

Aug. 31, 1965

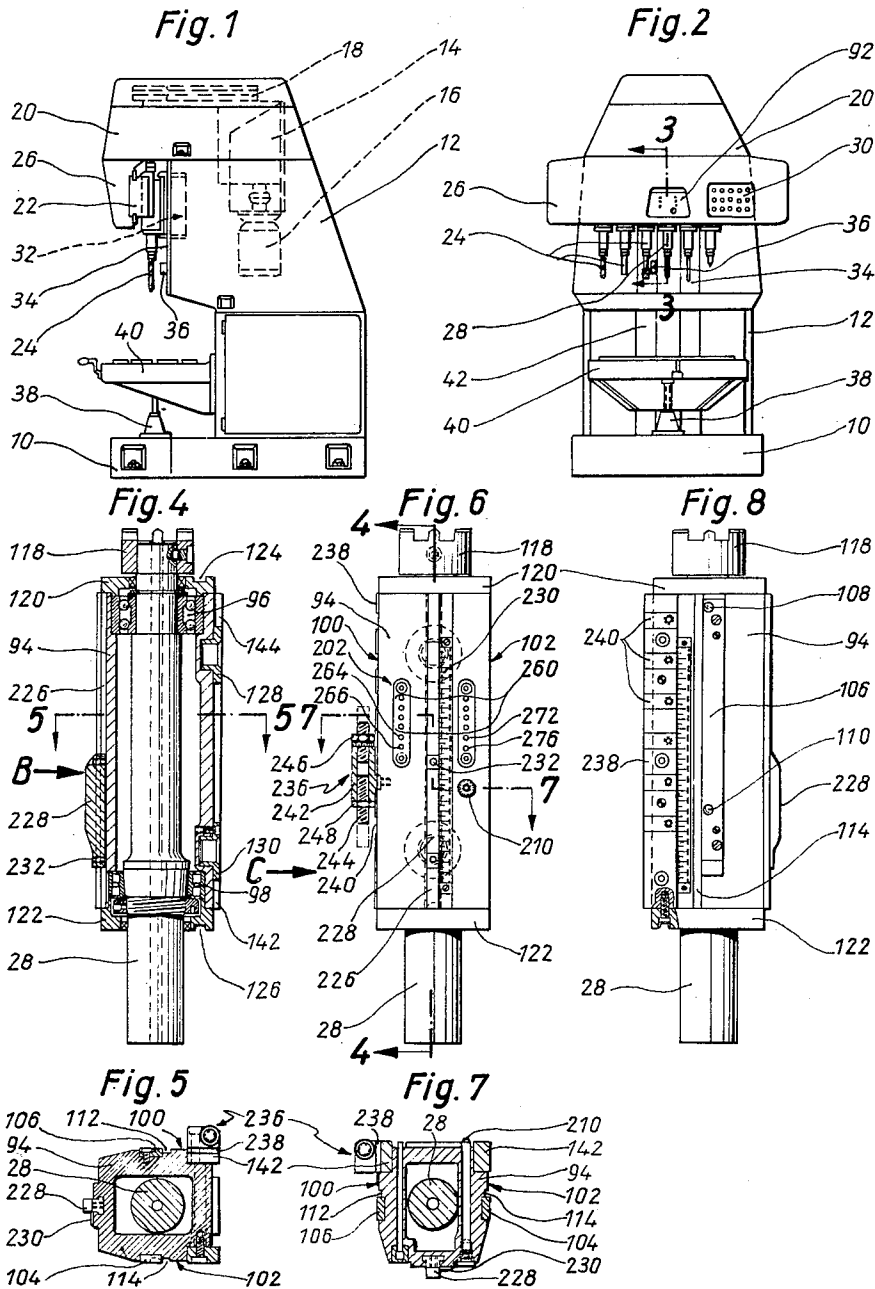
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3,203,017

MAGAZINE SPINDLE DRILLING MACHINE

Filed Jan. 11, 1963

8 Sheets-Sheet 1



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Fig. 16

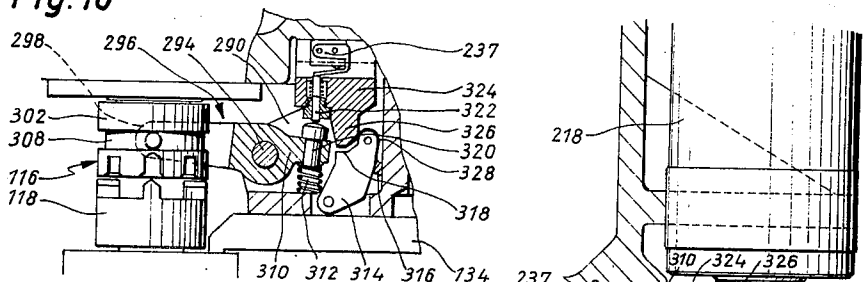
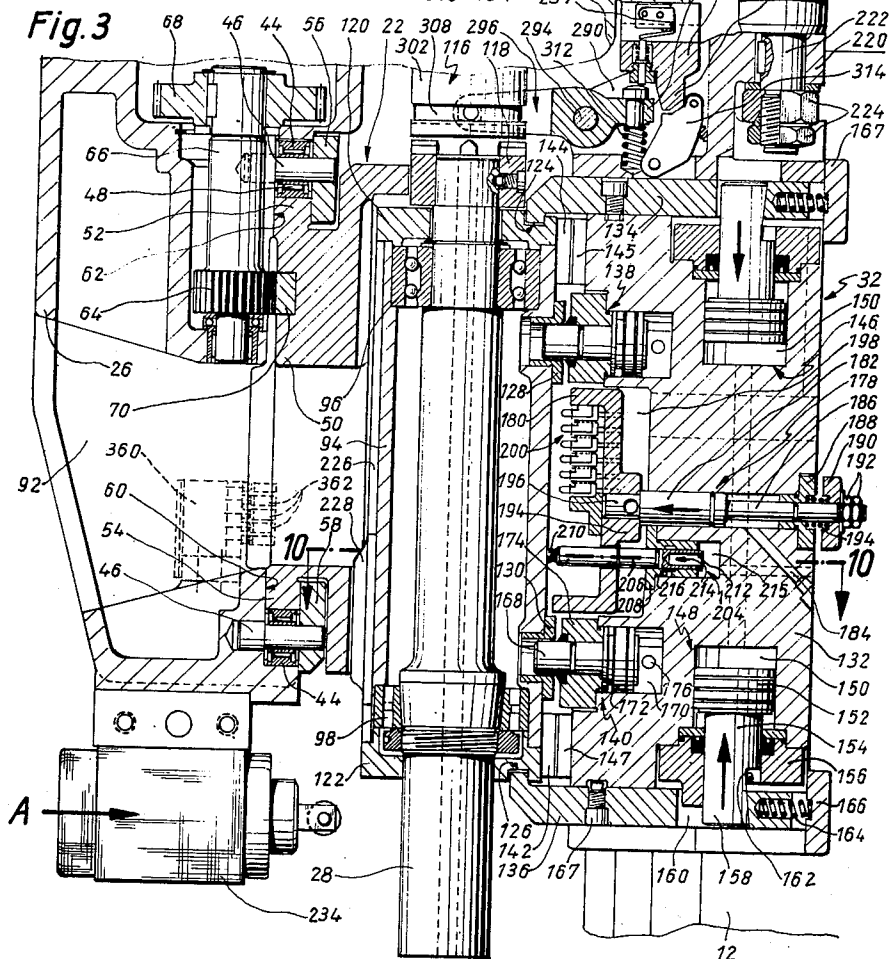


Fig.3



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Fig. 9

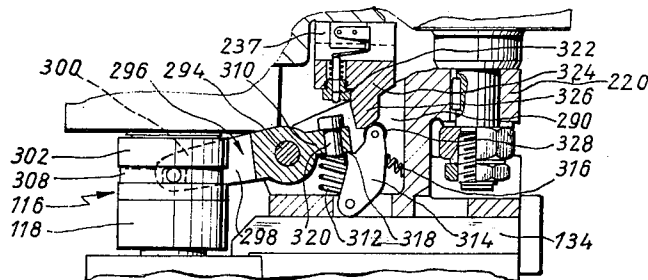


Fig. 10

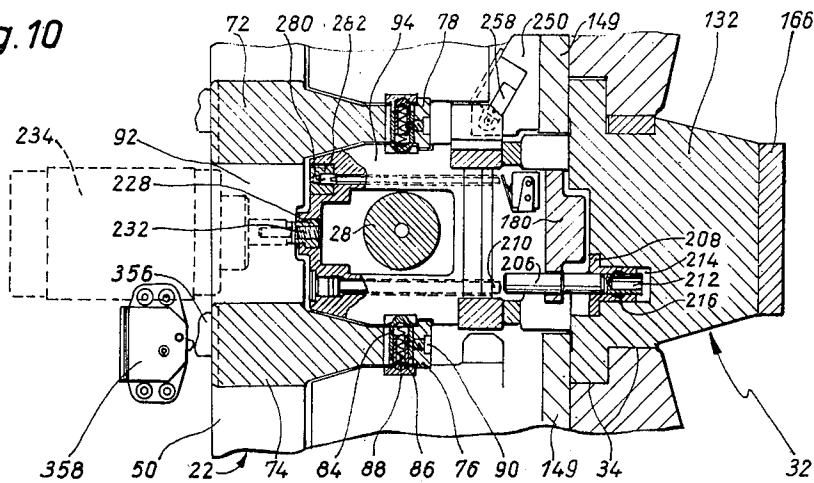
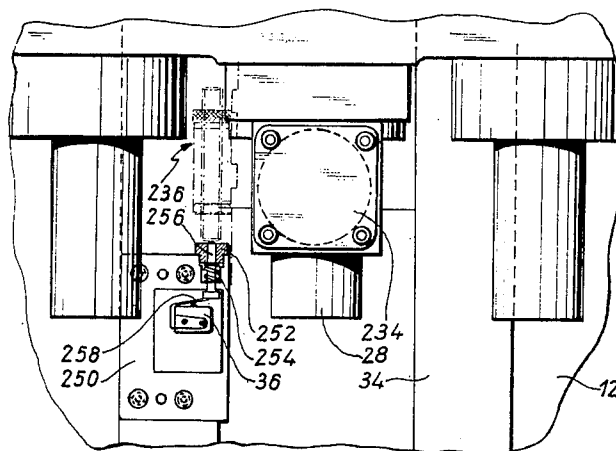


Fig. 11



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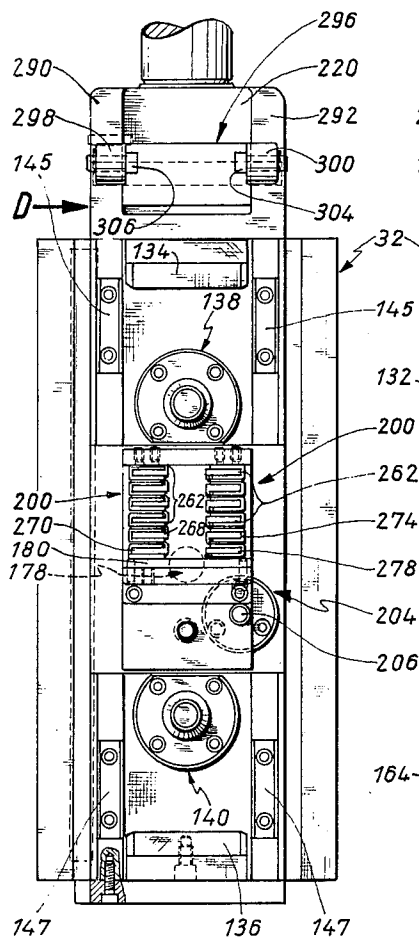


Fig. 12

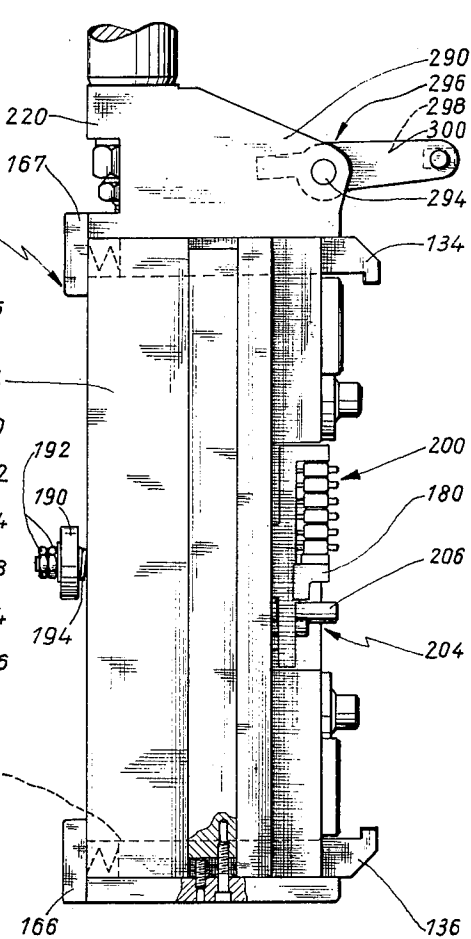


Fig. 13

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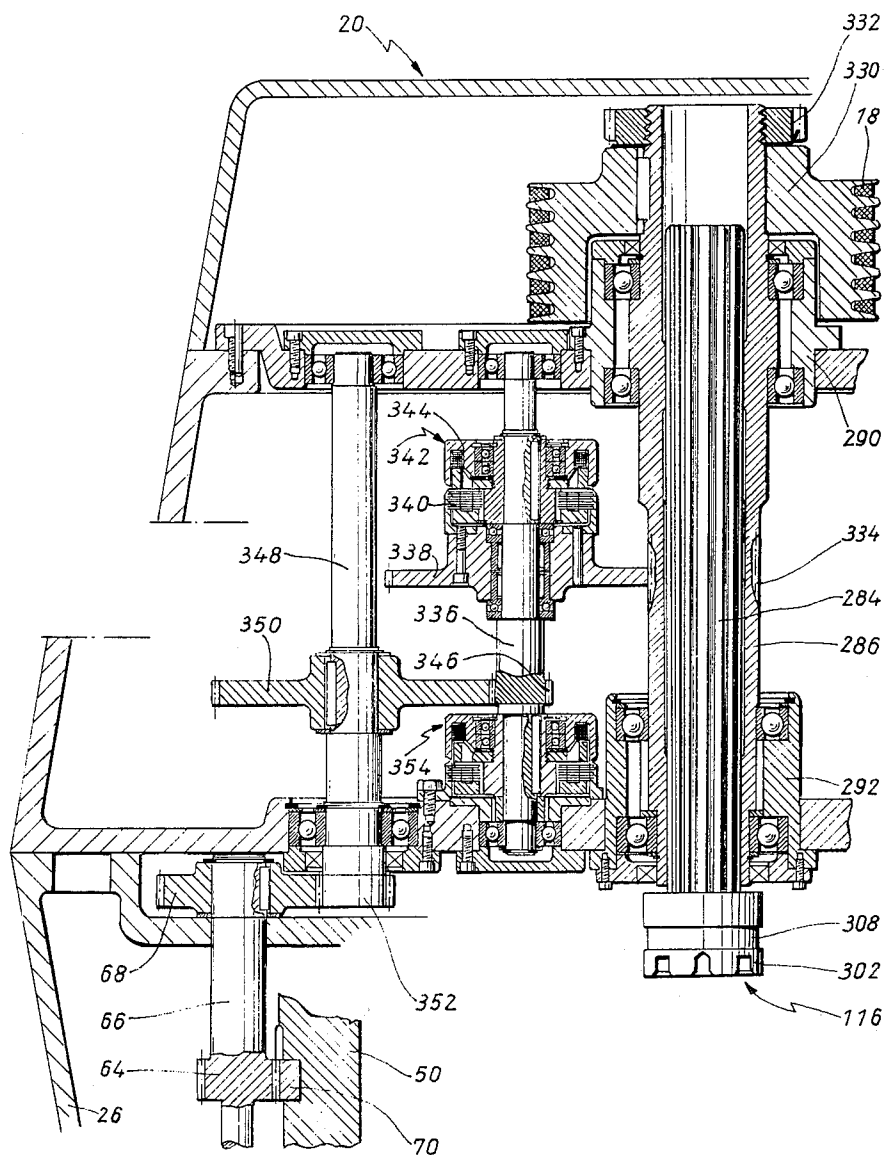
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Fig. 14



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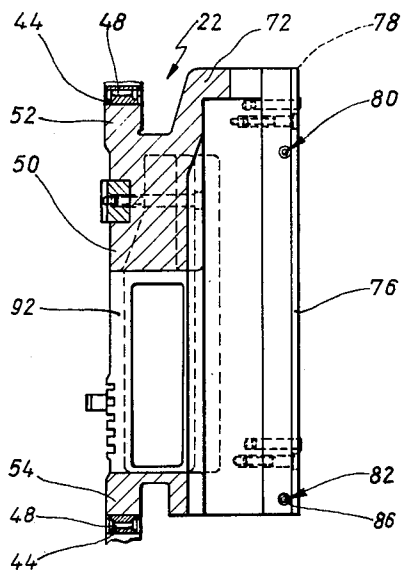
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Fig. 15



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MAGAZINE SPINDLE DRILLING MACHINE

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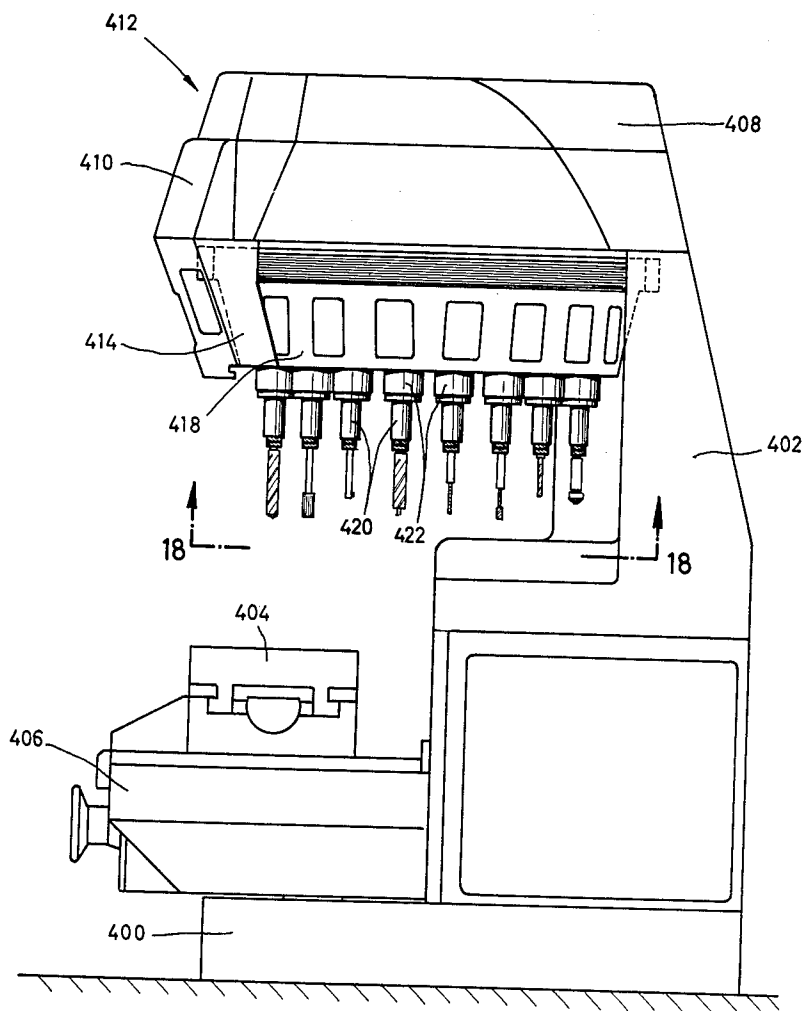


Fig. 17

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MAGAZINE SPINDLE DRILLING MACHINE

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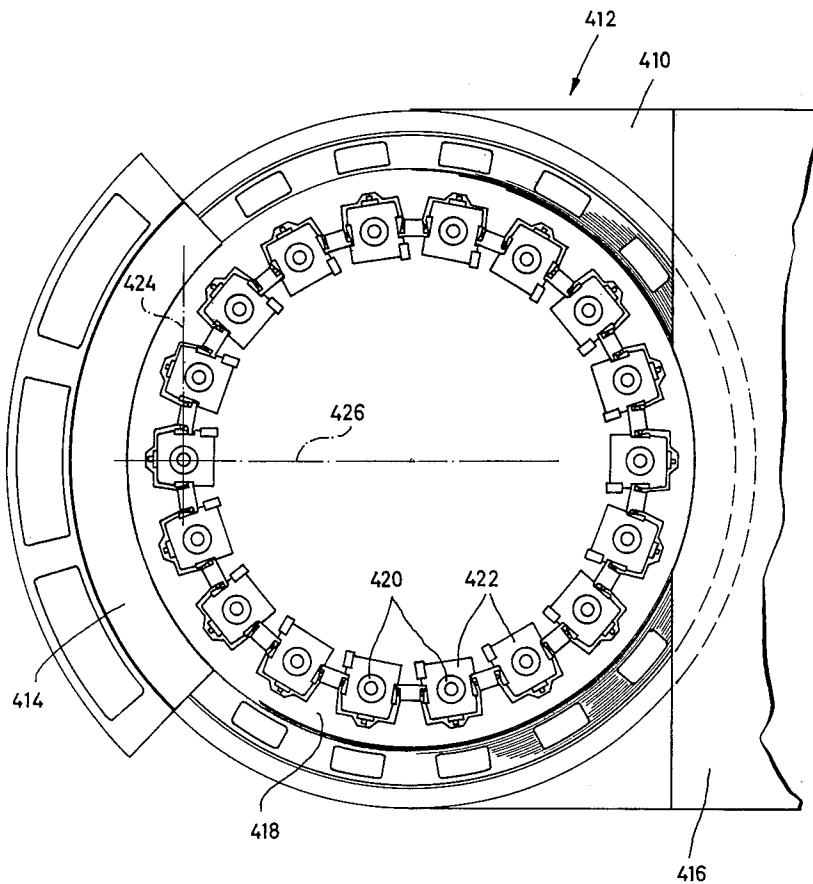


Fig. 18

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MAGAZINE SPINDLE DRILLING MACHINE
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Filed Jan. 11, 1963, Ser. No. 250,915

9 Claims. (Cl. 10—138)

This invention relates to drilling machines of the spindle magazine type and, more particularly, to an improved machine of this type, characterized by simplified mounting of the spindles in the magazine, function settings of each spindle independently of a program control, and stable mounting of the spindles in the working position in such a manner that radial forces on the tool can be absorbed by the spindle, the drilling machine of the invention being particularly suitable for precision drilling operations.

For the purpose of expeditiously performing different operations, such as drilling, countersinking, tapping, spot surfacing, and the like in rapid succession and without change of tools, it is known to use a drilling machine provided with a spindle magazine so that the different spindles having the particular respective tools to be used can rapidly be brought to the working station. In such magazine type machines, spindles carrying certain tools are mounted in spindle sleeves. The spindle magazine is usually designed in an annular or ring form and is so arranged as to extend in a substantial horizontal direction and to embrace the machine frame. This magazine is so mounted that it can move transversely of the spindle axes so that the selected spindles or spindle sleeves in the magazine can be brought automatically into cooperative relation with a feed unit mounted on the machine frame for movement parallel to the spindle axes in the operating direction. To control the various functions to be performed by the individual spindles, such magazine type spindle drilling machines may include an electronic control arrangement which is controlled by a program strip so that the various operations may be carried out completely automatically.

Another known arrangement for automatic operation involves the use of control drums in the machine, in place of a program control device. These control drums, which are moved in synchronism with the spindle magazine, are provided with depth stops, speed preselecting devices, feed rate devices, and the like, coordinated with the respective individual spindles.

In order to properly mount the spindles or their sleeves in the magazine, it is necessary to form precision guideways in the magazine. These precision guideways are difficult to form as they may, for structural reasons, have only a relatively small vertical dimension or height. This has the disadvantage that a force acting radially at the front edge of the tool is not opposed by a sufficient counterforce at the precision guideway.

It is further necessary either to provide the control for each individual spindle on a program strip or to set the control for each individual spindle on a control drum. Thus, before beginning an operation, a complete program must be provided. This makes it impossible to provide a selective variation in the functions of the individual spindles, such as a speed increase or the like. Consequently, when it is desired to set the machine for a different program, the machine must stand idle during the time required to mount all of the tools therein and to reset the program either on the strip or on the drum. During fitting of the tools, only the individual tools can be interchanged, for example, for sharpening, and this leads to the possibility that, upon re-installation of the tool, there is a danger that a tool may be replaced upon the wrong spindle with the possibility of resultant damage to the tools and to the workpiece.

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In accordance with the present invention, a drilling machine of the magazine spindle type is provided featured by a very simple mounting of the spindles in the magazine and providing for function setting of each spindle independently of a program control. Each spindle is stably mounted, when at the working station, in such a manner that radial forces occurring at the tool can be absorbed by the spindle. The machine is particularly advantageous for precision drilling operations.

An important feature of the invention, as applied to magazine type spindle drilling machines including a spindle magazine supporting a number of spindle devices and movable relative to the machine frame transversely of the spindle axes to bring the selective spindle devices to a selected working station in which they are conveyed into working position by means movable on the machine frame parallel to the spindle axes, is that the tool spindles are removable individually from the spindle magazine in any desired position of the latter. Preferably, they are removed from the magazine together with the associated cooperating spindle device. Furthermore, setting means are provided on the spindle devices which, in the operating position of the perspective spindle, cooperate with associated control elements for the operation of the machine and controlling the operation thereof. By this arrangement, it is possible to set the various operating functions for each individual spindle in advance and on the individual spindle device.

Another advantageous result of this arrangement is that the spindle devices are easily changeable even with the spindle inserted therein, and without in any manner affecting the operation of the other spindles in the magazine. By the use of insertable spindle devices for the magazine, there is provided a simple and inexpensive construction of the magazine and wherein each spindle, with its associated tool, can be removed readily and a new spindle, entirely different in its functions, inserted in its place. From this feature, there arises the advantageous possibility that, if a duplicate set of spindle devices is available, an almost uninterrupted use of the machine may be attained.

The magazine holder of the drilling machine of the invention, as well as the magazine itself, may have any desired form. For example, it may be designed as an annular magazine holder and magazine or as a linear magazine holder and magazine and, in the annular form, may be designed to accommodate the greatest possible number of spindle devices in the spindle magazine.

In order to disengage individual spindle devices from the magazine without the necessity of operating levers or other fastening means, the invention advantageously provides that the spindle devices be held in the magazine by releasable detent means. To assure satisfactory locking of the individual spindles or spindle devices in the working position during feeding, the invention provides a feed slide movable relative to the machine frame, and which may be coupled to the particular spindle device then at the working station by hydraulically operated coupling means.

It is desirable that each spindle be moved at high speed to the start of the working stroke or position, and then be advanced at a much lower working speed. In accordance with the present invention, this change in the speed of movement of the spindle or spindle device toward the work is effected in a particular simple manner by a switching means which is displaceable parallel to the spindle axis. For example, this means may include a cam which may be designed to operate an electric switch, for switching from a high positioning speed to a slower working feed.

Limitation of the feeding movement of the feed slide is advantageously controlled by providing each spindle de-

vice with a respective depth stop which is adjustable and displaceable in a direction parallel to the spindle axis. For example, this may comprise a setting screw cooperable with a switching means on the frame to limit the feed movement of the feed slide, and graduated scales may be provided on each spindle device to set the position of the respective feed limiting device.

In order to preset the working functions of each spindle or spindle device in advance, there is provided, on each individual spindle device, at least one and preferably several setting means for controlling the speed of rotation of the spindle. These setting devices selectively cooperate with a corresponding number of switch elements at the working station and carried by the feed slide, these switch elements being designed as switches which cooperate with a preselecting gear for preselecting the speed of rotation. Thus, each setting device can be set for a particular speed, and it is further possible to combine speeds by the adjustment of different setting devices at each spindle device.

To effect such operations as tapping or spot facing with the invention apparatus, the latter may be provided with a special switch unit which can be set by hand as necessary. However, preferably a construction is provided wherein there is arranged at each spindle a tapping setting means which can effect a change in the direction of rotation of the tool spindle and a reverse movement of the feed slide, when the limit of thread depth has been reached. Preferably, means are included for delaying the return of the spindle device for a preselected time interval.

Advantageously, the setting means are arranged next to each other on the individual spindle devices by the provision of one or more holders. The setting means may be designed, for example, as cams each cooperable with a selected switch when the respective spindle device is moved to the working station. A simpler arrangement results if the setting means are designed as pins which are displaceable transversely of the spindle axis between an inactive position and an active position.

In order to avoid damage to the individual spindle devices as well as to the machine, it is important that the setting devices can cooperate with the corresponding switching elements only when the respective spindle is at the working station and is reliably coupled with the feed slide. For this purpose, the switch elements cooperating with the setting means on the individual spindle devices are positioned on at least one support in the feed slide which is movable, preferably hydraulically, into active position only after completed coupling of the spindle device to the feed slide so that the switch elements can be engaged by the setting means only after such coupling has been completed.

The feeding of the feed slide can be effected by a threaded spindle mounted in the machine frame and engageable with a nut on the feed slide. However, in order to provide a widely adjustable feed rate, each spindle device preferably includes a feed control element which, when the spindle device is moved to the working station, co-acts with a regulating means, such as a hydraulic regulating means, to adjust the working feed rate. Additionally, gripping of the spindle devices to the feed slide is effected by hydraulically operated wedge-type gripping means which retain the spindle device when the hydraulic gripping pressure has been released.

While the drive for shifting the spindle magazine may be effected by a second drive motor which is separate from the drive motor of the preselecting means, a simpler and less expensive construction is attained if the magazine drive is effected from the preselecting gear.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

In the drawings:

FIGS. 1 and 2 are, respectively, somewhat schematic side and front elevation views of a drilling machine embodying the invention;

FIG. 3 is a partial horizontal sectional view of the drilling machine, on a larger scale, and taken along the line 3—3 of FIG. 2;

FIG. 4 is a detailed axial sectional view, on a smaller scale, of the spindle device shown in FIG. 3, and taken on line 4—4 of FIG. 6;

FIG. 5 is a sectional view taken on the line 5—5 of FIG. 4;

FIG. 6 is an elevation view of the spindle device, looking in the direction of the arrow B of FIG. 4;

FIG. 7 is a sectional view taken on the line 7—7 of FIG. 6;

FIG. 8 is a view looking in the direction of the arrow C of FIG. 6, a feed limiting member being omitted;

FIG. 9 is a detail view of the coupling means, shown in FIG. 3, for coupling the tool spindle in a spindle device to a driving spindle, the coupling means being shown in the coupled and locked condition;

FIG. 10 is a transverse sectional view taken on the line 10—10 of FIG. 3;

FIG. 11 is a partial elevation view looking in the direction of the arrow A of FIG. 3 and illustrating the arrangement of a limit switch on the machine frame cooperable with a feed limiting member;

FIG. 12 is a front elevation view of the feeding means in accordance with the invention;

FIG. 13 is a side elevation view of the feeding means, looking in the direction of the arrow D of FIG. 12;

FIG. 14 is a sectional view through the preselector gearing serving to drive the tool spindle and to shift the spindle magazine;

FIG. 15 is a transverse sectional view through the spindle magazine;

FIG. 16 is a view, similar to FIG. 9, but showing the coupling means in the disengaged position;

FIG. 17 is a view, similar to FIG. 1, but illustrating the apparatus of the invention as provided with an annular spindle magazine; and

FIG. 18 is a partial sectional view, to a larger scale, taken on the line 18—18 of FIG. 17.

General operation of machine

The magazine type spindle drilling machine illustrated generally in FIGS. 1 and 2 includes a machine frame 12 supported on a base plate 10. A preselecting gear 14 is provided in the frame 12 and is driven by a motor 16. Through a belt drive 18, motor 16 operates a switch gear in a housing 20, and shown in greater detail in FIG. 14, at the preselected speed of rotation. The switch gear, as will be described more fully hereinafter, drives a selected tool spindle 24 when the latter is in the working position, the tool spindles 24 being arranged in the spindle magazine 22 movable transversely of the machine frame 12 in a magazine holder 26 which is positioned below the switch gear housing 20. Through automatic means, each tool spindle is automatically moved to the working station.

In the illustrated arrangement, the magazine holder 26 and the spindle magazine 22 are designed for relative rectilinear movement, but it should be understood that the magazine and its guide may be any desired form, such as annular. As illustrated in FIG. 2, the working station is preferably established at the vertical median plane of the magazine holder 26, and a tool spindle 28 is arranged at this position. It should be mentioned that the tool spindles, which are arranged in spindle devices to be described hereinafter, are manually removable from the spindle magazine in a simple manner. A control panel 30 is provided for the operation of the machine, and is preferably arranged on the magazine holder 26.

The feeding of a tool spindle at the working station is effected by a feed unit generally designated at 32 and

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which is slidably guided in the machine frame 12 through the medium of a channeled guideway 34 extending parallel to the axes of the spindles, as best seen in FIG. 10. The feed movement is limited or controlled by a limit switch 36 which is positioned on the front of the machine frame. For mounting the work on the machine, a bracket or working table 40 is provided which is vertically displaceable by means of a suitable actuating device 38 and which is guided in a flat track, or other suitable guideway 42, on the machine frame.

Detailed description of feed unit, spindle suspension and magazine, and relative arrangement of magazine and magazine holder

Referring to FIG. 3, spindle magazine 22 is arranged for displacement longitudinally of magazine holder 26. For this purpose, the magazine holder is provided with upper and lower rolls 44 rotatable in needle bearings 48 on axles 46 secured in magazine holder 26. Disposed between the rollers 44 is the bearing portion 50 of the magazine 22, which, as best seen in FIGS. 3 and 15, includes an upper guide rail 52 and a lower guide rail 54 having horizontal guiding surfaces engageable with the rolls 44. Magazine 22 is retained in position in magazine holder 26 by retainer rails 56 and 58 secured to the projecting ends of axles 46. As seen in FIGS. 3 and 15, these rails 56 and 58 engage the right longitudinal sides of the respective guide rails 52 and 54. The left sides of the respective guide rails 52 and 54 engage guiding surfaces 60 and 62 of magazine holder 26.

Shifting of magazine 22 is effected by a drive pinion 64 secured on or formed integrally with a transmission shaft 66 rotatably mounted on a vertical axis in the upper portion of magazine holder 26. A gear 68 is secured to shaft 66, as by means of a key, and is operable by the switch gear in housing 20. A rack 70 in the bearing portion 50 of magazine 22 engages the drive pinion 64. The magazine is provided with a number of holding devices 72 and 74 corresponding to the number of spindles or spindle devices to be carried by the magazine.

Referring to FIG. 10, these supports or holding devices 72 and 74 are spaced from each other longitudinally of the magazine and project from the right of bearing portion 50, as viewed in FIGS. 10 and 15. As best seen in FIG. 15, these holding devices extend through the entire vertical extent of the magazine. For the purpose of holding the spindle devices in the supports 72 and 74, each support has secured to its outer end surface a guide ledge or strip 76, 78, which guide ledges are secured in position by screws and properly located by pins or the like. Each guide ledge has positioned, in spaced relation longitudinally thereof, double acting spring pressed detents 80 and 82. Each detent 80 or 82 includes an outer detent pin 84 which is generally tubular in section and has an inner detent bolt 86 telescopically engaged therein and extending in the opposite direction. A spring 88 is arranged interiorly of these detent pins, and tends to urge the same apart, with the maximum relative displacement of the locking bolts or pins being limited by an abutment screw 90 in the guide ledge and having an end engaging guide slots in the two locking bolts. As the detent devices 80 and 82 are double acting, each guide ledge is arranged for cooperation with a pair of adjacent spindle devices, as best seen in FIG. 10.

The cross sectional form of the holding support is so designed, with respect to the cross sectional form of the respective spindle devices, that the latter can be positioned in the holding support with very little play. For the purpose of setting a spindle device mounted in the spindle magazine 22, a recess 92 extends through the magazine holder 26 and the magazine 22.

The spindle devices and their arrangement in the magazine

Each spindle device includes a housing 94 in which the tool spindle 28 is rotatably mounted by means of a

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ball bearing 96 and a roller bearing 98 of known construction. Referring to FIGS. 5, 8 and 10, a pair of opposite sides 100 and 102 of each housing 94 has secured therealong strips 104 and 106, respectively, with each strip having two recesses 108 and 110 located at the same longitudinal spacing as the detents 80 and 82 of the magazine. These strips 104 and 106, as best seen in FIGS. 5 and 7, further form guide grooves 112, 114 in the longitudinal sides 100 and 102 of the housing 94. When the spindle device is inserted in the spindle magazine, the detents 84 or 86 engage in the recesses 108 and 110 to releasably retain the spindle device in the magazine. In addition, each guide ledge 76 and 78 has an edge engaged in a groove 112 or 114 to assure proper location and guiding of the spindle device into the magazine.

When at the working station, each spindle 28 is driven through a driving claw coupling or clutch element 116 illustrated, as shown in FIG. 3, as operated from the gear in housing 20, this claw coupling engaging a driven member 118 on each individual spindle 28. When each spindle device is at the working station, driving thereof is effected by the feed unit 32. As illustrated in FIGS. 1 and 3, the feed unit 32, in the starting position, is at the level of the spindle magazine. For driving purposes, and as best seen in FIGS. 3, 4, 6 and 8, covers 120 and 122 are provided at the upper and lower ends of each housing 94. In the outer surface of each cover 120 or 122, and adjacent their side edges facing the feed unit 32, each cover is formed with a clamping groove 124 or 126, respectively. Along the same side of the housing 94, there are provided adjustment bushings 128 and 130 which are spaced from each other longitudinally of the housing 94. When a spindle device inserted in the magazine 22 is brought into the working station by shifting of the magazine, clamping slides 134 and 136, illustrated in FIG. 3 as arranged on the upper and lower ends of a slide block 132, have their down turned ends engaged in the grooves 124 and 126. At this time, the adjusting bushings 128 and 130 are aligned with hydraulically operated adjusting devices in slide block 132, and generally designated at 138 and 140. Also, at this time, upper and lower contact strips 144 and 142, shown in FIGS. 3, 4 and 5 as positioned on the spindle housing 94, engage contact strips 145 and 147, respectively, on the slide block 132. Slide block 132 is guided, in a known manner, in the guideway or keyway 34 of the machine frame 12 and is secured in this guideway by clamping strips 149, as best seen in FIG. 10.

Clamping of the spindle devices to the slide-block and operation of the spindle devices

Gripping or clamping of each spindle device to the slide block 132, when the spindle device is in the working station, as shown in FIGS. 3 and 10, is effected automatically. Operation of the clamping slides 134 and 136 is effected by vertically oriented clamping devices 146 and 148. As these are similar in construction, only one will be described specifically. A hydraulically operated pressure piston 152 is mounted in a cylindrical bore 150 in guide block 132 and has a shank 154 extending through a sealing bushing 156 serving as a packing for the bore 150. Each shank 154 has its end 158 designed as a traction wedge engaging a correspondingly designed recess 160 of the respective clamping slide. This end section 158 has a sloping or wedge face 162 engaging a correspondingly sloping or wedge face of the recess 160, the face of the recess 160 being biased into engagement with the sloping surface 162 by means of a compression spring 164 which is seated in a recess in the outer end of each clamping slide. The outer end of each spring 164 is seated in a recess in a clamping bar 167 secured to the slide block 132.

When a hydraulic fluid under pressure is introduced into each bore 150 between the bushing 156 and the facing surface of the piston 152, the pistons are moved

unwardly in the direction indicated by the arrows of FIG. 3. As a result, the clamping slides 134 and 136 are moved to the right, as viewed in FIG. 3, to firmly clamp the spindle device to the slide block 132. The maximum displacement of the clamping slide is determined by abutment screws 167 therein engageable with recesses in the ends of the slide block 132.

Simultaneously with the clamping operation just described, the spindle device is adjusted through the medium of the adjusting devices 138 and 140. As these adjusting devices are substantially identical, only one will be described in detail. During the adjusting, each of the bushings 128 and 130 has engaged therein a bolt 163 which is a part of the shank of a piston 172 slidably mounted in a cylindrical bore 170 which is pressure sealed by a packing or other suitable means 174. Oil or hydraulic fluid under pressure can be introduced into the bore 170 through an inlet 176.

As best seen in FIGS. 3, 10, 12 and 13, a starting device, generally designated 178, is mounted in the slide block 132 between the adjusting devices 138 and 140. This starting device is arranged to move a switch holder 180 a selected distance in the direction of the arrow shown in FIG. 3. The starting device includes a piston 182 arranged in a corresponding cylindrical recess in the block or slide 132, and hydraulic fluid under pressure may be introduced into this recess through an inlet line 184. Extending from the right end of the transport piston 182, as viewed in FIG. 3, there is a setting shank 186 for determining the amount of movement of the piston. This setting shank extends through a sealing plate 188 and has secured to its outer end a strike plate 190 fastened thereon by means of nuts 192. Movement of the starting device to the right, and to a starting position, is effected by a compression spring 194 embracing the shank 186 and engaged between sealing plate 188 and strike plate 190, the spring being seated in recesses in these plates.

As viewed in FIG. 3, the switch holder 180 has a U-shaped cross section and is formed with an enlargement 194 which is rigidly secured on a reduced extension 196 of the piston 182. In its retracted or starting position, the switch holder 180 is disposed in a recess 198 in slide block 132.

As best seen in FIG. 12, switch support 180 carries two spaced rows of electric switches 200 which are connected through circuitry, not shown, with corresponding function controlling elements in the preselecting gear 14, certain switching operations effecting the operation of the machine being initiated by operation of the switches 200. For this purpose, and as best seen in FIGS. 6, 7 and 10, on the side of the spindle holder housing 94 facing the slide block 132, there are provided two rows of setting devices 202, the number of setting devices corresponding to the number of switches 200 on the support 180. The setting devices are positioned in correspondence with the switches 200, and the purpose of these setting devices will be described hereinafter.

Referring to FIGS. 3 and 10, it will be noted that a feed setting device 204 is provided in the slide block 132 below the starting device 178. This feed setting device 204 is provided with a feeler in the form of a bolt or pin 206 slidably mounted in a guide bushing 208 for longitudinal or axial displacement in pressure-proof sealed relation. Feeler 206 extends through switch support 180 for cooperation with an adjustable setting pin 210 on each spindle housing 94. In its end within the guide bushing 208, bolt or pin 206 is formed with a recess 212 which opens into a chamber 215 communicating with a pressure fluid system. Under the pressure of the fluid, bolt 206 is arranged to engage the setting pin 210, and the feed rate is then determined by the amount of pressure fluid passing through an outlet slot 214 under certain controlled pressure conditions. The pressure fluid passes through an annular groove 216 in the guide bushing 208 and into a hydraulic actuator 218. The feed rate is determined by

the relative displacement of the setting pin 210. Thus, the further the feeler 206 is moved under the fluid pressure in the direction of the spindle device, the greater is the rate of pressure fluid entering the hydraulic actuator.

The mentioned hydraulic actuator includes a feed piston as shown in FIG. 3, and this feed piston determines the feed of the unit. This piston has a pin 222 extending therefrom and secured to a knob or ear 220 by means of nuts 224. Knob or ear 220 is preferably integral with or fixedly secured to the slide block 132 and is located above the upper clamping slide 134.

There is further provided in the unit embodying the invention, in a known manner not illustrated, means for first moving the spindle device at a high speed to the vicinity of the workpiece to be machined. In order to adjust the length of travel of the spindle device at high speed into the working position adjacent the workpiece, and in a simple manner, that side of the spindle housing 94 facing away from the slide block 132 is formed with a T-shaped guide groove 226 extending over the entire length of the housing 94, as best seen in FIGS. 3, 4 and 6. A control cam 228 is positioned in the groove 226 and is adjustable along the groove to any desired position and with reference to a setting scale 230. Cam 228 is secured in adjusted position by screws 232.

The control cam 228 operates a cut-off valve 234 mounted on magazine holder 26 adjacent the bottom edge thereof in any suitable manner. Upon initiation of the machine operation, a quantity of pressure fluid flows the feed unit, after clamping to the spindle as described, is moved downwardly as a unit with the latter, the spindle device being disengaged from its releasable detent latching in the spindle magazine. The high speed downward travel of the spindle device is limited by control cam 228 engaging the cut-off valve. This cut-off valve interrupts the inlet of the pressure fluid effecting the high speed feed, and further conditions the apparatus for inlet of fluid under pressure from the feed setting device 204 to operate the feed slide at the working feed speed.

For the exact setting of the length of travel of the feed unit during the working feed, each spindle device is provided with an individual feed limiting member generally designated at 236, and which will be described more specifically in connection with the switch means associated therewith. Limiting member 236 is secured to a mount or ledge 238, illustrated in FIG. 6 as arranged on the left longitudinal slide of the housing 94. For rough adjustment, the limiting member can be selectively fastened in any one of several grooves 240 provided in the ledge 238 at preselected vertical spacings. For fine adjustment of the path of travel, a support body 242 of the limiting member has a threaded spindle 244 extending therethrough for longitudinal displacement by means of a setting nut 246, the spindle 244 being locked in adjusted position by means of a nut 248.

For controlling the movement of the feed unit, limiting member 236 cooperates with the limit switch 36 of FIGS. 1 and 11, and which is mounted on a bracket 250 on the machine frame 12 (FIG. 11). A guide bushing 252 on the bracket 250 slidably receives a switch pin 256 which is displaceable in a vertical direction. Pin 256 is biased outwardly by a spring 254 and cooperates with the operator 258 of limit switch 36. When, during the working feed of the feed unit 32, limiting member 236 strikes pin 256 as indicated, for example, in FIG. 11, the feeding movement of the feed unit in the working direction is interrupted or is reversed to move the feed unit in the opposite direction at high speed. The particular function performed is, in part, dependent upon the setting of the setting devices 202 of the respective spindle device. When the feed unit has returned to its starting position, a switch 237 (FIG. 3) is operated. This switch is positioned on the knob or ear 220 and stops the op-

eration of the machine. The particular arrangement will be described more fully hereinafter.

The setting elements and their function

By means of the setting elements 202, cooperating with switches 200 of support 180, it is possible to preset all the functions of the respective spindle devices intended to be inserted into the magazine, such as the speed of rotation, feed, working depth, etc. These functions can be set, for each spindle device, with precision and while the spindle device is outside the machine.

In accordance with the invention, and as best seen in FIG. 6, the first four setting elements 260 in both rows of setting elements 202 are intended for speed preselection, and each of these elements can cooperate individually with a respective switch 262 of holder 180, as shown in FIG. 12. This arrangement has the advantage of providing a favorable combination of speeds available from the preselecting gear 14 through the switch gear 20. To delay the return movement of the feed unit for certain operations as, for example, spot facing, the left row in FIG. 6 is provided with a setting element 264 and also with a setting element 266 for coupling the respective spindle device to the feed unit, the setting elements 264 and 266 cooperating, respectively, with switches 268 and 270 of the switch unit 180 and as shown in FIG. 12.

In the right-hand row as viewed in FIG. 6, there is a setting element 272 provided for tapping which, if threads are to be cut, is so adjustable that a switch 274 cooperable thereby is operated. This has the effect that, as the limit member 236 engages the switch pin 256, the feed unit is retracted to its starting position at the working speed, and with a reversal of the direction of rotation of the spindle occurring simultaneously with the reversal of direction of movement of the feed unit. In addition to the mentioned setting devices or elements, there is further provided a reserve setting element 276 which is cooperable with a reserve switch 278.

As best seen in FIGS. 7 and 10, the setting elements are designed as pressure pins which are adjustable through bores in the spindle holder 94 on both sides of the spindle. At their outer end, each of these setting elements has a threaded head 280 engaged in a chuck 282 in the spindle housing 94, and this head is accessible from the exterior, with a proper tool, for resetting of the setting element. However, the setting elements are not removable through an outwardly tapering recess.

Spindle drive and magazine drive

Referring particularly to FIGS. 3 and 14, it will be remembered that it has been mentioned that tool spindle 28 is driven by coupling to suitable drive means. The switch gear in housing 20, as seen in FIG. 14, is provided with a drive spindle 284 which carries the claw coupling 116 engageable with the claw coupling 118 on each of the spindle devices. In order to provide continuous driving or rotation of spindle 284 during feeding movement of the unit, it is splined and is arranged for axial displacement relative to the switch gear in a wedge bushing 286 which is mounted in the drive gear housing 20 by means of ball bearings 290' and 292'. In the illustrated construction, the coupling jaw 116 is so designed that, in the starting position, the tool spindle of the spindle device at the working station is disengaged automatically from drive shaft 284 and is automatically coupled to the drive shaft when the feed unit moves in a working direction.

Referring particularly to FIGS. 3, 9 and 16, the automatic clutch operating means is adjacent the fastening ear 220 for the piston 218. This automatic clutch operating means includes a shifting fork 296 pivoted on an axle 294 and movable between bearing faces 290 and 292 (FIG. 12). The fork arms 298 and 300, as best seen in FIGS. 9, 12 and 16, embrace the driving half 302 of the claw coupling 116 and have pins, such as

304 and 306, engaged in a circumferential groove 308 in the driving half. On the opposite end of the switching fork 296, there is a lug or abutment 310. A compression spring 312 is disposed below this lug and tends to bias the shifting fork 296 in a counterclockwise direction to couple the jaws 116 and 118. To insure reliable coupling between the jaws 116 and 118 during feeding movement of the machine, a pawl 314 is pivotally mounted to the right of lug 310, as seen in FIGS. 3, 9 and 16. A compression spring 316 engages the pawl 314 and biases the latter counterclockwise to engage a locking nose 318 beneath the end of lug 310 to hold the coupling 116-118 firmly engaged. This position of the parts is shown in FIG. 9.

A bolt 320 is mounted in the lug 310 and, during return movement of the feed unit, cooperates with a pin 322 for actuating the limit switch 237 to stop the machine operation. Pin 322 is spring biased to the operative position and is so arranged in a supporting strap 324 that, upon contact of bolt 320 therewith, pin 322, after a short displacement, offers such a resistance that the shifting lever 296 is turned clockwise to the position of FIG. 16 wherein the drive spindle 284 is disengaged from the tool spindle 28. In order to release the blocking of switch lever 296 by the pawl 314 in advance of the clutch shifting operation, the supporting strap 324 is formed with a deflecting cam 326 engageable with a roller 328 on pawl 314. Such engagement rocks the pawl 314 clockwise to disengage its nose 318 from beneath the lug 310, in opposition to the spring 316.

In further accordance with the invention, splined shaft 284, during uncoupling from the spindle shaft, operates to shift the spindle magazine through operation of switch gear in housing 20. Driving of shaft 284, as well as of the entire switch gear, is effected from the preselecting gear 14 through the belt drive 18 of FIG. 1 to a multi-grooved pulley 330 which is keyed to the wedge bushing 286 and secured thereon by a nut 332.

For shifting magazine 22, bushing 286 is formed with a gear portion 334 meshing with a gear 338 rotatably mounted on an intermediate shaft 336. Gear 338 is pinned or otherwise secured to move with one half 340 of an electric coupling or clutch 342. The other half 344 of electric clutch or coupling 342 is keyed or otherwise secured to rotate with intermediate shaft 336. When coupling 342 is engaged, intermediate shaft 336 is rotatable with gear 338 which is driven by gear portion 334 of bushing 286. Shaft 336 has a pinion 346 formed thereon which is engageable with a gear 350, so that gear 350 is then rotated. Gear 350 is keyed, or otherwise secured, to rotate with a transmission shaft 348. Through a pinion 352, transmission shaft 348 drives a gear 68 which, through shaft 66 and pinion 64, previously mentioned, shifts magazine 22.

As best seen in FIG. 14, below electric coupling 342 on intermediate shaft 336, there is arranged an electric brake 354 whose function is to arrest magazine 22 whenever a respective spindle device inserted thereinto is at the working station. This occurs as a cam 356 on magazine 22 operates a limit switch 358, as best seen in FIG. 10. Through operation of switch 358, electric coupling 342 is disengaged and rotation of shafts 336, 348 and 66 is arrested by engagement of brake 354. By way of example, control of the position of magazine 22 may be effected through a multi-cam switch 360 cooperating with cams 362 inserted into magazine 22 and each associated with a respective spindle device, the switch 360 and cams 362 being illustrated in broken lines in FIG. 3. As an advantageous result, if there are six spindle devices inserted into the magazine, the magazine can be selectively conditioned to move only three of the spindle devices into the working position, for example.

FIGS. 17 and 18 illustrate a drilling machine embodying the invention which differs from that described in that the magazine and the magazine holder are annular.

Referring to these figures, a machine frame 402 is mounted on a base plate 400 and is provided with an adjustable table 406. Table 406 is a work supporting table and is provided with suitable clamping means 404 for the workpiece. Machine frame 402 has a preselecting gear box 408 arranged thereon and combined with a switch gear box 410 which is disposed below the gear box 408. These two gear boxes conjointly form a support 412 which extends laterally from frame 402 in the direction of table 406.

On the lower side of the support 412, as viewed in FIG. 17, an annular spindle magazine 418, shown in plan in FIG. 18 and to a larger scale, is rotatably mounted in a magazine receiver 414 or in a corresponding bearing bridge 416 of frame 402, or in both. As previously described for magazine 22, annular spindle magazine 418 is arranged to have removably inserted therein a plurality of spindle holder housings 422 each including a tool spindle 420. These housings 422, which are individually removable from and replaceable in magazine 418 as desired, are arranged at equal angular distances from each other. The spindles 420 can be brought selectively into the working station by rotation or angular displacement of magazine 418 about its axis. Such rotation can be effected by a suitable step-by-step switching mechanism, such as equivalent to the arrangement previously described for magazine 22. The working station is illustrated by the intersection of the two axes 424 and 426. In the working station, the respective tool spindle is coupled automatically with the tool drive and feed in the same manner as described for the embodiment of FIGS. 1-16.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A magazine spindle drilling machine comprising, in combination, a machine frame; tool spindle driving means located at a working station of the machine; a relatively elongated spindle magazine mounted for movement on said machine frame past the working station transversely of the axis of tool rotation and of the direction of tool feed, said magazine having a side surface parallel to the direction of tool feed and being formed with a plurality of uniformly spaced spindle device compartments each extending longitudinally parallel to the direction of tool feed; a plurality of spindle devices interchangeably insertable into the compartments of said magazine for selected movement by said magazine into the working station of the machine for coupling to said driving means; each spindle device including a tool spindle rotatable about the axis parallel to the axis of tool rotation and transverse to the direction of magazine movement; cooperating guiding and positioning means extending longitudinally of said compartments and of said spindle devices, whereby each spindle device is slidably insertable into and removable from the magazine in any position of the latter; feed slide means facing outwardly toward said magazine side surface, and juxtaposed with each spindle device moved into the working position, each magazine compartment having a longitudinally extending opening through said magazine side surface for exposing a spindle device therein for juxtaposition with said feed slide means; the plane of transportation of said spindle devices to the working position, and in the direction of tool feed, being parallel to the direction of tool feed and outwardly adjacent said feed slide means; indexing and clamping means operable to index and clamp each spindle device, when at the working station, to said feed slide means for movement as a rigid unit with the latter, the movement of each spindle device, during indexing and clamping to said feed slide means, being perpendicular to said plane of transportation; said feed slide

means being mounted for rigidly guided reciprocation in said frame parallel to the direction of tool feed to move the respective spindle device bodily and longitudinally out of the magazine and axially into the work engaging position, and for return of the removed spindle device into its compartment in the magazine whereby, when in the working position, each spindle device is supported solely by said feed slide means.

2. A magazine spindle drilling machine, as claimed in claim 1, in which each spindle device has shoulders thereon extending longitudinally of the direction of transportation of the spindle devices by said magazine, said shoulders being adjacent said side surface of said magazine; said clamping means comprising traction members mounted on said feed slide means for movement perpendicular to said plane of transportation, each traction device including a lip extending longitudinally of the direction of travel of said magazine and lying outwardly of said shoulders on each spindle device moved into the working station; and fluid pressure actuated means co-operable with each traction member and operable, when connected to a source of fluid pressure, to draw the associated traction member inwardly to clamp the feed device at the working station to said feed slide means; said fluid pressure actuated means stably maintaining its operated position irrespective of loss of fluid pressure.

3. A magazine spindle drilling machine comprising, in combination, a machine frame; tool spindle driving means located at a working station of the machine; a spindle magazine mounted for movement on said machine frame past the working station transversely of the axis of tool rotation and of the direction of tool feed, said magazine being formed with a plurality of uniformly spaced spindle device compartments each extending parallel to the direction of tool feed; a plurality of spindle devices interchangeably insertable into the compartments of said magazine for selected movement by said magazine into the working station of the machine for coupling to said driving means; each spindle device including a tool spindle rotatable about the axis parallel to the axis of tool rotation and transverse to the direction of magazine movement; cooperating guiding and positioning means extending longitudinally of said compartments and of said spindle devices, whereby each spindle device is slidably insertable into and removable from the magazine in any position of the latter; feed slide means juxtaposed with each spindle device moved into the working position, each magazine compartment having a longitudinally extending opening for exposing a spindle device therein for juxtaposition with said feed slide means; indexing and clamping means operable to index and clamp each spindle device, when at the working station, to said feed slide means for movement as a rigid unit with the latter; said feed slide means being mounted for rigidly guided reciprocation in said frame parallel to the direction of tool feed to move the respective spindle device bodily out of the magazine and axially into the work engaging position, and for return of the removed spindle device into its compartment in the magazine whereby, when in the working position, each spindle device is supported solely by said feed slide means; and including spindle movement control devices on said frame; individually adjustable spindle movement setting elements of each spindle device co-operable with respective control devices when the respective spindle device is moved into the working station; a preselecting gear for controlling the speed and direction of rotation of the tool spindle, and the feeding and retraction of the tool spindle as well as the feeding and retracting speeds thereof; said spindle movement control devices including a tapping depth setting device controlling said preselecting gear for a tapping operation; said spindle movement setting elements on each respective spindle device including a tapping depth setting element co-operable with said last-named setting device upon movement of the respective spindle device into the

working station; said tapping depth setting device, upon an attainment of threaded depth corresponding to the setting of said tapping depth setting element, operating through said preselecting gear to reverse the direction of rotation of the tool spindle and to retract the latter at the feed speed established by the setting of said setting element.

4. A magazine spindle drilling machine comprising, in combination, a machine frame; tool spindle driving means located at a working station of the machine; a spindle magazine mounted for movement on said machine frame past the working station transversely of the axis of tool rotation and of the direction of tool feed, said magazine being formed with a plurality of uniformly spaced spindle device compartments each extending parallel to the direction of tool feed; a plurality of spindle devices interchangeably insertable into the compartments of said magazine for selected movement by said magazine into the working station of the machine for coupling to said driving means; each spindle device including a tool spindle rotatable about the axis parallel to the axis of tool rotation and transverse to the direction of magazine movement; cooperating guiding and positioning means extending longitudinally of said compartments and of said spindle devices, whereby each spindle device is slidably insertable into and removable from the magazine in any position of the latter; feed slide means juxtaposed with each spindle device moved into the working position, each magazine compartment having a longitudinally extending opening for exposing a spindle device therein for juxtaposition with said feed slide means; indexing and clamping means operable to index and clamp each spindle device, when at the working station, to said feed slide means for movement as a rigid unit with the latter; said feed slide means being mounted for rigidly guided reciprocation in said frame parallel to the direction of tool feed to move the respective spindle device bodily out of the magazine and axially into the work engaging position, and for return of the removed spindle device into its compartment in the magazine whereby, when in the working position, each spindle device is supported solely by said feed slide means; and including spindle movement control devices on said frame; individually adjustable spindle movement setting element of each spindle device cooperable with respective control devices when the respective spindle device is moved into the working station; a preselecting gear for controlling the speed and direction of rotation of the tool spindle and the speed and direction of feed and retraction of the tool spindle; said spindle movement control devices including a setting device operable, at the limit of feed, to delay retraction of the tool for a preselected time; said spindle movement setting elements including a setting element cooperable with said last-named setting device to condition the same, when the respective spindle device is moved to the working station, to effect such delay in the return movement of the tool.

5. A magazine spindle drilling machine comprising, in combination, a machine frame; tool spindle driving means located at a working station of the machine; a spindle magazine mounted for movement on said machine frame past the working station transversely of the axis of tool rotation and of the direction of tool feed, said magazine being formed with a plurality of uniformly spaced spindle device compartments each extending parallel to the direction of tool feed; a plurality of spindle devices interchangeably insertable into the compartments of said magazine for selected movement by said magazine into the working station of the machine for coupling to said driving means; each spindle device including a tool spindle rotatable about the axis parallel to the axis of tool rotation and transverse to the direction of magazine movement; cooperating guiding and positioning means extending longitudinally of said compartments and of said spindle devices, whereby each spindle device is

slidably insertable into and removable from the magazine in any position of the latter; feed slide means juxtaposed with each spindle device moved into the working position, each magazine compartment having a longitudinally extending opening for exposing a spindle device therein for juxtaposition with said feed slide means; indexing and clamping means operable to index and clamp each spindle device, when at the working station, to said feed slide means for movement as a rigid unit with the latter; said feed slide means being mounted for rigidly guided reciprocation in said frame parallel to the direction of tool feed to move the respective spindle device bodily out of the magazine and axially into the work engaging position, and for return of the removed spindle device into its compartment in the magazine whereby, when in the working position, each spindle device is supported solely by said feed slide means; comprising a bank of individual switches carried by said feed slide means; a preselecting gear for controlling the speed and direction of rotation of the tool spindle, and the speed and direction of feeding and retraction of the tool; said switches controlling the operation of said preselecting gear; and a bank of individually adjustable switch operators carried by each spindle device and cooperable with said switches when the associated spindle device is at the working station; the switch operators of each spindle device being positioned thereon in adjacent relation and each having its position corresponding to a respective one of said switches.

6. A magazine spindle drilling machine, as claimed in claim 5, in which said switch operators are relatively elongated pins which are mounted for longitudinal displacement transversely of the spindle axis; said pins being adjustable to and securable in either an inactive position or an active position.

7. A magazine spindle drilling machine, as claimed in claim 5, including at least one holder on said feed slide means supporting said switches; means normally biasing said holder to a position in which said switches are retracted; and means operable, responsive to indexing and clamping of a spindle device, at the working station, to said feed slide means, to project said holder to engage the switches with selectively positioned switch operators on the then indexed and clamped spindle device.

8. A magazine spindle drilling machine, as claimed in claim 7, in which said last-named means comprises hydraulic actuating means.

9. A magazine spindle drilling machine comprising, in combination, a machine frame; tool spindle driving means located at a working station of the machine; a spindle magazine mounted for movement on said machine frame past the working station transversely of the axis of tool rotation and of the direction of tool feed, said magazine being formed with a plurality of uniformly spaced spindle device compartments each extending parallel to the direction of tool feed; a plurality of spindle devices interchangeably insertable into the compartments of said magazine for selected movement by said magazine into the working station of the machine for coupling to said driving means; each spindle device including a tool spindle rotatable about the axis parallel to the axis of tool rotation and transverse to the direction of magazine movement; cooperating guiding and positioning means extending longitudinally of said compartments and of said spindle devices, whereby each spindle device is slidably insertable into and removable from the magazine in any position of the latter; feed slide means juxtaposed with each spindle device moved into the working position, each magazine compartment having a longitudinally extending opening for exposing a spindle device therein for juxtaposition with said feed slide means; indexing and clamping means operable to index and clamp each spindle device, when at the working station, to said feed slide means for movement as a rigid

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unit with the latter; said feed slide means being mounted for rigidly guided reciprocation in said frame parallel to the direction of tool feed to move the respective spindle device bodily out of the magazine and axially into the work engaging position, and for return of the removed spindle device into its compartment in the magazine whereby, when in the working position, each spindle device is supported solely by said feed slide means; hydraulic fluid actuator means for moving said feed slide means in a tool feeding direction; a feeding speed control means for said feed slide means, said speed control means comprising a longitudinally adjustable variable orifice element on said feed slide means and controlling the rate of hydraulic fluid supply to said actuator means; and an operator positioned on each respective spindle device and engageable with said orifice element when

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the respective spindle device is at the working station to adjust said orifice element longitudinally to set the feeding speed in accordance with the setting of said operator.

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