

Feb. 4, 1964

H. G. BIEKER
SEMI-AUTOMATIC DRILL PRESS ASSEMBLY AND
METHOD OF DRILLING STACKED SHEETS

3,120,136

Filed May 18, 1960

5 Sheets-Sheet 1

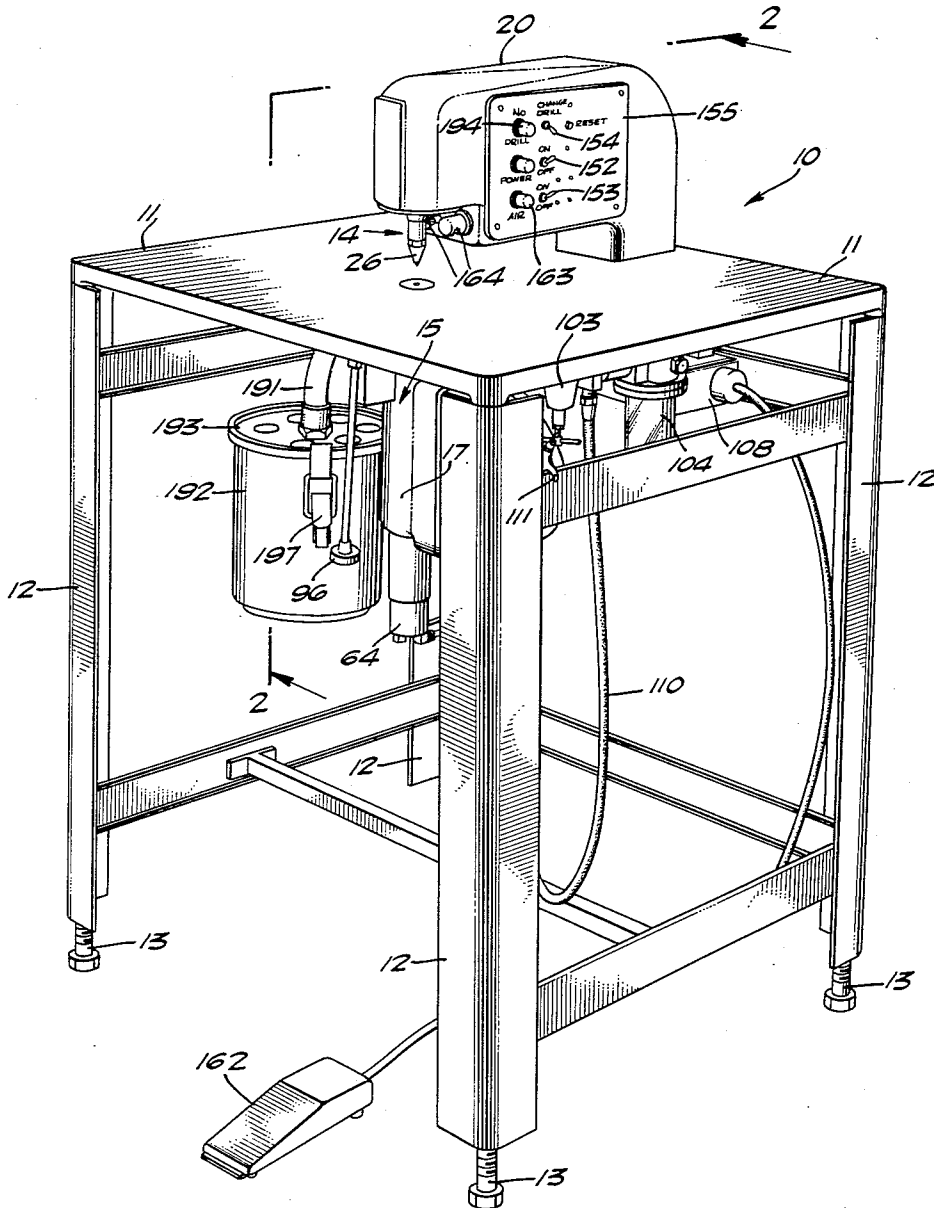


FIG. 1.

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5 Sheets-Sheet 2

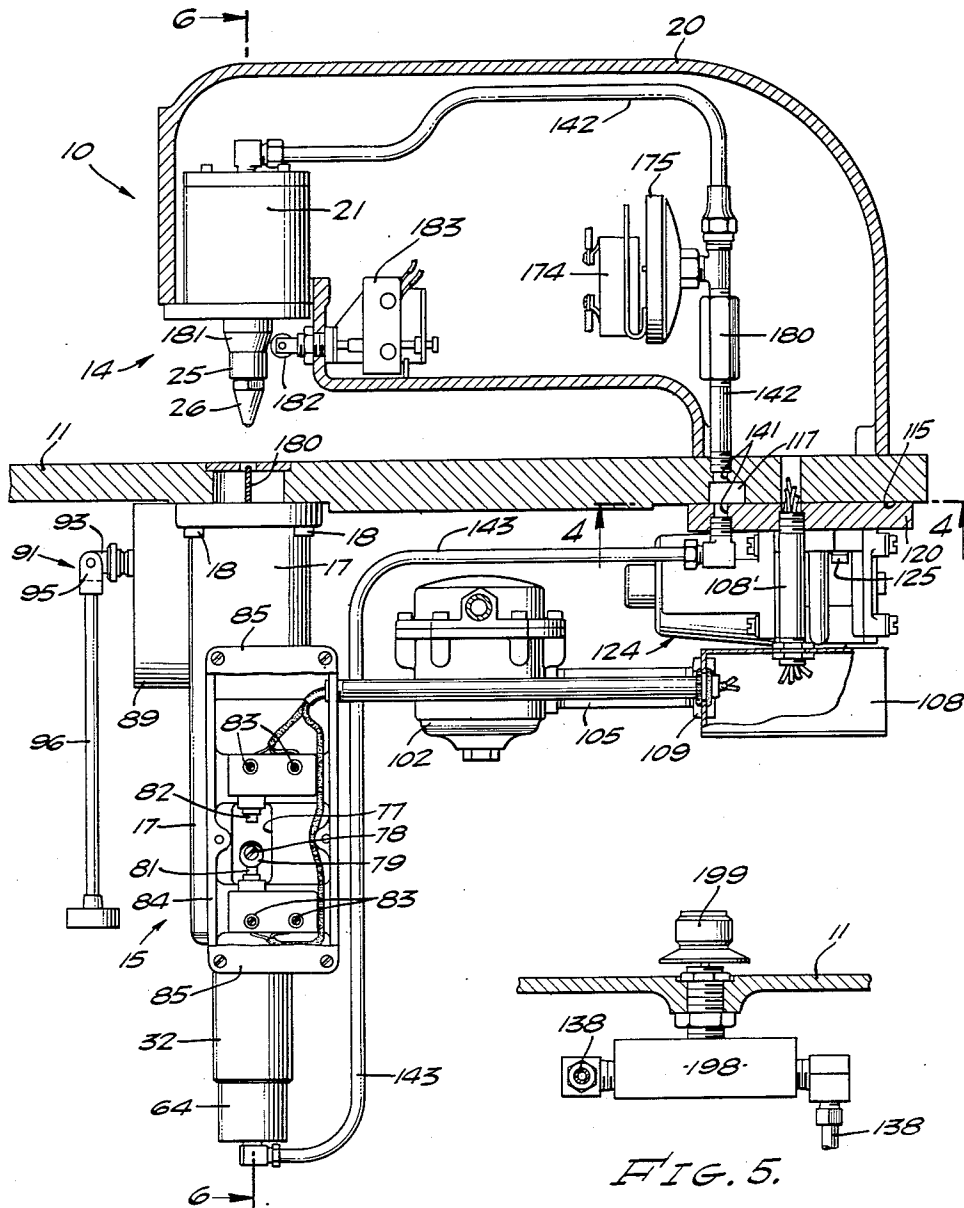


FIG. 2.

FIG. 5.

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5 Sheets-Sheet 3

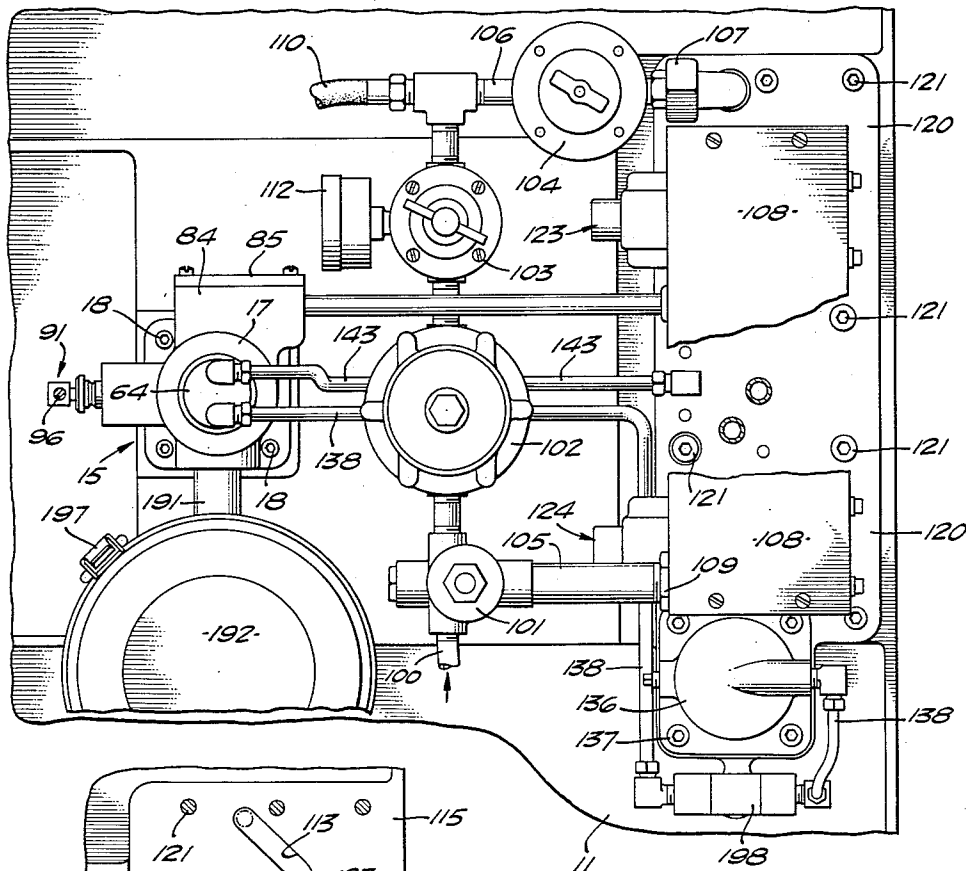


FIG. 3.

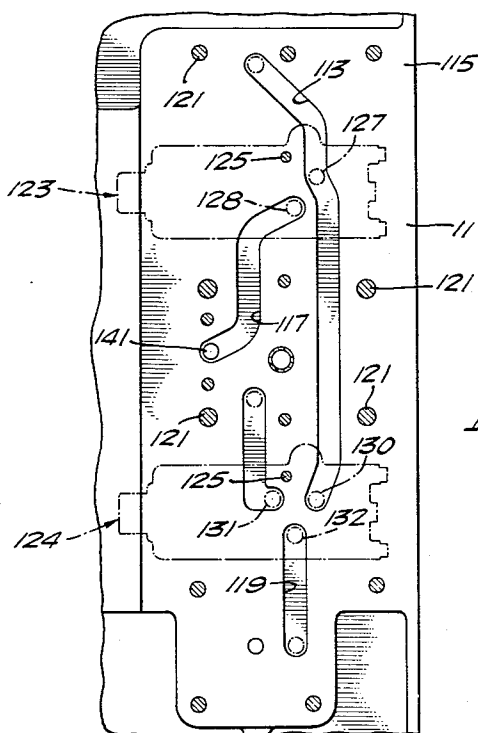


FIG. 4.

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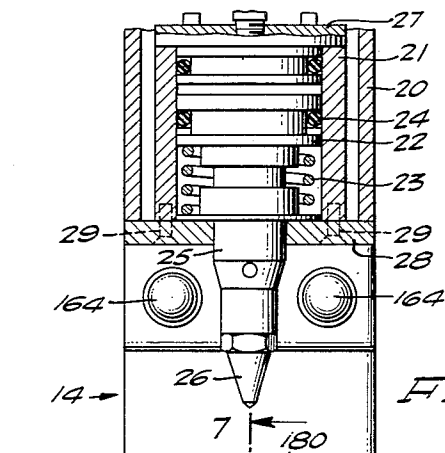


FIG. 6.

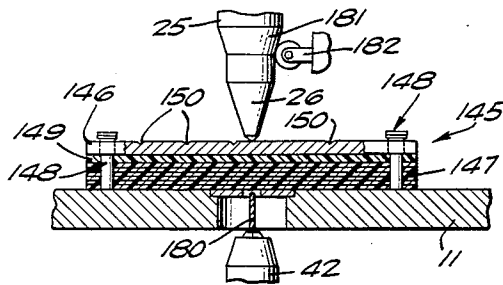


FIG. 8.

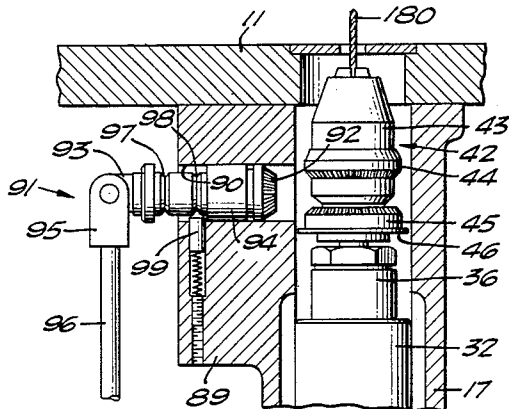
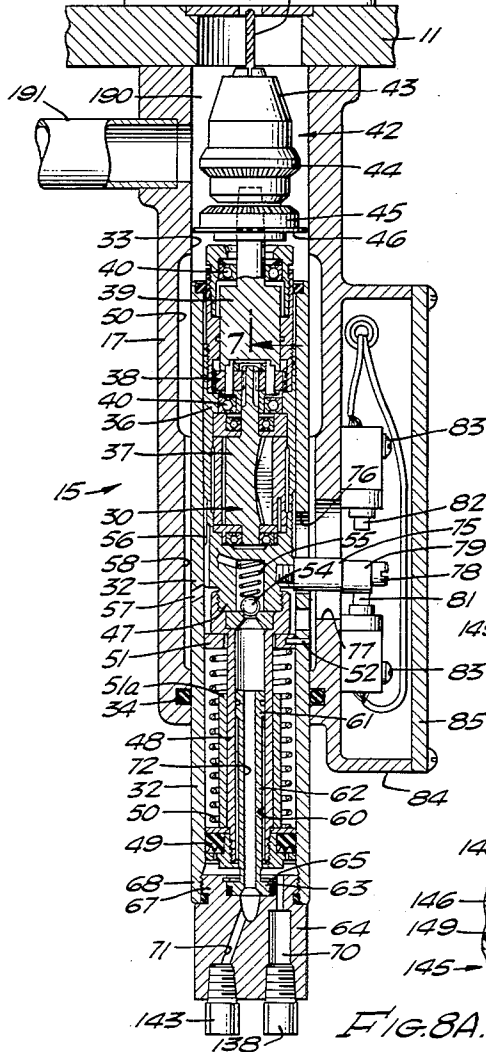


FIG. 9.

FIG. 7.

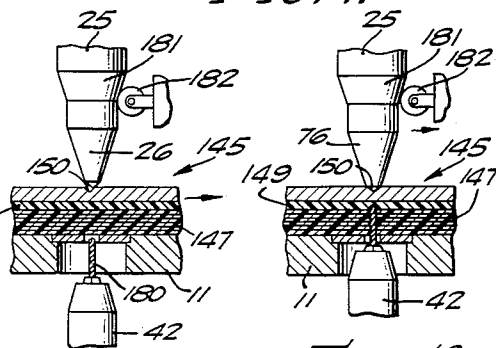


FIG. 10.

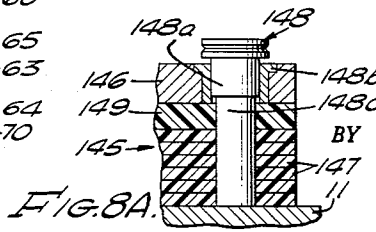


FIG. 8A.

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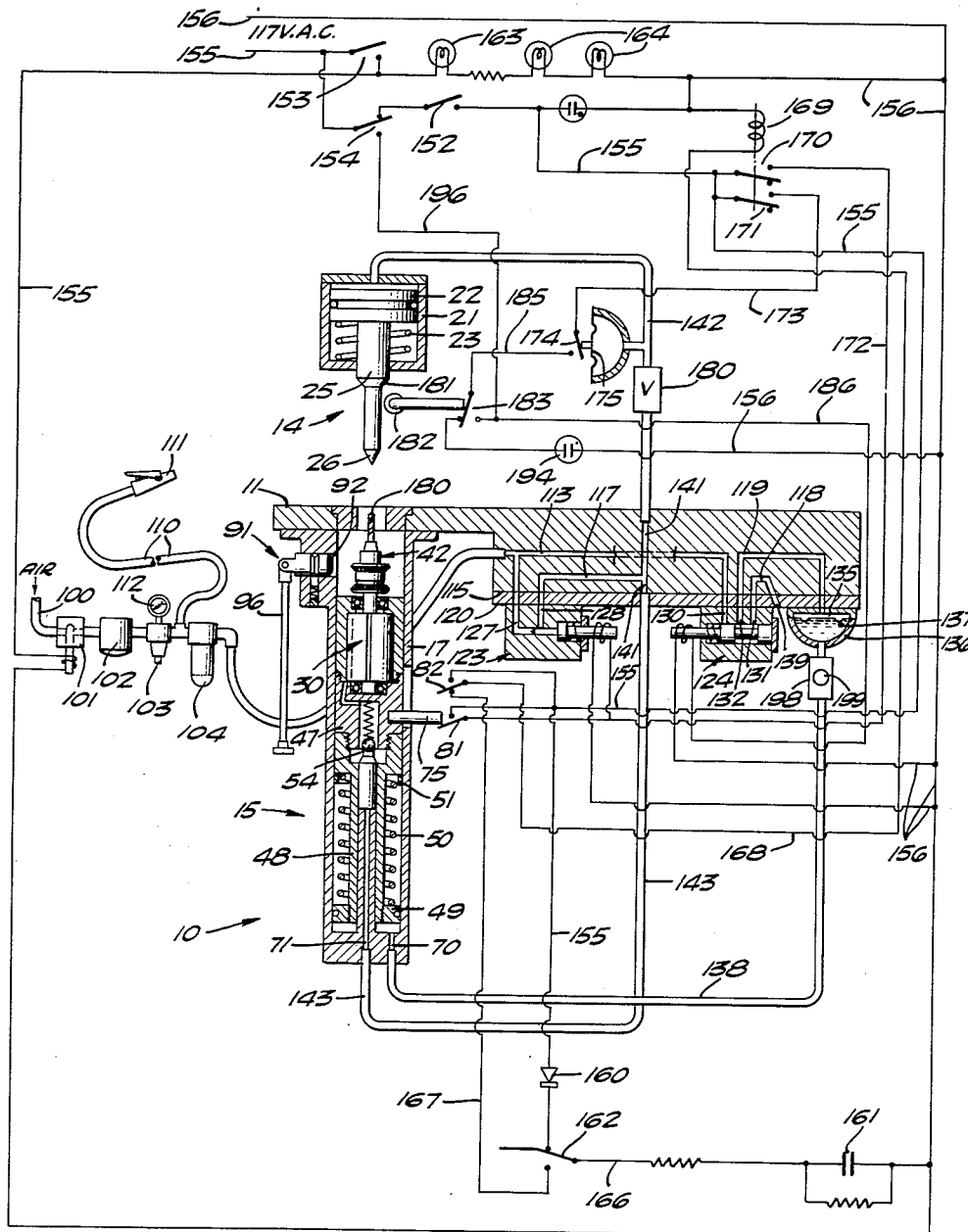
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FIG. 11.

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SEMI-AUTOMATIC DRILL PRESS ASSEMBLY AND
METHOD OF DRILLING STACKED SHEETS
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Filed May 18, 1960, Ser. No. 29,924
50 Claims. (Cl. 77—32.2)

This invention relates to drilling apparatus and more particularly to an improved high speed semi-automatic drill machine or press having numerous unique features and operable upon the initiation of an operating cycle to locate the work precisely, clamp it in place and then advance and retract the drill before releasing the workpiece.

There have been various proposals heretofore for drill presses intended to relieve the operator of various routine tasks associated with repeated drilling operations to the end that such tasks might be performed mechanically and in predetermined phase relationship. However, such attempts have been subject to many shortcomings and disadvantages all of which are avoided by the present invention. For example, prior designs have been characterized by their complexity both from a functional and a structural standpoint. These designs also fall far short of meeting acceptable tolerance variations essential to most present day manufacturing requirements. Another outstanding shortcoming is their lack of adaptability to drill widely varying workpieces.

An illustrative embodiment of the invention to be disclosed herein is particularly suitable for the high speed precision drilling of printed circuit boards of a great variety of sizes and design arrangements of the circuitry. As is well known to those skilled in that art, a multiplicity of holes are required to be drilled through such board with substantially no tolerance variation. The material normally present in these boards includes copper foil and other thin metal layers which are extremely difficult to drill cleanly, precisely, free of burrs and rigidly to size dimensions. By the present invention there is provided a semi-automatic drill press which has met these and other exacting requirements in a fully satisfactory manner by which a relatively inexperienced operator can readily drill approximately 10,000 openings an hour using a single drill bit and with results so accurate and uniform that there are substantially no rejects owing to malfunctioning of the drilling operation. No known prior drill press can approach these results.

In its essential form the drill press embodies a smooth surfaced work support having a drill bit opening aligned with a high speed reciprocally-supported drilling device, the drill tip of which is normally retracted below the work-supporting surface. Overlying the drilling device is a combined work locator and clamping device having a tapered lower end seatable in a complementally shaped recess formed in the underlying surface of a template secured to the workpieces. Preferably a plurality of workpieces are pinned or clamped in aligned arrangement to the template to the end that this assembly may be moved into approximate position beneath the tapered end of the clamping device.

The drilling cycle is initiated when the operator depresses a foot or the like switch whereupon air pressure is supplied to the clamping device and to the drill motor. Lowering of the clamping device against the template enables the tapered end of the former to shift the work in any direction necessary to bring it precisely into drilling position simultaneously with the clamping of the work under pressure against the supporting surface. As this occurs the air pressure activates a hydraulic circuit to elevate the turbine-driven drill through the work and into a backup sheet interposed between the work and the template. As this point is reached the hydraulic circuit is deactivated and the drill is retracted followed by the with-

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drawal of the clamping means and the deactivation of the entire control circuit.

Should the operator misalign the work so badly that the clamping device strikes the template to one side of the locating depression, the hydraulic circuit employed to advance the drill remains deactivated and a warning signal is activated as the clamping means retracts until the operator repositions the work and again closes the foot switch.

Another feature involves the use of the air exhausting from the turbine motor in cooperation with housing means surrounding the drill chuck to flush away cuttings into an air and cuttings separator. By reason of this arrangement the work supporting surface remains free of cuttings at all times.

Another feature of the arrangement is the use of a single control relay in combination with a pair of solenoid-operated valves. This relay is arranged to be energized instantly by an electrical charge stored on a capacitor and released through the relay instantly the operator closes a control switch. Another feature contributing greatly to the high speed and positiveness of the operation is the used of a sealed hydraulic circuit functioning to advance the drill and operated by air pressure automatically as the work is accurately located and clamped to the work supporting surface.

Other features of interest include numerous details of the design all characterized by their simplicity, low cost, and the ease with which they can be assembled and disassembled for servicing, and in particular, by the protection afforded the apparatus and the operator against injury and the hazards usually associated with the operation of high speed equipment.

Accordingly it is a primary object of this invention to provide an improved high speed semi-automatic drill press characterized by its simplicity, reliability, unusual accuracy and exhibiting over-all performance and safety attributes not heretofore known or available.

Another object of the invention is the provision of a semi-automatic drill press which is compact, light in weight, and having power operated components adapted to be sequentially activated through a complete operating cycle in response to a single initiating impulse.

Another object of the invention is the provision of a semi-automatic drill press having a power driven drill operable automatically to perform a drilling cycle if and when work clamping means accurately shifts the work precisely to the desired drilling position and clamps it there.

Another object of the invention is the provision of a drill press having a turbine driven drilling unit normally retracted within a concealing housing and reciprocable therefrom to drill a workpiece when work clamping means therefor has closed against the work and functioning to hold work rigidly in place until the drill has completed its operating cycle.

Another object of the invention is the provision of a drill press having a work supporting table top and wherein the drilling unit and the major controls therefor are secured to the underside of the drilling surface.

Another object of the invention is the provision of a semi-automatic drill press having a workpiece supporting table top formed on another surface thereof with open-sided flow passages arranged to be closed and placed in communication with flow control devices supported on a cover plate securable across said flow passages.

Another object of the invention is the provision of a drill press having an air-driven motor arranged to be programmed through a drilling cycle by pressurized air employed in combination with a sealed hydraulic assembly.

Another object of the invention is the provision of a

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high speed semi-automatic drilling machine having provision for clamping a plurality of superimposed workpieces to be drilled to a work supporting surface under high pressure during the drilling operation thereby avoiding the formation of burrs and irregularities at the rim edges of the bores in individual ones of the workpieces.

Another object of the invention is the provision of an improved jig unit and template adapted to clamp a plurality of superimposed printed circuit boards or the like to a rigid template member and featuring retainer pins having a friction fit with both said template and with cooperating bores through the printed circuit boards to be clamped thereto and so constructed as to accommodate dishing of the template in use without permitting detachment of any workpiece from the jig.

Another object of the invention is the provision of a jig unit and template for use with a semi-automatic drill press and adapted to releasably support a plurality of workpieces to be drilled by locating depressions formed in the exterior of the template remote from the drill tip.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawings to which they relate.

Referring now to the drawings in which a preferred embodiment of the invention is illustrated.

FIGURE 1 is a perspective view of a drilling machine incorporating the features of this invention;

FIGURE 2 is a fragmentary sectional view on an enlarged scale taken along line 2—2 on FIGURE 1;

FIGURE 3 is a bottom plan view looking upwardly from the underside of FIGURE 2 with parts broken away to show details;

FIGURE 4 is a fragmentary cross-sectional view taken along line 4—4 on FIGURE 2 with the outline of the two solenoid valves shown in phantom to indicate their position relative to the flow passages formed in the underside of the table top;

FIGURE 5 is a view on an enlarged scale partly in section and showing details of the device for regulating the rate of drill advance;

FIGURE 6 is a vertical sectional view taken along line 6—6 on FIGURE 2;

FIGURE 7 is a fragmentary longitudinal sectional view taken along line 7—7 on FIGURE 6;

FIGURE 8 is a fragmentary sectional view through the drilling zone and showing details of the combined work holder and template when improperly positioned for drilling;

FIGURE 8A is a fragmentary sectional view on an enlarged scale through one of the template work holder pins;

FIGURE 9 is a view similar to FIGURE 8 but showing the work and template holder assembly in the process of being automatically shifted into precise drilling position;

FIGURE 10 is a view similar to FIGURES 8 and 9 but showing the work clamped accurately in position and the drill fully advanced; and

FIGURE 11 is a schematic view of the essential components together with the fluid circuits and the electrical control mechanism therefor, the parts being shown in their normal rest position with the service and power supply switches in open position.

Referring to the drawings and more particularly to FIGURES 1 and 2, there is shown a semi-automatic drilling machine designated generally 10 incorporating the present invention. The main work supporting surface is provided by a cast metal plaque or table top 11 provided with a suitable polished smooth upper surface here shown as being completely free of obstructions, locator pins and the like heretofore commonly used. It will be understood that the work supporting surface need not be flat but may be concave, convex or of other suitable shape to accommodate that of work to be drilled. Cast-

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ing 11 is suitably supported by a framework having four legs 12 detachably secured to the corners of the casting. Preferably the lower ends of the legs are provided with leveling screws or the like 13.

The two principal operating components of the drilling machine or press include a combined work locating and clamping device designated generally 14 overlying and vertically aligned with a drilling device designated generally 15 secured centrally to the underside of table top. The remaining components comprise auxiliaries employed to control, operate or supplement clamping device 14 and drilling device 15. Drilling device 15 includes a generally cylindrical outer housing 17 detachably secured to the underside of table top 11 by cap screws 18 (FIGURE 2). Work clamping device 14 is supported within the outer end of an L-shaped hollow housing 20 suitably clamped at its rear end to table top 11 by threaded fasteners not shown.

Clamping device 14 comprises a cylinder 21 (FIGURE 6) slidably supporting therein a piston 22 normally urged upwardly by a coil spring 23. Piston 22 includes a resilient O-ring seal 24 and has extending downwardly therefrom a piston rod 25 to the lower end of which is detachably secured a conical tipped stylus 26. An O-ring sealed cap 27 closes the other end of cylinder 21 while a similar closure cap 28 is secured across the lower end of the cylinder as by screws 29.

Of importance in the precision drilling of printed circuit boards is the high pressure applied by clamping device 14 to the superimposed boards in the contacting areas thereof in the immediate area undergoing drilling. This pressure is at least several hundred p.s.i. and preferably about 1000 p.s.i. thereby preventing any possibility of tearing or producing ragged edges about the rims of the bores. Nor is it possible for cuttings to be dispersed between the boards by centrifugal action.

The Drilling Assembly

Referring now more particularly to FIGURES 2, 6 and 11, drilling device 15 will be understood as having a suitable high speed air turbine motor 30 of well known construction enclosed within the upper end of a cylindrical housing 32. The latter housing has a sliding fit within bore 33 extending lengthwise through housing 17, and is held assembled therein in any suitable manner, such as by a set screw or the like not shown. An O-ring or the like fluid seal 34 is preferably provided between the lower end of housing 17 and the exterior of tubular housing 32 to prevent the escape of air at this point.

Air turbine motor 30 is encased within still another cylindrical housing 36 and its accurately finished exterior surface has a close sliding fit with the accurately finished bore of tube 32 to the end that turbine motor and its housing 36 may reciprocate in precise path axially of housing 32 while advancing the drill bit into the work and retracting it at the end of the drilling operation. Before describing the means for accomplishing this reciprocation, it is pointed out that the motor rotor 37 is connected through suitable gearing 38 to drive a spindle 39 journaled in anti-friction bearings 40, 40. Desirably rotor 37 operates at a speed of 20,000 r.p.m., although such a high speed is not essential to the practice of the invention.

Firmly fixed to the upper end of spindle 39 is a high precision collet type chucking device 42 having a generally conventional control sleeve 43 modified to include a ring gear 44 fixed thereto and dynamically balanced along with the entire chuck assembly. A similar ring gear 45 is fixed to the stem of spindle 39 for rotation independently of chuck sleeve 43 and is dynamically balanced as is essential for high speed operation. The manner in which gears 44 and 45 cooperate in the operation of the chuck will be described in greater detail presently. To be noted at this point is the fact that gear 45 preferably includes a radial flange 46 closely spaced from the

side wall of bore 33 and functioning in a beneficial manner in connection with the flushing of drill cuttings from the chamber housing the drill chuck.

Reciprocation of the drilling motor and chuck device is accomplished by the structure now to be described. Secured to a threaded boss 47 projecting axially from the lower end of motor housing 36 is a tubular stem 48 connected at its end to a piston 49 having a close sliding fit with the internal bore of housing 32. Piston 49 is normally urged to its lower or retracted position by a stiff coil spring 50 having one end bearing against piston 49 and its other end bearing against a stop ring 51 held in assembled position as by one or more pins or set screws 52. In its fully retracted position, the flanged upper end of stem 48 is held seated against the adjacent face of stop ring 51 by spring 50 (FIGURE 6). The advance travel of the drill is normally determined automatically by means to be described and forming part of the automatic control circuit. However, a secondary and supplemental safety stop of a positive type is also provided and comprises a stop sleeve 51a surrounding stem 48 with its lower end resting firmly against piston 49. The length of stop sleeve 51a is so selected that the axial distance between the underside of stop ring 51 and the adjacent end of sleeve 51a represents the maximum possible advance travel of the drilling unit. Stop sleeves 51a of different lengths may be substituted for one another to adapt the drilling unit for use in drilling material of thicknesses differing so much as not to be satisfactorily compensated for by the use of a thicker or a thinner back-up sheet in the work holding jig. It is also pointed out that stop sleeve 51a limits the advance of the drilling device during chucking of the drill bit at which the major portion of the control circuit is deactivated as will be described in greater detail below.

Threaded boss 47 of the motor housing proper is provided with a well enclosing a check valve 54 normally held seated against a seating ring by a light coil spring 55. Check valve 54 opens at about 15 p.s.i. and controls the flow of pressurized air through hollow stem 48 into the interior of the turbine motor in known manner and at sufficient pressure and quantity to assure operation of the rotor at very high speeds, as for example, 20,000 r.p.m. The exhaust air ports from the rotor chamber are not shown but will be understood as being of conventional design and opening through motor housing 36 into the annular passages 56 formed in the exterior surface of the motor housing. This exhaust air passes through ports 57 in housing 32 into flow channels 58 formed lengthwise along the interior of outer housing 17. As will be described later, this upwardly flowing exhaust air is utilized to carry away drill cuttings.

Referring back to the lower end of the motor housing, it is pointed out that tubular stem 48 supporting piston 49 has an accurately finished interior bore 60 slidably supporting a small diameter piston 61 formed integrally on the upper end of a stationary tube 62. The enlarged lower end 63 of tube 62 is sealingly seated in an axial well on the inner end closure plug 64 and held so assembled by a split ring keeper 65. The threaded boss 67 on the end of plug 64 mates with the threaded lower end 68 of housing tube 32.

Plug 64 is provided with a passage 70 for conveying hydraulic fluid to and from the lower end of tube 32 as an incident to the advance and retraction of piston 49 and the attached drilling device in performing a drilling operation. A second passage 71 through plug 64 terminates in the well in communication with passage 72 extending through piston 61 and stem 62. In this manner, pressurized air flows through passages 71, 72, into the upper end of the hollow stem 48 and past check valve 54 into the rotor chamber of turbine motor 30. From the foregoing it will be appreciated that pressurized liquid is employed to advance the motor and drilling chuck assembly whereas pressurized air is employed first to drive

the motor and thereafter to carry away drill cuttings to a place of disposal to be described presently.

The axial travel of the drilling unit is governed in the following manner. Referring again to FIGURE 6, it is pointed out that a threaded travel limit pin 75 is firmly seated in the side of the drilling motor housing and projects laterally through an elongated opening 76 in the latter housing and through a similar aligned opening 77 in main housing 17. Adjustably secured to the outer end of pin 75, as by a cap screw 78, is an eccentric disc 79. This disc may be adjusted to any desired position and then locked in place by tightening cap screw 78. Positioned laterally to either side of pin 75 in the path of travel of the drilling unit are contactors 81, 82 of a pair of micro-switches adjustably secured to the outer side wall of housing 17 by screws 83 and within an integral enclosure 84 of that housing. Enclosure 84 is normally sealed by a removable cover plate 85.

The means provided for operating chucking device 42 despite the fact that it is completely surrounded by housing 17 will be described by reference to FIGURES 2, 7 and 11. The upper forward side of housing 17 for the drilling device is provided with an enlargement or boss having a horizontally disposed bore 90 slidably seating therein a manual operator device 91 for chucking device 42. Device 91 comprises a spur gear 92 having teeth mateable with the teeth of ring gears 44 and 45 when the latter are properly positioned for this purpose. Spur gear 92 is fixed to the inner end of a shaft 93 having a cylindrical section 94 loosely journaled in and slidable lengthwise of bore 90 between the retracted position shown in FIGURE 7 and a second position in which it is engaged with the teeth of gears 44, 45. The outer end of shaft 93 is connected through a universal joint 95 with an operating handle 96.

The reduced end of shaft 93 is provided with a pair of annular grooves 97, 98 to seat spring pressed detent pin 99 slidably supported within a well opening through the side wall of bore 90 in the manner made clear by FIGURE 7. When detent 99 is seated in groove 97 the operating device is held in its operating position with spur gear 92 engaged with chuck operating gears 44, 45. Normally, however, detent 99 is seated in groove 98 and holds spur gear 92 in its retracted or disengaged position. Desirably, section 94 is provided with a sealing gasket to prevent the motor exhaust air from escaping therepast, an action which could carry drill cuttings into the journal for shaft section 94. A feature of the manual operator device 91 is that it preferably so arranged that its chuck operating spur gear 92 cannot be engaged with chuck gears 44, 45 until and unless the drilling device is in its fully advanced position. The significance of this will become apparent in connection with the detailed description of the operation of the drill press.

Auxiliary Devices of the Drilling and Clamping Assemblies

Reference will now be had to FIGURES 2 to 5 and 11 for a description of the auxiliaries employed in controlling and operating work clamping device 14 and drilling device 15. Referring first to FIGURE 11, it is pointed out that pressurized air enters from a suitable source through pipe 100 and passes in series fittings interconnecting a master solenoid cut-off valve 101, a filter 102, a pressure regulator 103 and a lubricator 104 for delivery into distributing manifold passages formed on the underside of the work supporting table top 11.

An important feature of these auxiliaries in the actual commercial embodiment of the invention is best shown in FIGURE 3 and resides in the fact that the various pipe fittings interconnecting components 101, 102, 103, 104 are arranged in the form of a U. One leg 105 of these fittings comprises the metal conduit protecting the electrical leads to solenoid valve 101 whereas the other leg 106 forms the conduit conveying the pressurized air into the

distributing manifold passages. The latter conduit is detachably secured to the cover plate 120 to the manifolding through a pipe coupling union 107. The other leg 105 is detachably connected by coupling union 109 to the side wall of a metal housing or junction box 108 for the electrical connections. Accordingly, it will be understood that the auxiliaries 101, 102, 103, 104 are detachable as a unit from the drill press simply by disconnecting couplings 107, 109 and lifting the described U-shaped conduit assembly interconnecting these auxiliaries from the underside of the drill press table.

It is also pointed out at this point that preferably there is connected to the air line at a suitable point as between regulator 103 and lubricator 104 a hose 110 having a manually controlled air nozzle 111 found to be useful to flush away cuttings, debris and foreign matter generally from the drilling machine and particularly from chucking device 42. Occasionally cuttings will collect in the recesses of well chamber 190 in which the drilling chuck is located and it is then a simple matter to dislodge these by a blast from air nozzle 111. It will also be understood that pressure regulator 103 preferably includes a pressure gauge 112 disposed in a convenient position for reading and by which the operator can note the pressure conditions existing in the air manifold line.

The simplified cored-type of manifolding provided by this invention for distributing the air to the various components and avoiding the need for numerous plumbing connections will now be described. Referring first to FIGURE 4 representing a fragmentary showing of the underside of table top 11 along the rear edge thereof, it will be understood that the lower surface is machined smooth throughout the generally rectangular area designated 115. This surface includes a small rectangular extension 116 merging with one end of surface 115 and lying in the same plane. A number of sinuous air distributing passages are cast into this portion of table top 11 and open downwardly through surfaces 115, 116 as is made clear by FIGURE 4. These passages include the main or inlet manifold passage 113 as well as auxiliary manifold passages 117, 118 and 119. Normally sealing these passages closed is a cover plate 120 held in place by cap screws 121.

Rigidly secured to the underside of cover plate 120 are certain other of the auxiliaries including, in particular, air control solenoid valves 123 and 124 as well as the electrical fitting junction box 108. The latter box is suitably supported on the underside of the valves 123 and 124. The latter are secured to cover plate 120 with their ports sealingly engaged with passages leading into the overlying air distributing passages, as by assembly cap screws 125 (FIGURE 4). For example, the inlet of valve 123 is connected to manifold passage 113 through port 127 and its outlet is connected to distributing passage 117 through port 128 (FIGURE 4). Solenoid valve 124 will be understood as having a spool valve arranged to control flow through three separate ports including an inlet port 130 in communication with passage 113, a first outlet port 131 in communication with passage 118 and a third port 132 in communication with passage 119.

Manifold passage 119 of the air distributing system has its discharge end opening into a sealed chamber 135 (FIGURE 11) of a housing 136 held sealingly engaged by cap screws against surface 116 (FIGURE 4) on the underside of table top 11. Housing 136 is divided into two chambers by a flexible diaphragm 137 (FIGURE 11) and the side thereof opposite air chamber 135 is filled with hydraulic fluid as is a conduit 138 leading from this chamber to passage 70 opening into the lower end of drilling device housing 32. Accordingly, it will be recognized that this portion of housing 136, conduit 138 and the chamber formed below piston 49 provides a closed or captive fluid circuit maintained filled with liquid at all times. It will therefore be recognized that the application of air pressure to chamber 135 will be in-

stantly effective on diaphragm 137 to force liquid from housing 136 through flow control valve 198 into the lower end of tube 32 to advance the drill of the drilling unit into the workpiece. The moment air pressure within chamber 135 is relieved the stiff spring 50 overlying piston 49 acts to retract the piston and to return the fluid to housing 136 as the drilling motor is retracted to its non-operating position. Pressurized air then present in chamber 135 is released to the atmosphere by backflow through passage 119, port 132 of valve 124 and then through port 131 into passage 118 and to the atmosphere through vent port 139.

Air is supplied simultaneously to activate the work clamping device 14 and to drive the turbine motor 30 under the control of solenoid valve 123. To this end it will be understood that air flowing from outlet port 128 of valve 123 enters passage 117 which opens into the mid-section of a vertical port 141 (FIGURES 4 and 11) the opposite ends of which are respectively connected to a conduit 142 leading into the top of the pneumatic operator of clamping device 14 by way of flow control valve 180 and a second conduit 143 discharging into a passage 71 of the drilling device. Accordingly, it will be seen that air flows simultaneously to clamping device 14 and to the rotor chamber of turbine motor 30. Flow control valve 180 will be understood as including an adjustable needle valve restricting the flow rate into the clamping device and a check valve which opens to dump the trapped air from the clamping device very quickly following the completion of the drilling operation and the opening of the air venting port.

Template and Work Holder

Still another important auxiliary used with the present invention is best shown in FIGURE 8 and comprises a combined work holder and template designated generally 145. As here shown, this device comprises a rigid plate 146 of a size approximating the size of the material to be drilled. Its opposite surfaces are accurately finished flat and the plate includes suitable means for readily and detachably clamping the work to be drilled securely and accurately in a predetermined position on its underside.

As here shown, template 145 is designed for convenience in the drilling of a plurality of identical printed circuit boards or plaques 147. These are adapted to be clamped precisely in superimposed relation by a pair of locator pins 148 each having an enlarged shank 148a having a friction fit in a sleeve bearing 148b firmly seated in bores through the opposite edge portions of template 145. The smaller diameter shank portion 148c of pins 148 have an appreciably closer friction fit with appropriately positioned aligned bores in the rim edges of workpieces to be drilled than referred to above in connection with shank portions 148a and sleeve bearings 148b. The importance of this differential fit of shank portions 148a and 148c lies in the fact that the very snug fit of the workpieces with shank portions 148c assures that the workpieces will remain assembled in tightly compressed relation throughout the drilling operation and that any relative movement caused by the dishing of template 147 as high pressure is applied thereto by stylus 26 will take place between shank portions 148a and bearings 148b. Hence, cuttings cannot enter between the boards in any area at any time. It is also desirable to provide a back-up sheet 149 between the lower surface of template 146 and the work to be drilled. Preferably, this sheet is of a material generally similar in drilling characteristics to the workpieces to be drilled and has a sufficient thickness to receive the conical tip of the drill bit with a margin of safety yet prevent this tip from ever contacting the template proper.

A very important feature of the template and work holder concerns the provision in the upper surface of plate 146 of conical depressions 150 having the center of each in precise alignment with the axis of the associated hole

to be drilled in the workpiece. These precision locator depressions are prepared in advance and are designed to cooperate with the conical tip of work-clamping stylus 26.

From the foregoing it will be apparent that conical tip of stylus 26 and the complementally shaped depressions 150 are admirably suited to cooperate in positioning the work to be drilled precisely and as an incident to the lowering of the clamping stylus 26 against the template. So long as the tip of the stylus strikes inside the marginal rim of depression 150, the engaging inclined surfaces of each will be effective automatically to shift the template and the workpiece clamped therein bodily in any planar direction parallel to table top 11 as necessary to position the work with unerring precision. Should the operator have positioned the work carelessly and outside the operating range of the automatic positioning device the stylus will simply come to rest against the flat top surface of plate 146 and will be inoperative to close a switch essential to the advance of the drilling device, a feature which will be described in more detail presently. Under these improper drilling conditions a warning signal light 194 (FIGURE 1) goes on and the stylus may be retracted by depressing the foot switch 162 while the operator corrects the position of the workpiece. This is a simple matter since, in its fully retracted position, the conical tip of the stylus is positioned only slightly above the template and it is therefore a simple matter for the operator to align the stylus with the desired underlying depression 150. There remains to be described the semi-automatic electrical control circuit and certain incidental features of the invention.

The Control Circuit and Operation of the Drill Machine

The control circuit for programming the various components and sub-assemblies of the described drill machine through an operating cycle will be described by the aid of FIGURE 11. The manually controlled switches of that figure are in their open inactive positions corresponding to the disconnected position of the drill from the power supply, and all others are in their normal starting positions at the beginning of an operating cycle. The manually controllable switches include a master power switch 152, a switch 153 controlling the supply of pressurized air and a "change drill" switch 154. These three switches are shown mounted on a supporting cover plate 155 secured over the access opening to the interior of the main casting 20 supporting clamping device 14 (FIGURE 1).

For convenience in describing the circuit and to minimize the need for unnecessary reference characters, those portions of the circuit which are always connected to one side of the power supply whenever switch 152 is closed are designated 155 and those always connected to the other side of the line are designated 156.

To prepare the drill for operation the operator closes main power switch 152 and air solenoid switch 153. The latter completes a circuit via leads 155, 156 to the coil on the air solenoid valve 101 to open the latter and admit air under pressure through filter 102, pressure regulator 103 and lubricator 104 to the first of the several air distributing passageways sealed closed by cover plate 120. The closing of the main switch 152 completes the power supply through silicon diode 160 which rectifies the A.C. power supply to place a polarized charge on capacitor 161. This capacitor has a design capacity of 20 microfarads and a charging time of 0.1 second, though it will be appreciated that both values may be changed to suit the needs of a particular drilling operation. The charging of this capacitor is controlled by foot switch 162 (FIGURE 1) which must be closed in its upper position for charging to take place. The foot switch is normally held closed in its upper position unless the operator holds the pedal depressed against the action of a spring within that device. It should also be pointed out that the closing of air switch 153 completes the circuit through pilot lamp 163 and lamps 164, 164 supported on hous-

ing 20 and having reflectors appropriately designed to illuminate the immediate drilling area surrounding stylus 26.

Now let it be assumed that a group of printed circuit boards 147 are properly mounted over retaining pins 148 of the combined template and work holder 145 and that the latter is placed on the table top with one of the positioning depressions 150 of the template directly beneath the conical tip of stylus 26. As the operator holds the workpiece and template lightly in this position, he depresses foot switch 162 to initiate a complete drilling cycle the instant the position of the foot switch contactor is reversed. As the lower contact of this switch closes, the charge stored in capacitor 161 is released into lead 166, the lower contact of switch 162 and via lead 167 through the downwardly closed switch 82 of drilling device 15 and via lead 168 to energize the coil of stepping relay 169. Relay 169 is located within housing 20 and its armature controls a pair of independent and normally open contactors 170 and 171. Closing of upper contact 170 completes the power supply through lead 172 to the coil of air valve 123 moving it from the normally closed position shown in FIGURE 11 to its open position. The closing of the other contactor 171 of stepping relay 169 activates a lead 173 leading to the switch blade of a normally open air pressure operated switch 174. This switch closes automatically whenever the air pressure being admitted to the work clamping device 14 reaches a sufficient pressure to bias diaphragm 175 to the left as viewed in FIGURE 1.

The closing of upper contact 170 of stepping relay 169 supplies power through lead 172 to the coil of air valve 123 moving the latter to its open position to supply pressurized air to conduits 142 and 143 simultaneously. Air admitted to conduit 142 passes through a flow control valve 180 and into the chamber housing clamping device piston 22 causing the latter to move downwardly pressing the pointed end of stylus 26 into depression 150 of template 146. As the air pressure builds up in conduit 142 it flexes diaphragm 175 outwardly and closes switch 174. Simultaneously with the admission of air into the cylinder of the clamping device 14 air is also admitted from manifold passage 117 into conduit 143, passage 71 and past check valve 54 of the air motor to drive the rotor of the later at high speed along with the attached chuck 42 and drill bit 180 clamped therein.

Simultaneously with the closing of the switch 170 to supply air to the clamping device and to the turbine motor, lower contact 171 of this relay is also closed. This completes the circuit through lead 173 to switch blade 174 controlled by the air pressure sensitive diaphragm 175.

If the underlying locator recess 150 of the template is somewhat misaligned with stylus 26, the latter will quickly center the work beneath the stylus and continue downwardly into the depression to clamp unit 145 firmly against table top 11. In doing so cam surface 181 on the upper portion of the stylus spindle will act to shift the reciprocally supported lower contactor 182 of a sensing switch 183 shifting the latter from a closed position to the left to its alternate closed position to the right as viewed in FIGURE 11. However, it is to be understood that switch 183 will close to its alternate position only if the stylus enters a depression 150. Switch 174 being closed by reason of the pressurized air supply to device 14, lead 185 will be energized and the closing of the switch 183 to the right supplies power to lead 186 and thereby closing a circuit to the coil of solenoid valve 124 to open this valve.

The opening of valve 124 closes off venting passage 118 and admits pressurized air from manifold passage 113 to passage 119 and chamber 135 of the hydraulic actuator employed to advance the drilling device. Accordingly, the application of pressure to diaphragm 137 instantly forces fluid from housing 136 through flow control valve 198 and conduit 138 into the chamber

beneath piston 49 of the drilling device. The turbine motor 30 is then turning at full operating speed owing to the described prior admission of air and the advance of the drilling motor by hydraulic pressure applied to piston 49 advances the drill into workpiece 147 while the latter is held compressed at high pressure as 1000 p.s.i., the cuttings being centrifugally flung therefrom into chamber 190 surrounding the chucking device. The air exhausting from the turbine motor swirls upwardly past the rim of flange 46 of the chuck at very high velocity gathering up the cuttings and carrying them away through the large bore duct 191 into a filter and cuttings collector 192 supported from the lower end of conduit 191 (FIGURE 1).

Collector of filter 192 may be of any suitable construction but, as here shown, comprises a cup shaped main casing held detachably clamped to a cover 193 by means of toggle clamps 197. Cover 193 is provided with a plurality of large openings covered by an underlying pad of felting or the like filtering material permitting the air to escape but retaining the cuttings trapped at the bottom of the container which is preferably maintained covered with water admixed with a detergent containing a wetting agent. The wet chips quickly settle to the bottom of the water and can be dumped from time to time.

The moment the drilling device starts on its advance drilling movement pin 75 projecting laterally therefrom moves upwardly away from the "re-set" switch 81 allowing the latter to close. Closing of switch 81 completes a circuit shunting upper contact 170 of stepping relay 169 with the result that, upon the next activation of the stepping relay (which is effective to open contacts 170 and 171), the circuit to air valve 123 will remain energized to keep this valve open. Assurance is thereby provided that air valve 123 will remain open until the drilling device completes one full cycle and returns to its fully retracted position to open switch 81 as will be explained more fully presently.

The drilling motor continues its advance until pin 75 strikes the contactor 82 of the upper switch shifting it from its downwardly closed position to its upwardly closed position thereby energizing the coil of stepping relay 169 a second time. The second energization of this relay steps contacts 170 and 171 to their open positions. The opening of contact 171 discontinues the power supply to solenoid coil 124 allowing the latter to close thereby cutting off the air supply to chamber 135 and venting the air present in this chamber to the atmosphere via passages 119, valve 124, passage 118 and vent port 139. Spring 50 acting on piston 49 of the drilling device thereupon forcibly retracts the piston as the hydraulic fluid is forced back into housing 136 by way of valve 198. The initial retraction movement of the drilling motor permits upper switch 82 to close downwardly by spring action therein thereby reestablishing the initial condition of this switch. Further retraction of the drill causes pin 75 to open switch 81 thereby deactivating solenoid valve 123, permitting the latter to close and cut off air supply to the turbine motor as well as to the clamping device. Spring 23 of the latter then moves piston 22 and stylus 26 to their retracted positions allowing the stylus position sensing switch 183 to close to its initial or starting position. The return movement occurs quickly owing to the opening of the check valve in flow control valve 180.

Let it be assumed now that, following the completion of one drilling cycle, the operator shifts template assembly 145 to the position shown in FIGURE 8 wherein the underlying locator depression 150 is not aligned with the axis of stylus 26, and then depresses foot switch 162. The circuit functions as described above causing the air pressure admitted to the top of clamping device to lower the stylus. However, as it moves downwardly its pointed end will strike the facing surface of template 146 short of the downward travel required for cam surface 181 on the stylus spindle to open switch 183. The energization of

signal lamp 194 advises the operator that the parts are improperly positioned for drilling. The operator will instinctively attempt to operate the drill by again depressing the foot pedal thereby effecting a second energization of the stepping relay coil. As a result of the closing of the foot switch after a slight time delay, contacts 170 and 171 of this relay open in the same manner as though the drill had operated through a full cycle in the usual manner. The opening of the relay contacts restores all parts of the control circuit to their original positions including the withdrawal of the clamping device. Thereupon the operator shifts the workpiece to bring the selected depression 150 into alignment with the stylus and proceeds to operate the equipment in the usual manner.

When it is desirable or necessary to change drill bits the operator proceeds as follows: The first step is to close switch 154 from its normal upwardly closed position to its downwardly closed position. This supplies power through lead 196 to lead 186 to activate air valve 124. This admits air from passage 113 to passage 119 of the hydraulic actuator pressurizing the fluid in the latter and advancing the drilling device to its maximum extended position with sleeve 51a abutting stop 51 and firmly holds it in this position (FIGURE 7). In consequence, the operator knows that the air motor and chuck device 42 are in their extreme extended positions despite the fact that the normal advance control switch 82 is now de-activated owing to the position now occupied by the "change drill" switch 154.

When so held the manual chuck operating device 91 can be manipulated to bring its spur gear 92 into engagement with ring gears 44, 45 of the chuck. This is accomplished by the operator grasping handle 96 and pivoting it to a horizontal position and then applying pressure to shift gear 92 toward the chuck as detent 99 is disengaged from retaining groove 98. When the gear is properly engaged with the gears of the chuck, detent 99 seats in groove 97. The operator then rotates handle 96 in a direction to loosen chuck 42.

It will be understood that gear 92 operates to rotate gear 45 in one direction and gear 44 in the opposite direction thereby to loosen chuck sleeve 43. The new drill is inserted and its tip is manually held firmly at the proper height above the surface of table top 11 to assure drilling to the desired depth in the next workpiece. While the bit is so firmly held, the operator rotates handle 96 in the opposite direction to close the chucking device against the drill shank. Once this is accomplished chuck operating device 91 is moved back to the disengaged position shown in FIGURE 7, whereupon "change drill" switch 154 is returned to its normal position thereby deactivating the coil of valve 124. The valve then closes venting the air from chamber 135 and allows the drilling device to resume its normal inoperative position with the tip of the drill bit fully retracted below the surface of table top 11.

It is to be observed that during this bit changing or servicing operation it is impossible for the system to be energized accidentally or otherwise. This is for the reason that the operation of "change drill" switch 154 to move the chuck to its advance position for drill changing purposes renders the remainder of the circuit inoperative. Accordingly, the workman may proceed with complete confidence and safety and without risk that pressurized air will be suddenly admitted to the turbine driving the drill chuck spindle.

If the operator wishes to change the operating stroke of the drill in any way, this is accomplished by shifting the position of eccentric 79 on pin 75. Additional range of drill travel is accomplished by replacing the eccentric 79 with one of different dimensions as well as by shifting the position of the two limit switches cooperating with eccentric 79.

Control over the speed of drill advance is achieved by manually regulating a needle valve located in a restrictor 198 connected in hydraulic fluid conduit 138 (FIGURE

5). The needle valve of the restrictor is conveniently adjusted as by a control knob 199 mounted at some convenient location on the drill assembly. Preferably, the adjustable restrictor 198 is provided with a check valve around the restricted passage which opens freely when the air pressure is released from diaphragm 137 thereby permitting rapid return flow of the fluid from the piston chamber into housing 136. However, when air pressure is applied to diaphragm 137 the high pressure thereby imposed on the hydraulic fluid closes the check valve with the result that all flow must take place through restricted passage under the control of the adjustable knob 199.

While the particular semi-automatic drill press assembly herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended to the details of construction or design herein shown other than as defined in the appended claims.

I claim:

1. A fast action semi-automatic drilling assembly comprising a smooth surfaced work support, a combined work locator and clamping member adapted to be supported for movement toward and away from said work support and having a tapering end adapted to enter a complementally shaped facing recess in a template secured to the upper surface of a workpiece to be drilled and being effective to first shift the workpiece accurately into drilling position and thereafter to clamp the workpiece to said work support, and means including power driven drilling means responsive to the clamping of said template to initiate operation of said drilling means to drill a hole in the workpiece in axial alignment with said locator and clamping member.

2. A drilling assembly as defined in claim 1 characterized in that said last-mentioned means includes means operable in response to an initial actuating impulse to operate said work locator and clamping member and said drilling means in predetermined timed sequence whereby the workpiece is first accurately positioned and clamped and thereafter drilled.

3. A drilling assembly as defined in claim 1 characterized in that said drilling means is normally positioned on the opposite side of the work support surface from said clamping member, and means for advancing said drilling means to drill a workpiece and to retract the drill therefrom while said workpiece remains clamped to said work support.

4. A fast action semiautomatic drilling assembly comprising a workpiece support, unitary power driven drilling means movable as a unit from a normally retracted position clear of the surface of said workpiece support and having a drill movable into and out of drilling position with respect to a workpiece resting on said support, clamping means movably supported and spaced axially opposite the tip end of a drill in said drilling means, and coordinated power control means operable in sequence and through an automatically terminated cycle to move said clamping means toward said workpiece support to clamp a workpiece firmly against said support and responsive to completion of the clamping of the workpiece to energize and advance said drill into the workpiece and to then retract the drill from the workpiece before unclamping the workpiece.

5. A drilling assembly as defined in claim 4 characterized in the provision of safety means operatively associated with said clamping means and with said power control means, said safety means being conditioned by the advance of said clamping means to a predetermined proper clamping position to permit the operation of said drilling means whereby said drilling means remains inoperative if said clamping means fails to move into said predetermined clamping position.

6. In combination, a drilling machine having a smooth-

surfaced support, an opening in said support for a drill bit, means secured beneath said support having reciprocally mounted therein a drill bit and driving motor therefor normally retracted out of drilling position, pressurized liquid means for elevating said motor and drill bit while said motor is in operation, means for clamping a workpiece freely shiftable across the surface of said support in all directions to said smooth-surfaced support in an area overlying said drill bit, and means responsive to the clamping of the workpiece to initiate a complete operating cycle of said drill including the advance of the drill into the workpiece and the retraction of the drill clear of said workpiece.

7. The combination defined in claim 6 characterized in that said drill motor is of the air turbine type having an exhaust gas port adjacent the drill supporting end thereof, and means utilizing said exhaust gases from said motor to flush away drill cuttings.

8. The combination defined in claim 7 characterized in that said means for flushing away drill cuttings includes means for separating the gas and cuttings and holding the latter captive.

9. In a drilling machine of the type having a work supporting surface, a turbine-driven drilling device reciprocally supported for movement toward and away from said surface while performing drilling operations, means for clamping work to be drilled against said work supporting surface, cage means closely enclosing the drilling zone and in which the drill cuttings tend to collect, and means utilizing fluid discharging from said gas turbine to flush away drill cuttings from said cage means and into filtering chamber means in communication with said cage means.

10. A drilling machine as defined in claim 9 characterized in that said cage means comprises a generally circular chamber surrounding the shank end of the drill bit, and means in said cage means at the inner end thereof for restricting the fluid flow from said turbine in a manner to provide a high velocity flow of this fluid adjacent the inner surface of said circular chamber to aid in the high efficiency gathering of the drill cuttings for conveyance to said filtering chamber.

11. In a drilling machine assembly of the type having a power driven drill unit adapted to be advanced and retracted under automated control, said drill unit including drill chucking means having a rotatable clamping sleeve, housing means enclosing said chucking means and cooperating to conceal and protect said chucking means and a drill mounted therein in the retracted position thereof, and normally disengaged means mounted in part on said drill unit and manipulatable from the exterior of said housing means for operating said chucking means.

12. A drilling machine assembly as defined in claim 11 characterized in that said means for operating said chucking means is engageable only in the extended position of said drilling unit whereby a drill mounted within said chucking means has the drilling end thereof projecting beyond said housing means.

13. A drilling machine assembly as defined in claim 11 characterized in that said means for operating said chucking means is engageable when said drill unit is in the fully extended position thereof, and fluid power means for holding said drill unit temporarily in said fully extended position whereby the operator may hold a drill bit in the loosened chucking means with the end of the bit projecting a desired distance beyond the end of said housing means while the chucking means is being clamped closed by the said operating means therefor.

14. In combination, a drilling machine having a smooth-surfaced work support with an opening there-through for a drilling tool, means reciprocally supporting a drilling motor in alignment with said opening and enclosing said motor and drill chucking means mounted thereon, means for anchoring a workpiece to said work support under predetermined pressure, pressurized fluid

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means including automatically cycling means operable in response to a cycle initiating action and anchoring of the workpiece under said predetermined pressure to energize said motor and to reciprocate the same through a full drilling cycle terminating with said motor and drilling tool fully retracted within said enclosing means therefor.

15. The combination defined in claim 14 characterized by the provision of means for carrying the drill cuttings away from said drill enclosing means to a filtering and collecting chamber in communication with said drill enclosing means.

16. The combination defined in claim 15 characterized in the provision of means utilizing said pressurized fluid for holding said drill motor and chucking means temporarily in the fully extended position while the drilling tool it being accurately positioned and clamped in said chucking means.

17. The combination defined by claim 14 characterized in the provision of control means operable automatically as said motor returns to its fully retracted position at the end of a complete operating cycle to deactivate the supply of pressurized fluid to said motor.

18. In an automatic one cycle drilling machine, a work support means supporting a normally retracted fluid-energized means for clamping work to be drilled to said support, a fluid driven drilling device mounted for vertical reciprocable movement only on the opposite side of said work support from said work clamping means, fluid operated means for controlling the advance and retraction of said drilling device through a complete reciprocable drilling cycle, and cycle control means operable when energized to supply pressurized fluid to said clamping means and to said drilling device and thereafter to said means for advancing and retracting said drilling device through a full operating cycle.

19. A drilling machine as defined in claim 18 characterized in the provision of pressurized air to operate said clamping means and said drilling device, and in the provision of sealed liquid circuit means arranged to be placed under pressure by pressurized air to control the advance and retraction of said drilling device.

20. A drilling machine as defined in claim 19 characterized in the provision of manually adjustable means for controlling the flow of liquid along said sealed liquid circuit to control the rate of drill advance.

21. In combination, a flat support for work to be drilled and having an opening therethrough for a drill bit, an air turbine driven drilling device reciprocally supported in alignment with said opening, work clamping means reciprocally supported opposite said drilling device, air pressure operated means for operating said clamping means, means including a common air flow control for supplying pressurized air to said clamping means and to said turbine driven drilling device, and means operable in timed sequence after said air turbine is placed in operation to advance said drilling device into work clamped to said work support.

22. The combination defined in claim 21 characterized by the provision of means utilizing air discharging from said air turbine to flush away drill cuttings to a place of disposal therefor.

23. The combination defined in claim 21 characterized by the provision of control means including means movable with said turbine driven drilling device to limit the advance of said drilling device and for restoring all parts of the described combination in their respective starting positions.

24. The combination defined in claim 21 characterized in that said means for advancing said drilling device comprises closed variable capacity chamber means filled with liquid and including means responsive to air pressure to transmit a force through said liquid to advance the drilling device rapidly and forcibly.

25. A drilling machine assembly comprising a flat work support, a rigid bracket having one end fixedly secured

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to said support near one edge remote from the operator's station, a fluid operated work clamping means carried by the other end of said bracket and effective in the extended position thereof to clamp work to be drilled to said work support, fluid operated and controlled drilling means mounted on the opposite side of said work support from said clamping means, a plurality of fluid control valves for said clamping means and for said drilling means including a channeled manifold plate mounted against one side of said work support and co-operating therewith to close said channels, said channels providing fluid distributing channels extending between said control valves, and means extending from said valves to said clamping means and to said drilling means for supplying and controlling fluid to operate the same.

26. A drilling machine assembly as defined in claim 25 characterized in that said means for supplying and controlling fluid to said drilling means includes chamber means of variable capacity charged with liquid and having one end arranged to extend said drilling means and its other end separated from pressurized air by a flexible diaphragm.

27. A drilling machine assembly as defined in claim 25 characterized in the provision of adjustable flow metering means in said liquid charged chamber means by which the rate of flow of liquid to said drilling means can be readily adjusted to vary the rate of advance of the drill into the work.

28. A high speed semi-automatic drilling machine operable to complete a drilling cycle through a plurality of separate workpieces in an elapsed time of approximately one second, said drilling machine including a workpiece support interposed between a self-retracting air driven turbine drill and self-locating air-operated clamping means, said clamping means having a tapered end engageable in a tapering depression in a cooperating template secured to the workpiece being drilled and effective to shift the same in any direction perpendicular to said support as an incident to the clamping action thereof, and control means responsive to an initiating action to commence a drilling cycle and including means operable to terminate said drilling cycle and restore said clamping means to the open position thereof if the work and its template are so misaligned that the tapered end of said clamping means cannot enter the cooperating depression in said template.

29. A high speed drilling machine as defined in claim 28 characterized in the provision of means effective upon the entry of the tapered end of said clamping means into the cooperating depression of said template to advance said turbine drill through said plurality of workpieces and to retract the drill therefrom followed by the movement of said clamping means away from said template.

30. In a semi-automatic drilling machine of the type having an air-driven reciprocally supported drilling device, an air-operated work clamping device and hydraulically actuated means for controlling the reciprocation of said drilling device, that improvement in control means for said drilling machine which comprises a first solenoid valve means for controlling the supply of pressurized air to rotate said drilling device and to operate said work clamping device, second solenoid valve means controlling the activation of said hydraulic means controlling reciprocation of said drilling device, and means including manually actuated means operable instantly upon actuation to initiate a single complete operating cycle of said drilling machine.

31. A semi-automatic drilling machine as defined in claim 30 characterized in that said control means includes a single relay arranged to be energized from a stored electric charge under the control of said manually actuated means and effective when first energized to activate said first solenoid valve means.

32. A semi-automatic drilling machine as defined in

claim 31 characterized in that said control means includes switch means positioned to be actuated by the reciprocation of said drilling device and including a switch conditioned by the initial advance of said drilling device to maintain said first solenoid valve energized until the drilling cycle approaches the end of a complete cycle and second switch means operable at the end of the drilling stroke to deactivate said hydraulic means operating to advance the drilling device.

33. A semi-automatic drilling machine as defined in claim 31 characterized in that said drilling machine and the control means therefor includes sensing means for determining when the work being drilled is in correct drilling position and including means effective to prevent the actuation of one of said solenoid valve means when the sensing means finds the work is out of position.

34. A semi-automatic drilling machine as defined in claim 33 characterized in that said control means includes signal means arranged to be energized when said sensing means determines the work to be drilled is out of drilling position.

35. A semi-automatic drilling machine as defined in claim 31 characterized in the provision of a manually operable switch in said control means movable from a first normally closed position to a second temporarily closed position in the latter of which positions said switch is effective to activate said hydraulic solenoid valve to advance the drilling device to its fully advanced position while said first solenoid valve means remains closed.

36. A semi-automatic drilling machine as defined in claim 35 characterized in that said drilling device is provided with a collet type bit chucking device surrounded by a housing, and manually operable means engageable with said chucking device for opening and closing the same when said drilling device is held in the advance position thereof by said hydraulic means.

37. A workpiece holder for use with a semi-automatic drilling machine of the type having a combined workpiece locator and clamping device in alignment with a reciprocable power driven drilling unit, said holder comprising a rigid one-piece template having a plurality of fingers or the like secured thereto and engageable with one or more workpieces to hold the workpieces firmly aligned with one another and with said template, said fingers projecting beyond the workpiece engaging surface of said template by a distance no greater than the thickness of the workpiece whereby no part of said fingers project beyond the exposed surface of a workpiece secured to said template and fingers, and one or more tapering depressions confined to the exterior face of said template opposite said workpieces and positioned directly opposite the place where a drill bore is desired, said tapering depression being operable to receive the pointed tapering end of a work clamping device and effective in cooperation therewith to shift the workpiece and its holder as necessary to center said depression precisely with the axis of a clamping device.

38. That method of drilling sheet material to produce bores free of burrs and roughness at their rim edges which comprises stacking a plurality of similar sheets to be drilled in closely compacted superimposed relation with a back-up sheet against the side of the stack remote from the drill, securing a rigid template against the outer face of said back-up sheet to provide a unitary template and workpiece assembly, compressing said entire stack assembly against a flat stationary surface under a pressure of hundreds of p.s.i. while advancing a drill at high speed through said stack and into said back-up sheet to a distance short of penetration into said rigid plate to bore aligned bores through said superimposed sheets, and maintaining said stack assembly compressed until after the retraction of the drill.

39. A combined work holder and template for use on a high speed drilling machine of the type utilizing a work

clamping means having a reciprocable stylus with a tapered end engageable in a complementally shaped seating recess formed in said work holder and cooperating therewith to position the work to be drilled as the latter is pressed under high pressure against the drilling machine work support table, said work holder comprising a flat-surfaced wide-area rigid template, a plurality of bores through said template at wide spaced points, workpiece mounting pins frictionally supported in said bores and projecting from said flat surface, said pins being accurately finished to a diameter adapted to have a press fit with aligned openings through superimposed openings in thin sheet workpieces to be drilled and having a total projecting length substantially equaling the combined thickness of the workpieces to be supported thereover while being drilled.

40. A semi-automatic power-driven tool having a rigid frame, means for clamping a plurality of flat workpieces firmly together in stacked relation and including a rigid locator plate having a flat exposed surface parallel to said workpieces and formed on the exposed surface thereof with conical locator depressions having axes spaced identically to the spacing of the axes of areas to be cut away in said stacked workpieces, means rigidly interconnecting said locator plate and said stacked workpieces and movable bodily therewith transversely of said tool frame and parallel to the plane of said locator plate and of said workpieces, means for moving an imperforate locator stylus having a conical point into and out of contact with said locator plate between drilling operations and for seating said conical point in a selected one of said conical depressions whereby said stylus point is effective as it enters a depression of said locator plate to shift said plate and stacked workpieces laterally as necessary to align the stylus axis with the conical depression axis, means for holding said stylus forcibly seated in a depression for a predetermined period in excess of that required to advance the drill into the workpieces to retract the drill therefrom, and power-driven cutting tool means reciprocally supported on said tool frame for the movement of tool means into said stacked workpieces while the same are held clamped against movement, and control means operably interconnecting said stylus and said cutting tool means and operable when energized to operate said stylus and said cutting tool means through an operating cycle and including means for holding said cutting tool out of operation if the point of said stylus is prevented for any reason from seating in a conical depression of said locator plate.

41. A power-driven tool as defined in claim 40 characterized in that said tool means comprises a drill rotatable about an axis parallel to said stylus axis, and said stacked workpieces including a back-up plate clamped to said workpieces on the side thereof remote from said drill and into which the point of the drill is advanced during a drilling cycle of said power-driven cutting tool means.

42. A high speed semi-automatic drilling machine operable to complete a drilling cycle through a plurality of separate workpieces in an elapsed time of approximately one second, said drilling machine including a workpiece support located in the path of advance and interposed between a reciprocally-supported self-retracting high-speed drill and a reciprocally-supported self-locating fluid-operated clamping means, said clamping means having a tapered end means rigidly securing together a stack of workpieces to be drilled including a cooperating template having conical depressions in its exterior face free of communication with one another for seating the tapered end of said clamping means and cooperating with said conical depressions to shift said stack of workpieces in any direction perpendicular to the path of travel of said clamping means as an incident to the clamping action thereof, and control means responsive to an initiating action to commence a drilling cycle and including means operable to terminate said drilling cycle and restore said

clamping means to the open position thereof if the work and its template are so misaligned that the tapered end of said clamping means cannot enter the cooperating depression in said template.

43. A high speed drilling machine as defined in claim 42 characterized in the provision of means effective upon the entry of the tapered end of said clamping means into the cooperating depression of said template to advance said drill through said plurality of workpieces and to retract the drill therefrom followed by the movement of said clamping means away from said template.

44. In combination, a high-speed drilling machine having rigid workpiece supporting means adapted to support a workpiece in different positions while successive drilling operations are being performed thereon, drilling means for drilling holes in a workpiece from the surface thereof in contact with said supporting means, clamping means operable to clamp a workpiece against said supporting means under compression of at least 100 p.s.i. acting axially of the hole to be drilled, and control means for operating said drilling means and said clamping means through a clamping and a drilling cycle for maintaining the portion of the workpiece undergoing drilling under said compression pressure so long as the drill is being advanced into and retracted from the workpiece and for entirely releasing said pressure as the drill emerges from the hole.

45. In a drilling machine for performing a plurality of drilling cycles through a stack of similar workpieces held snugly pressed against one face of a template while being drilled and while being slid from one drilling position to another on a workpiece support, that improvement which comprises drilling means reciprocable into and out of the stacked workpieces from the side thereof opposite said template, clamping means in axial alignment with said drilling means and positioned opposite the exposed exterior surface of said template, coordinated fluid pressure means for advancing said clamping means and said drilling means toward the stacked workpieces from the opposite remote surfaces thereof and including means responsive to the clamping of the stacked workpieces against said workpiece support under a predetermined pressure of at least 100 p.s.i. as a prerequisite to initiation of a drilling cycle and for maintaining the portion of the stacked workpieces being drilled under compression of at least 100 p.s.i. until the drill has been retracted entirely therefrom.

46. That method of drilling sheet material defined in claim 38 characterized in providing the outer face of said template with conical depressions in direct alignment with the axes of holes to be drilled through said sheet material, utilizing individual ones of said conical depressions in cooperation with a rigid conical locator reciprocable toward and away from the outer face of said template to shift said template laterally in any direction as the conical locator moves into one of said conical depressions and to the extent necessary to position said sheets precisely in axial alignment with the path of advance of the drill, and thereafter initiating the afore-

mentioned compression of said entire stack assembly against a flat stationary surface while performing the drilling operation of that particular hole along an axis coincident with the axis of reciprocation of said conical locator.

47. That method defined in claim 46 characterized in that the performance of the corrective location of said stack assembly within the peripheral limits of said conical depressions, the compression of said stack assembly, the drilling of said stacked sheets, and the retraction of the drill and the release of the compression forces on said stack assembly are carried out in predetermined automatic sequence initiated by a single activating act on the part of an operator practicing said method of drilling sheet material.

48. That method defined in claim 47 characterized in the step of deactivating the drilling of said sheet material automatically in response to the movement of said conical locator against the outer face of said template in an area outside the rim of one of said conical depressions.

49. That method defined in claim 47 characterized in the step of checking to determine whether the point of said conical locator is inside or outside the rim of one of said conical depressions prior to clamping said material for the drilling operation, and automatically discontinuing all further steps forming part of the drilling cycle automatically if said conical locator engages the outer face of the template outside the rim of a conical depression.

50. That method defined in claim 47 characterized in the step of using an operator's hand to move said stack and template between successive drilling positions and the step of using the operator's foot to initiate a drilling cycle thereby enabling the operator to keep his hands firmly in place on the stack throughout the period required to complete a plurality of drilling cycles.

References Cited in the file of this patent

UNITED STATES PATENTS

779,251	Baggaley	Jan. 3, 1905
796,346	McBee	Aug. 1, 1905
1,244,112	Mackle	Oct. 23, 1917
2,017,865	Morgan	Oct. 22, 1935
2,267,336	Kindelberger	Dec. 23, 1941
2,271,717	Schwartz	Feb. 3, 1942
2,408,957	Schafer et al.	Oct. 8, 1946
2,420,759	Stelz	May 20, 1947
2,738,692	Jones	Mar. 20, 1956
2,850,927	Grinnell	Sept. 9, 1958
2,869,403	Bent	Jan. 20, 1959
2,873,629	Frautschi et al.	Feb. 17, 1959
2,881,589	Hitt et al.	Apr. 4, 1959
2,922,323	Weidner	Jan. 26, 1960
2,947,205	Wilson	Aug. 2, 1960

FOREIGN PATENTS

307,668	Great Britain	Mar. 14, 1929
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