a tool storage and conveying chain trained around said sprockets and having a plurality of tool holders secured along its length for successively being moved into and out of said station by said chain, said chain having mutually perpendicular pivot axes so as to flex in two directions and travel in said different planes, a guide and supporting rail mounted on said machine and extending adjacent and coextensive along said chain, and means forming a connection between said rail and said holders whereby the latter are guided, supported, and stabilized as they are conveyed by said chain.

14. In a metal working machine having a tool changing station, a tool storage and conveying mechanism having a plurality of tool holders secured along its length for successively being moved by said mechanism into and out of said station, a tool positioner and a tool spindle located on opposite sides of said station and in alignment with a tool therein, said positioner being reciprocal and engageable with a tool in said station for moving said tool into said spindle.

15. In a metal working machine having a tool changing station, a series of sprockets mounted on said machine for rotation in planes at right angles to one another, means for intermittently driving one of said sprockets, a tool storage and conveying chain trained around said sprockets and having a plurality of tool holders secured along its length for successively being moved by said chain into and out of said station, said chain having mutually perpendicular pivot axes so as to flex in two direc-

tions and travel in said different planes, a tool positioner and a tool spindle located on opposite sides of said station and in alignment with a tool therein, said positioner having a gripper which is reciprocal and engageable with a tool in said station for moving through said holder to position said tool in said spindle.

16. In a metal working machine having a tool changing station, a tool storage and conveying mechanism for successively moving a plurality of tools into and out of said station, a tool positioner and a tool spindle located on opposite sides of said station and in alignment with a tool in said station; said mechanism comprising, a series of sprockets mounted on said machine for rotation in planes at right angles to one another, means for intermittently driving one of said sprockets, a tool storage and conveying chain trained around said sprockets and passing adjacent said station, said chain having mutually perpendicular pivot axes so as to flex in two directions and travel in said different planes, a series of tool holders secured at spaced locations to said chain for successively moving into and out of said station, a guide and supporting rail mounted on said machine and extending coextensively with and adjacent said chain, and means forming a connection between said rail and said holders whereby the latter are guided, supported, and stabilized as they are conveyed by said chain; said positioner including a gripper extensible to engage said tool and move therewith through the holder in said station for inserting said tool in said spindle.

17. A spindle head and tool assembly for a metal working machine comprising, a spindle housing having a longitudinally open center, a rotatable spindle in said housing and having a tool receiving end and an opposite working end, a tool insertable through said receiving end into said head and partially through said working end where it protrudes therefrom in a working position, said tool having an external shoulder and said spindle having an internal shoulder, a segmental locking ring around said tool and located axially between said shoulders, a fluid actuated tubular piston in said spindle and around said tool, said piston and ring having complementary tapered surfaces whereby movement of said piston in one direction causes said ring to move radially between said shoulders and lock the tool axially in said spindle.

18. An extensible tool positioner for gripping, unlocking, and positioning a tool in a metal working machine, said positioner comprising, a housing adapted to be supported on said machine, a first sleeve reciprocally mounted in said housing for extension and retraction in respect thereto, said sleeve having a beveled end extending from said housing for actuating a tool holder, a second sleeve concentrically mounted within said first sleeve and reciprocal both with and in respect thereto, said second sleeve having an end extensible from said first sleeve and a collet actuator carried in said end, a collet in said actuator and having a releasing means, and means extending longitudinally and centrally in said positioner and connected with said actuator and defining a fluid passageway in communication with said releasing means.

19. An extensible tool positioner for gripping, unlocking, and positioning a tool in a metal working machine, said positioner comprising, a housing adapted to be supported on said machine, a first sleeve reciprocally mounted in said housing for extension and retraction in respect thereto, said housing defining a cylinder around said sleeve and a fluid passage in communication with said cylinder, said sleeve having a piston attached thereto and slidable in said cylinder for reciprocating said sleeve in a short stroke, said sleeve also having a beveled end extending from said housing for actuating a tool holder, a second sleeve concentrically mounted within said first sleeve and having a piston secured thereto and slidable in said first sleeve for reciprocating said second sleeve in a long stroke and relative to said first sleeve, said first sleeve when beginning its movement in one direction being en-

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gageable with said second sleeve piston to cause said sleeves to initially move together, said second sleeve having an end extensible from said first sleeve and a collet actuator carried in said end.

20. In a machine tool, a rotatable tool receiving spindle having work securing means, a flexible tool storage magazine comprising separate tool supports interconnected by flexible conveying drive means for positioning a pre-

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selected tool in a tool change station, a tool change member including releasable gripping means connected to move only rectilinearly to interchange tools between said spindle and said flexible magazine, and means connected to actuate said securing means for retaining a preselected tool in said spindle.

No references cited.