United States Patent

Suizu

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[45] Aug. 8, 1972

[54] **MULTIPLE-SPINDLE DRILLING MACHINE**

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[52] U.S. Cl. **408/46**, 408/48, 408/53

[51] Int. Cl. **B23b 31/18**

[58] Field of Search.....408/46, 48, 53, 88, 42, 117

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Primary Examiner—Gil Weidenfeld

Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A multiple-spindle drilling machine is provided with a plurality of drilling spindle units each of which is driven from a common power supply means but which are readily adjustable longitudinally and normal to the drilling spindle axis to provide a multiplicity of drilling patterns as the plurality of units are advanced simultaneously to accomplish a drilling operation. A plurality of drilling spindle units may be adjustably mounted on a common support in a horizontal row and additional horizontal rows may be provided having the identical or different lateral spacing therebetween. The horizontal rows of spindles may be disposed parallel to each other or may be inclined relative to each other.

7 Claims, 12 Drawing Figures

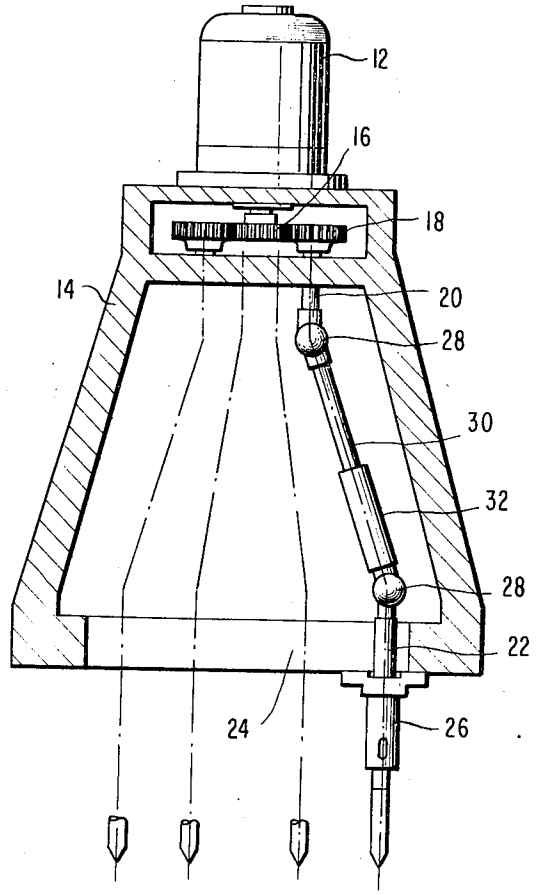


FIG. 1
PRIOR ART

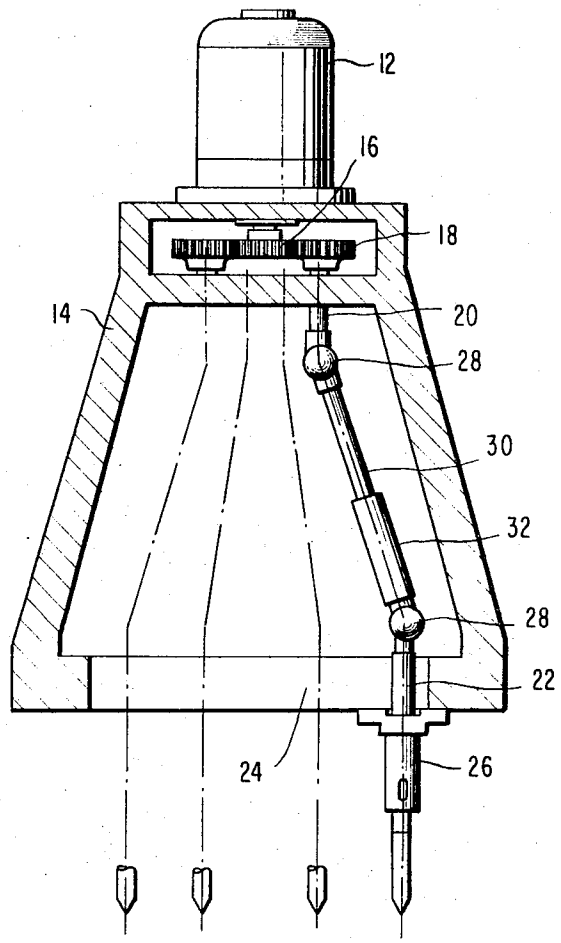


FIG. 2

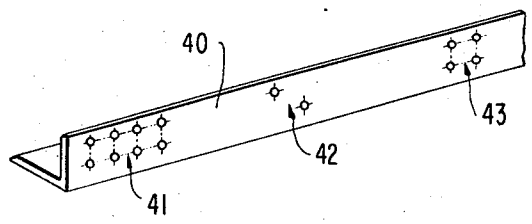


FIG. 3A

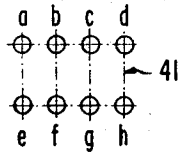


FIG. 3B

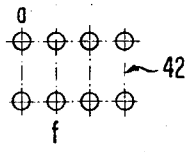
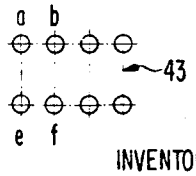


FIG. 3C



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ATTORNEYS

FIG. 4

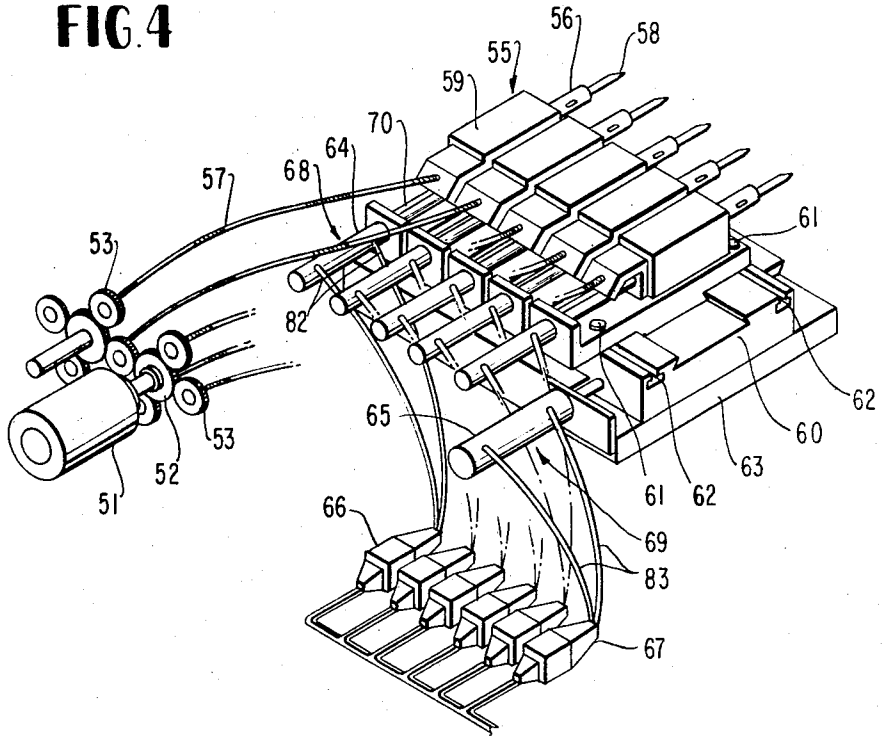
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FIG. 5

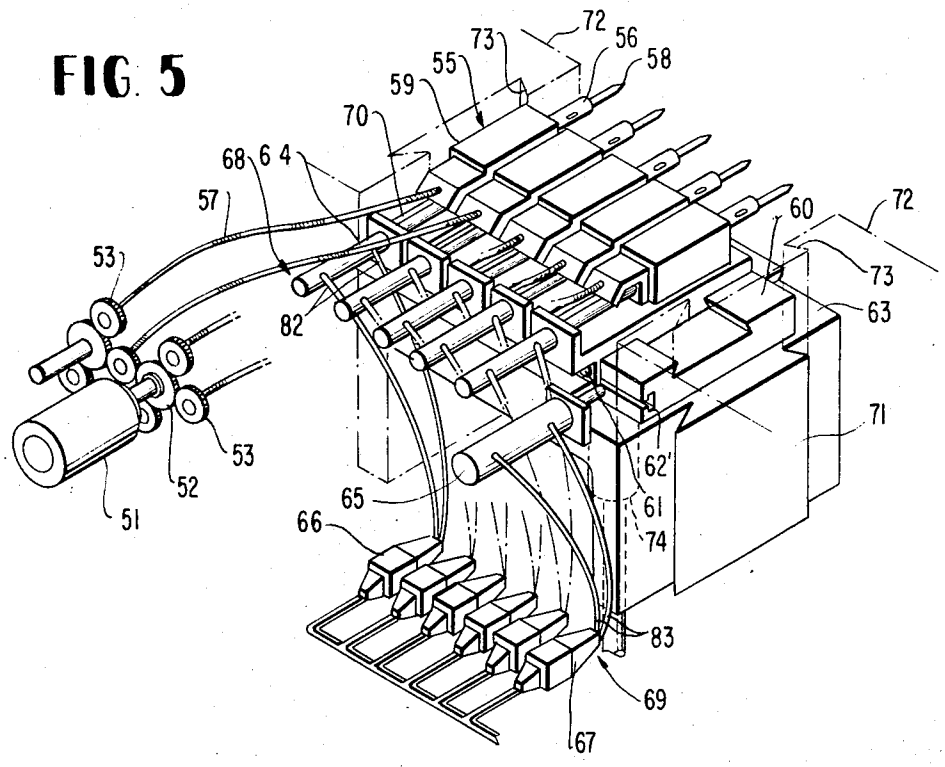
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FIG. 6

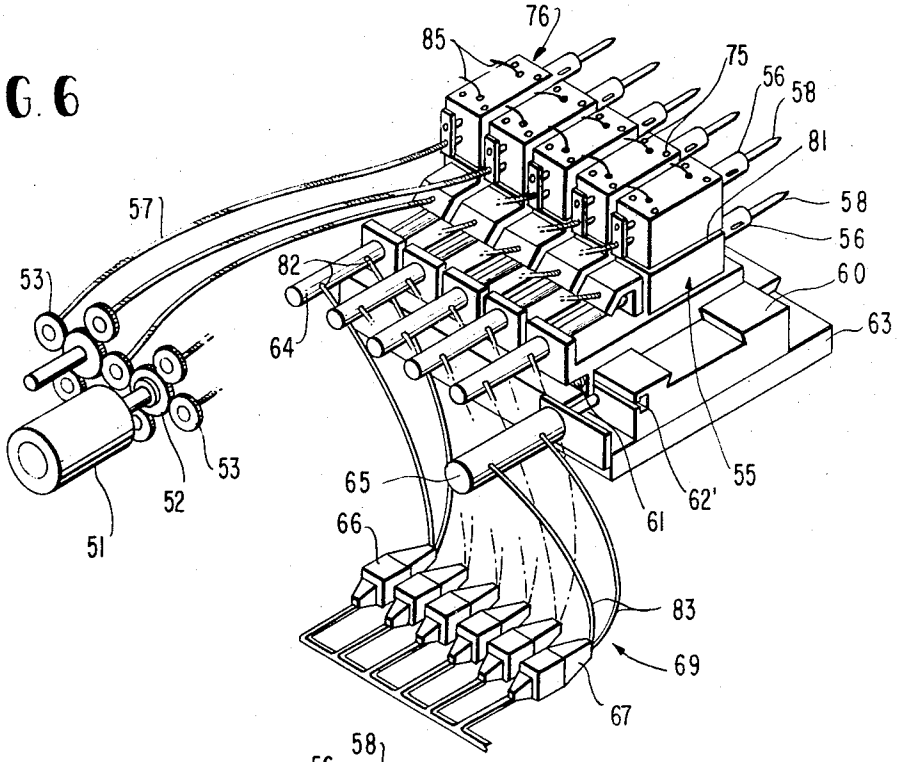


FIG. 7

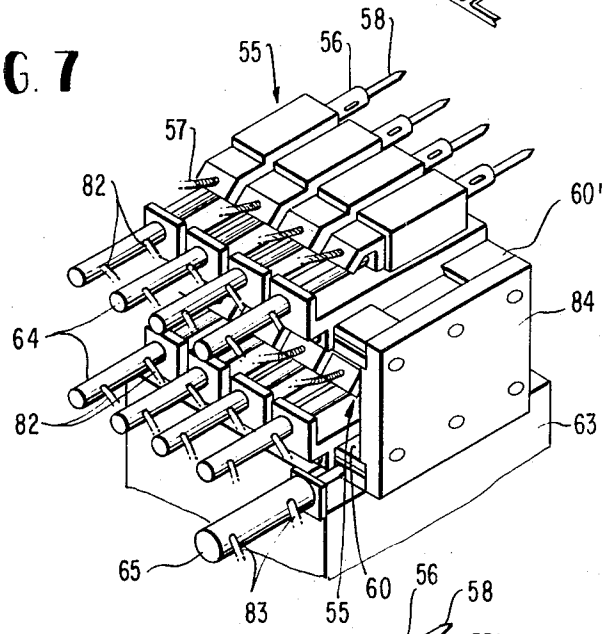
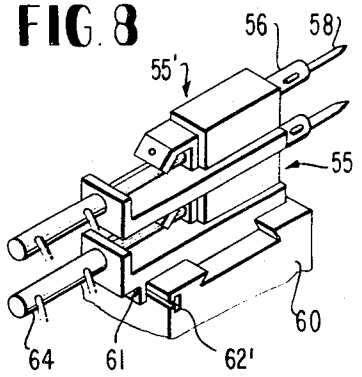


FIG. 8



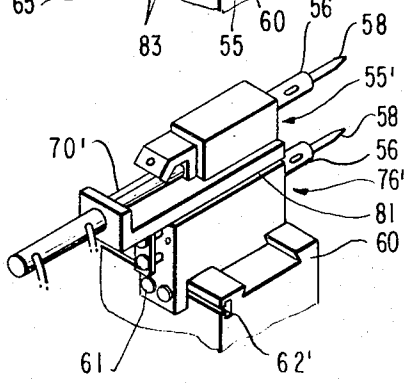


FIG 9

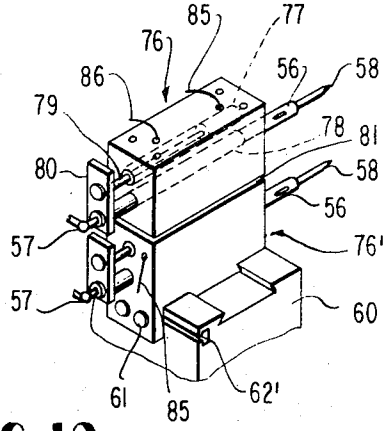


FIG 10

MULTIPLE-SPINDLE DRILLING MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a multiple-spindle drilling machine and more particularly a drilling machine which is adapted to drill a plurality of hole patterns by adjustably mounting the individual spindles and by selectively moving individual spindles into and out of operative drilling position.

2. Prior Art

Prior multiple-spindle drilling machines were capable of simultaneously drilling a plurality of grouped holes. Such machines were sometimes capable of providing a variation in the lateral spacing of the drilling spindles along a line normal to the drilling spindles. However, the prior machines did not provide for automatically advancing and retracting the individual drilling spindles into and out of drilling position prior to advancing the common support member during a drilling operation. It was usually necessary to physically remove or attach spindles in the desired location and as a result, such machines were only efficient when it was wished to drill a group of holes having the same number and disposition over and over.

SUMMARY OF THE INVENTION

The present invention provides for eliminating the aforementioned disadvantages of the conventional multiple-spindle drilling machine and provides a new and improved multiple-spindle drilling machine which may drill a plurality of different groups of holes which may vary as to number, location and angle.

According to one aspect of the present invention, there is provided a multiple-spindle drilling machine having a plurality of spindle units, each of which is slidably mounted on a common base portion in a direction normal to the axis of each spindle. Each spindle may be individually advanced and retracted into and out of operative position and a feeding mechanism is provided for feeding the base plate in the direction of the axes of the spindles whereby holes will be drilled only at those locations corresponding to a spindle unit which has been advanced into operative position.

The present invention also provides for drilling a plurality of horizontal parallel rows of holes wherein the spacing of the holes in each row may be the same or different in the direction normal to the axis of the spindle. Furthermore, the axes of the spindle units in one horizontal row may be disposed at an angle with respect to the axes of the spindle units in another horizontal row.

The other features and advantages of the present invention will be described in the following specification taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a multiple spindle head of a prior art conventional multiple-spindle drilling machine.

FIG. 2 is a perspective view of one example of workpiece which may be drilled by the machine of the present invention.

FIGS. 3A–3C are explanatory schematic arrangements of holes which may be drilled by the machine of the present invention.

FIG. 4 is a perspective view of a drill head according to the present invention having a plurality of drill units disposed parallel in one row.

FIG. 5 is a perspective view of a drill head similar to that shown in FIG. 4 but also movable in the vertical direction.

FIG. 6 is a perspective view of a drill head according to the present invention having a plurality of drill units disposed in parallel in upper and lower rows.

FIG. 7 is a perspective view of a drill head according to the present invention having a plurality of drill units disposed in parallel in upper and lower rows on separate base plates.

FIG. 8 is a perspective view of two vertically disposed drilling units arranged on a common base.

FIG. 9 is a view similar to FIG. 8 showing a modified arrangement for mounting the two vertically disposed drilling units.

FIG. 10 is a view similar to FIG. 8 showing a further modification of the arrangement of the two vertically disposed drilling units.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a conventional prior art multiple-spindle drilling machine which is capable of simultaneously drilling a plurality of grouped holes. A motor **12** is mounted on the drilling head **14** and is provided with an output gear **16** on the drive shaft thereof. The gear **16** is disposed in mesh with a plurality of circumferentially disposed gears **18** mounted on shafts **20**. A plurality of spindles **22** are mounted along a slot **24** in the head **14** and provide the drive for a plurality of drilling units **26**. The drive is transmitted to the spindles **22** from the shaft **20** by means of universal joints **28** and telescopicly splined shaft members **30** and **32**. Thus, all of the drill units **26** were operated simultaneously and such an arrangement was efficient if the exact same holes were to be drilled every time. However, if the machine were to drill a number of holes in a group different from a previous group, the drills had to be physically removed or attached each time which resulted in a gross inefficiency. If a significant variation in the grouping and number of the holes were desired, it often became necessary to drill each hole one by one.

FIG. 2 shows one example of a workpiece **40**, having a plurality of different hole groupings therein which may efficiently be achieved by the machine of the present invention. The hole groups **41**, **42** and **43** are shown schematically in FIGS. **3A**, **3B** and **3C** respectively. In order to drill the holes in group **41**, all eight drilling spindles a-h would be disposed in operative drilling position on the base plate and the eight holes would be drilled simultaneously as the base plate was advanced. In order to drill the hole group **42**, only units a and f would be disposed in operative position and the remaining units would be retracted to inoperative position prior to advancement of the base plate. Likewise, in order to drill the hole group **43**, drilling units *a*, *b*, *e*, and f would be disposed in operative position and the remaining drilling units would be retracted prior to advancement of the base plate. The ease in which such a selective disposition of the drilling units may be achieved will now be described with respect to the specific apparatus of the present invention.

FIG. 4 shows a drilling apparatus having a plurality of drill units disposed in parallel in a single horizontal row.

The drilling apparatus is comprised of an electric motor **51** which drives a main gear **52** disposed in mesh with a plurality of auxillary driving gears **53**. A displaceable member such as a flexible shaft **57** or a combination of universal joints and splined shafts are provided for connecting each gear **53** of the rotary drive portion to a spindle **56** in each drilling unit **55**. Each drilling unit **55** is comprised of a base **20** which is slidably mounted on a base plate **60** by means of a tongue and groove connection. A plurality of the drilling units **55** may be mounted side by side on the base plate **60** and freely adjusted thereon with respect to each other to determine the correct spacing of the holes to be drilled. ONce the drilling units **55** are disposed in the proper position, they may be secured in place by tightening a pair of nuts (not shown) slidably engaged in T-shaped grooves **62** formed in the base plate **10** and a pair of complementary bolts **61** extending through the base member **70** of each drilling unit **55**. The base plate **60** is slidably mounted on a main base member **63** for movement in a direction parallel to the spindles.

A plurality of spindle feeding mechanisms **68** are associated with each of the drilling units **55** for advancing the spindles along their axes. An additional feeding mechanism **69** is also provided for advancing the base plate **60** in the same direction so as to simultaneously advance all of the drilling units **55** to perform a drilling operation. The spindle feeding mechanisms **68** and the feeding mechanism **69** are comprised of hydraulic oil pressure cylinders **64** and **65** respectively and solenoid switching valves **66** and **67** respectively. A plurality of flexible tubes **82** and **83** are provided for connecting the cylinder **64** and **65** to the valves **66** and **67** respectively so that the command from a punched tape will actuate the solenoid valves by suitable relay means to first select the desired drilling unit **55** and forward it into operative position and thereafter operate the solenoid switching valve **67** so as to automatically advance the base plate **60** to perform a drilling operation. The spindle feeding mechanism **68** and the feeding mechanism **69** may also utilize a screw and nut drive or a rack and pinion type drive in order to carry out the advancing and retracting movements.

In the operation of the drilling apparatus, if it is desired to drill a single row of holes having a predetermined spacing, the drilling units **55** are first moved so as to align the spindles with the desired hole arrangement and secure the drilling units to the base plate **60**. Then only those drilling units **55** corresponding to the hole arrangement of the desired hole group are forwarded by the hydraulic oil pressure cylinders **64** and subsequently hydraulic oil pressure cylinder **65** is operated so as to advance the base plate **60** to drill the desired hole group simultaneously. After the completion of the drilling operation, the workpiece may be removed or the drilling apparatus according to the present invention may be shifted so as to prepare for the next drilling operation, at which time the above steps will be repeated.

FIG. **5** shows a drilling apparatus very similar to that shown in FIG. **4**, but additionally providing for the vertical movement of the drilling units. In this device, the base plate **60** is mounted on a main base portion having vertically disposed sliding portions **71** at both sides of the main base for guiding the main base in a vertical direction. The sliding portion **71** is in the form of a tongue and is slidably mounted in a complementary guide groove **73** formed in a stand **72**. An hydraulic oil pressure cylinder **74**, is provided on the lower surface at the center of the main base portion for moving the main base portion and all of the drilling units mounted thereon in a vertical direction. Thus, in the operation of this drilling apparatus, when it is desired to drill a hole arrangement having upper and lower rows of holes, the drilling apparatus will first drill one row and be vertically shifted so as to drill the other row of the hole arrangement.

FIG. **6** shows a drilling apparatus having a plurality of drill units disposed in parallel in upper and lower rows. The lower row of drilling units and the means for supporting, driving and advancing the drilling units in this row are identical to the arrangement shown in FIG. **6**. An upper row of drilling units, each of which is generally designated by **76** are mounted on top of a corresponding drilling unit **55** in the lower row and connected thereto by means of bolts **75**. Thus, in this arrangement, a hole arrangement consisting of two rows of holes may be drilled simultaneously without shifting the base plate **60** in the vertical direction.

The detailed structure of the additional drilling units **76** is best shown in FIG. **10**. A fluid cylinder **77** is mounted within the drilling unit **76** and a piston **79** is slidably arranged therein for reciprocating movement in response to fluid pressure selectively applied through conduits **85** or **86** to opposite sides of the enlarged piston head within the cylinder **77**. The spindle **56** is connected to a slidable quill shaft **78** which is mounted for sliding movement parallel to the cylinder **77**. The piston **79** and the quill shaft **78** are connected together for conjoint movement by means of a connecting plate **80**. The flexible drive shaft **57** is led into and extends through the quill shaft **78** to rotate the drill **58** mounted on the spindle **56**. In operation, when pressure is applied through conduit **85**, the piston **79** will be extended and the spindle **56** will be retracted into an inoperative position so that upon advancing movement of the entire drilling assembly by means of the feeding mechanism **69**, a hole will not be drilled at that particular location. Spacers **81** may be provided between the lower drilling units **55** and the upper drilling units **76** so as to vary the vertical distance between the two vertically disposed holes. The spacing units **81** may even be wedge shaped so as to vary the pitch of the upper drilling unit with respect to the lower drilling unit. Furthermore, one or more additional drilling units may be vertically mounted upon the upper drilling unit **76** in the same manner in which the drilling unit **76** is mounted on the lower drilling unit **55** so that any number of vertically aligned holes may be drilled simultaneously.

The present invention also contemplates the use of two or more drilling units similar to drilling units **76** disposed in vertical relationship. In this case, as shown in FIG. **10**, the lower drilling unit **76'** would be provided with a suitable tongue for sliding in the groove in the base plate **60**. Likewise, as shown in FIG. **9**, the drilling unit **55** may be provided with a plane base **70'** for mounting on top of a drilling unit **76'** which in turn is slidably mounted in the base plate **60**. Also, in FIG. **8**, the drilling unit **55'** may be mounted vertically on top of the drilling unit **55**.

In each of the above-described arrangements where two drilling units are vertically mounted on top of each other, the spindles must be vertically aligned and therefore the holes in the vertical row must be in vertical alignment. In order to stagger the holes laterally in a vertical row, the arrangement as shown in FIG. 7 may be utilized. A plurality of drilling units **55** are slidably arranged on a base member **60** similar to the arrangement previously described with respect to FIG. 6 and a second row of drilling units **55** are also slidably mounted on a base plate **60'** in the same manner. The base plates **60** and **60'** are spaced apart in the vertical direction sufficient to provide adequate clearance for the lower row of drilling units **55** and are held in spaced relationship by means of a pair of vertical end support plates **84**. Thus, the drilling units in each horizontal row may be adjusted in a manner to provide for the drilling two rows of holes wherein the holes in the upper row are not necessarily vertically aligned with the holes in the lower row. It is also contemplated that additional rows could be added in the same manner to drill three or more horizontal rows of holes simultaneously.

In all of the arrangements described above wherein a plurality of units are mounted in vertically disposed relationship, the locking groove **62'** in the base plate **60** is generally located on the side of the base plate **60** so that the nut and bolt arrangement for locking the drilling unit to the base plate will be accessible from the side of the drilling unit, rather than from the top as shown in FIG. 4.

Thus, the drilling apparatus according to the present invention provides for drilling a plurality of different hole groups having unusual configurations and also provides for changing from one hole pattern to another with a minimum amount of effort. It is also understood that the drilling units according to the present invention, may be very narrow in the lateral direction as compared with a conventional machine which has bulky gear mechanisms therein. For example; if the drilling units are disposed adjacent each other the minimum distance between the holes may be as small as 3.5 times the diameter of the drill.

What is claimed is:

1. A multiple spindle drilling machine comprising a main base, a base plate slidably mounted on said main base, a plurality of drilling units each having support means and spindle means, said spindle means being rotatably and movably mounted on said support means in parallel to each other and being reciprocable along the axis of rotation thereof relative to said base plate, each of said units being slidably mounted on said base plate for movement transverse to said axis of rotation, means for selectively reciprocating each of said spindle means relative to said support means into and out of operative position and means for shifting said base plate on said main base in a direction parallel to said spindles to simultaneously advance and retract said units during a drilling operation.

2. A multiple spindle drilling machine as set forth in claim **1** further comprising guide means on said main base and said base plate for guiding said base plate in the vertical direction and means for vertically reciprocating said base plate along said guide means.

3. A multiple spindle drilling machine as set forth in claim **1** further comprising means for locking each of said drilling units to said base plate at any desired position.

4. A multiple spindle drilling machine as set forth in claim **1** further comprising an additional drilling unit secured to said each first mentioned drilling units in vertical alignment therewith.

5. A multiple spindle drilling machine as set forth in claim **1** further comprising an additional base plate secured to and disposed in vertically spaced parallel relation to said first mentioned base plate and a plurality of drilling units slidably mounted thereon for movement transverse to said axis of rotation.

6. A multiple spindle drilling machine as set forth in claim **1** wherein said means for reciprocating each of said spindle means is comprised of cylinder means mounted on said support means, piston means reciprocable therein in opposite directions of the influence of pressurized fluid and means connecting said piston and spindle means for conjoint movement.

7. A multiple spindle drilling machine as set forth in claim **1** further comprising unitary drive means and a plurality of drive train means connected to said unitary drive means and each of said spindle means for imparting rotary motion to said spindle means.

* * * * *