

March 8, 1966

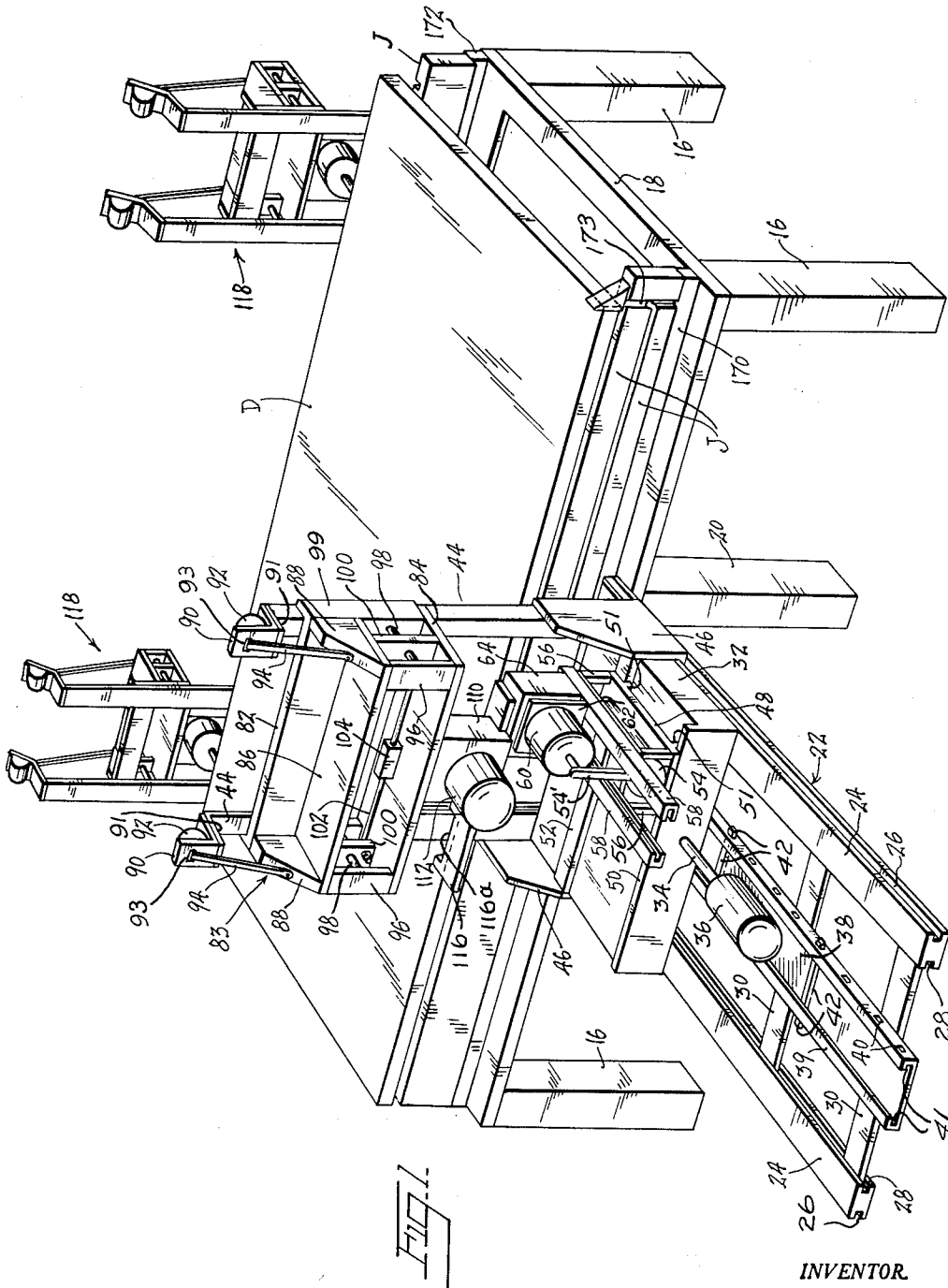
M. GOLDSTEIN

3,238,980

DOOR AND JAMB FINISHING APPARATUS

Filed May 21, 1963

7 Sheets-Sheet 1



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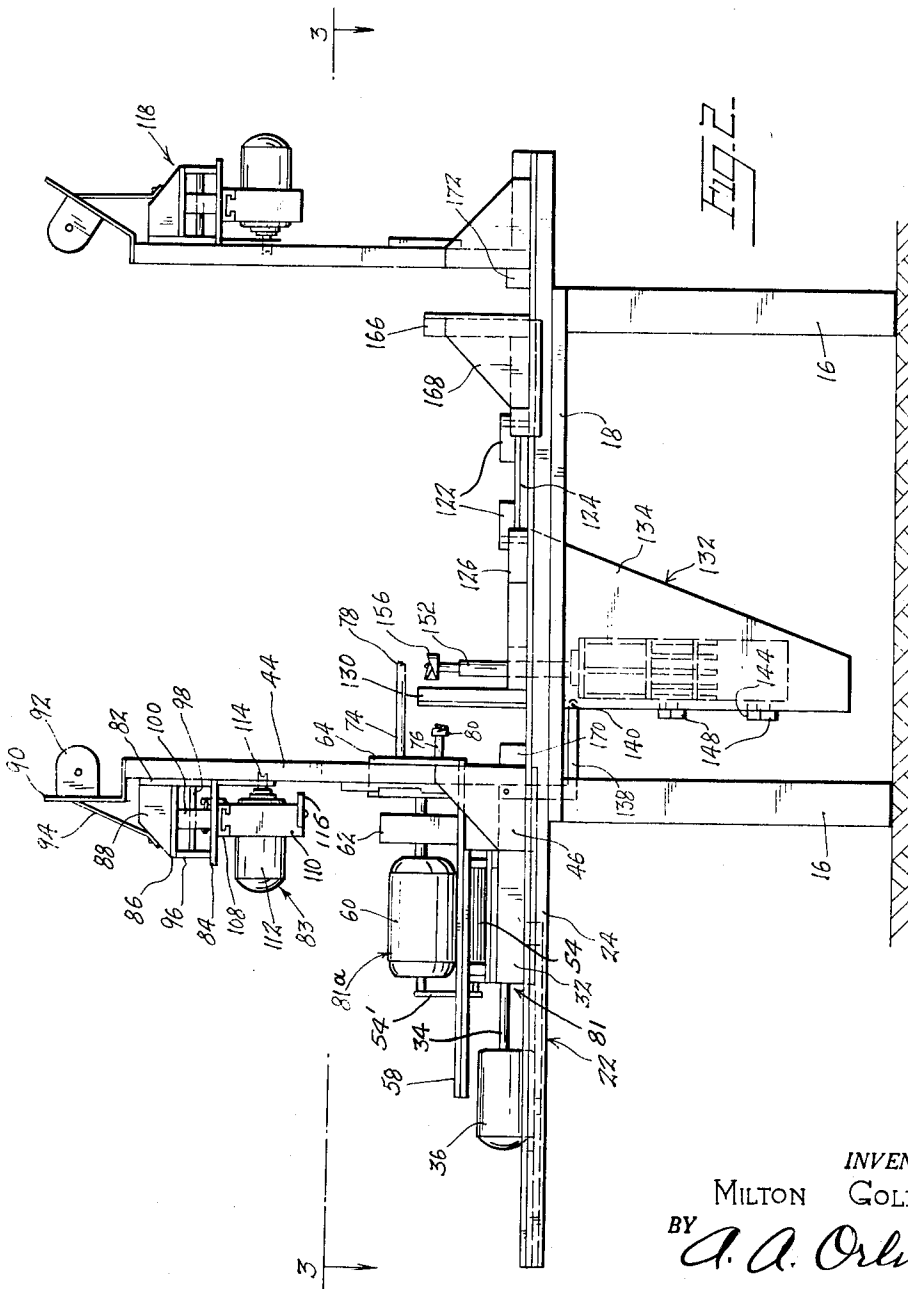
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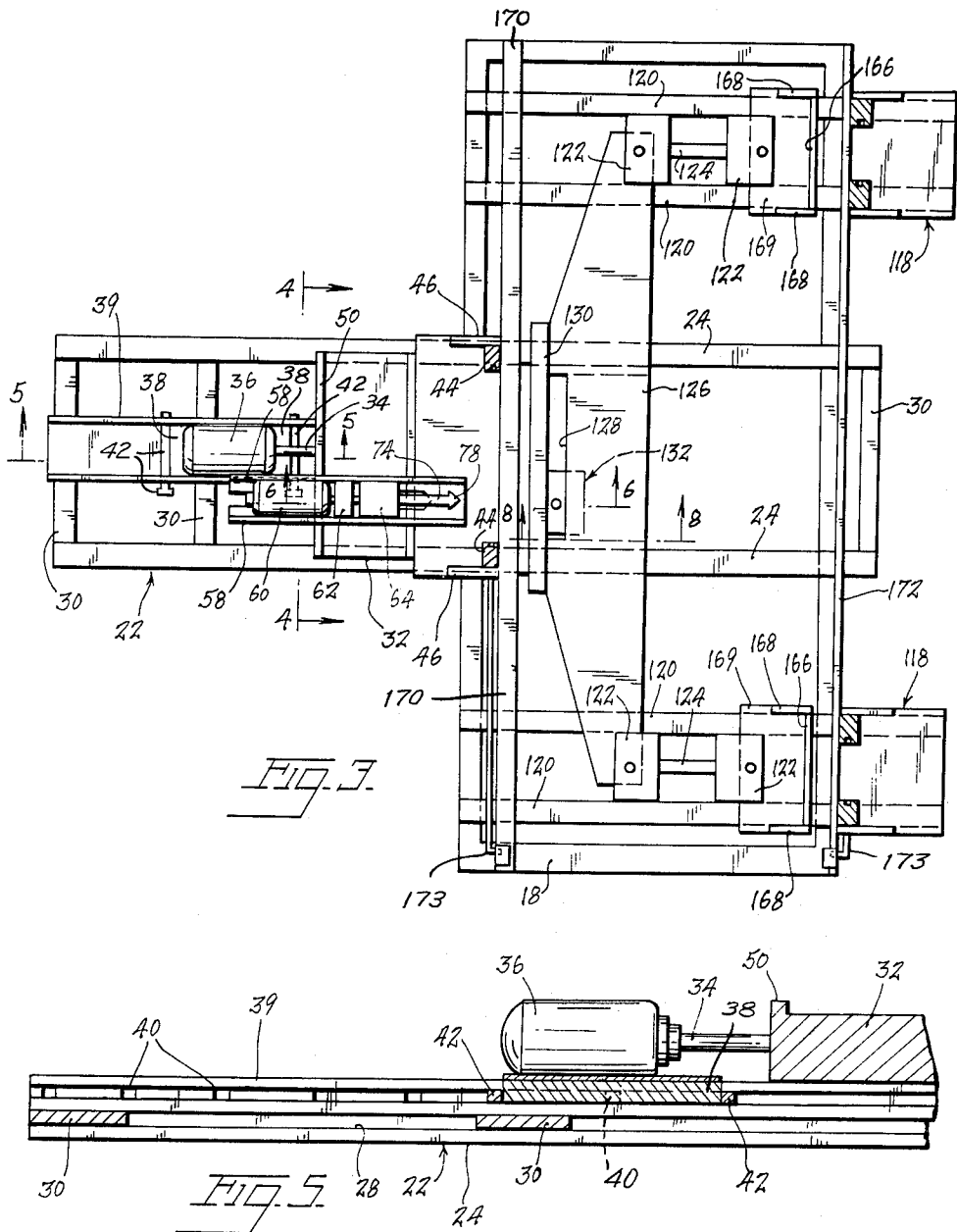
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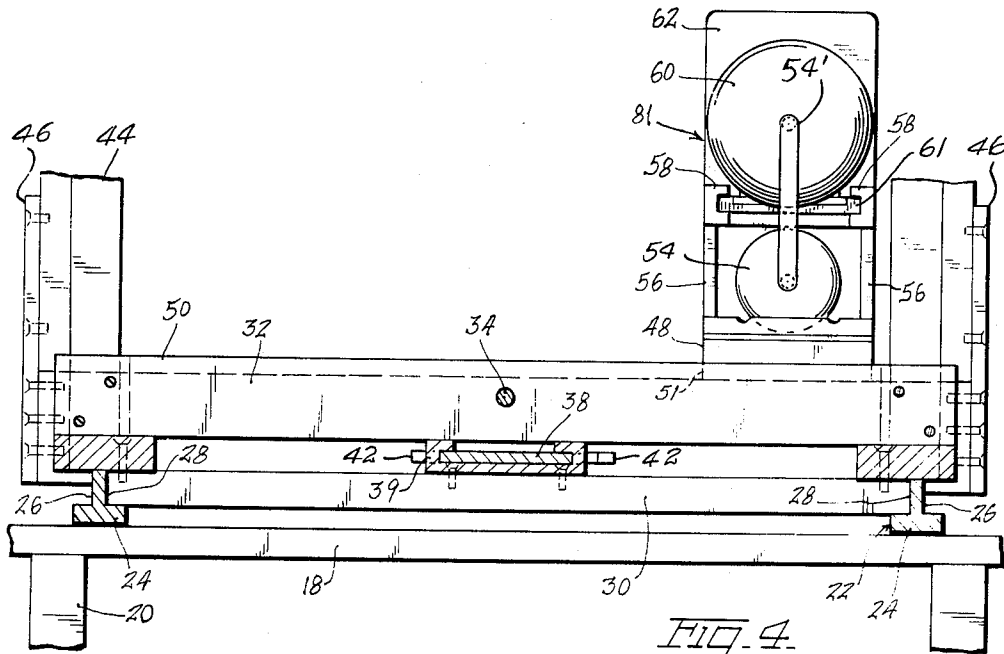


FIG. 4

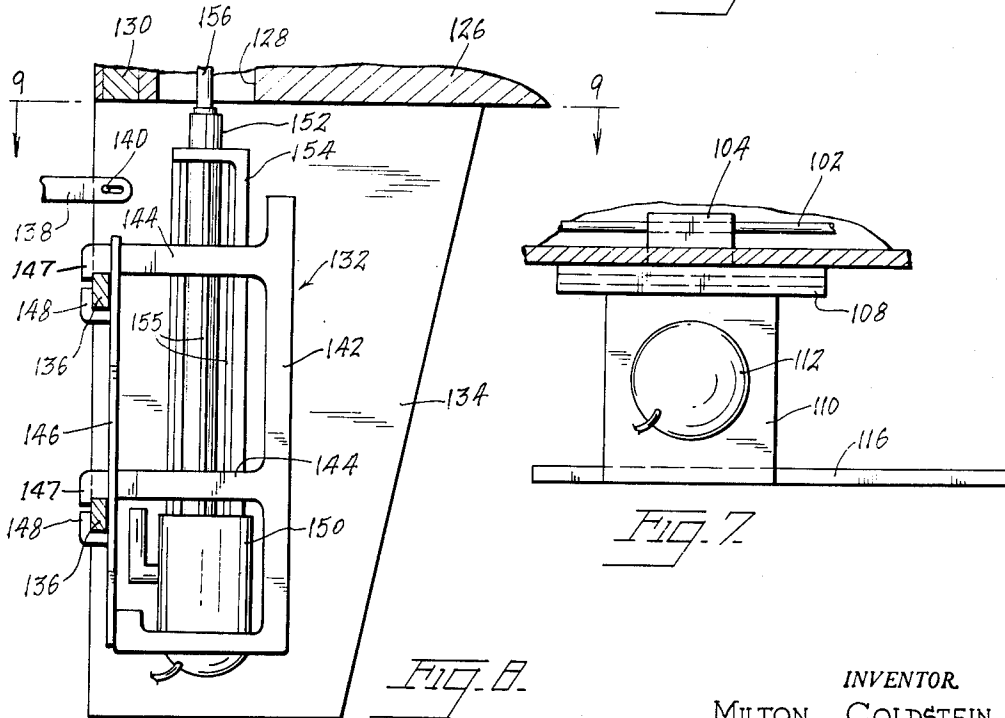


FIG. 7

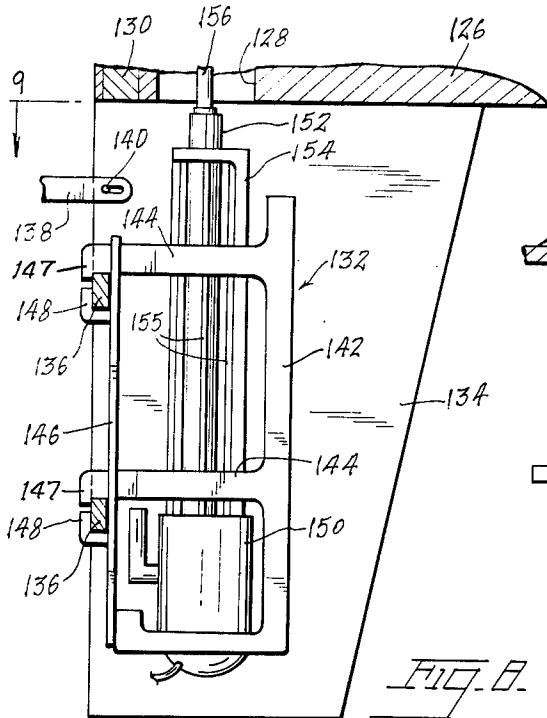


FIG. 8

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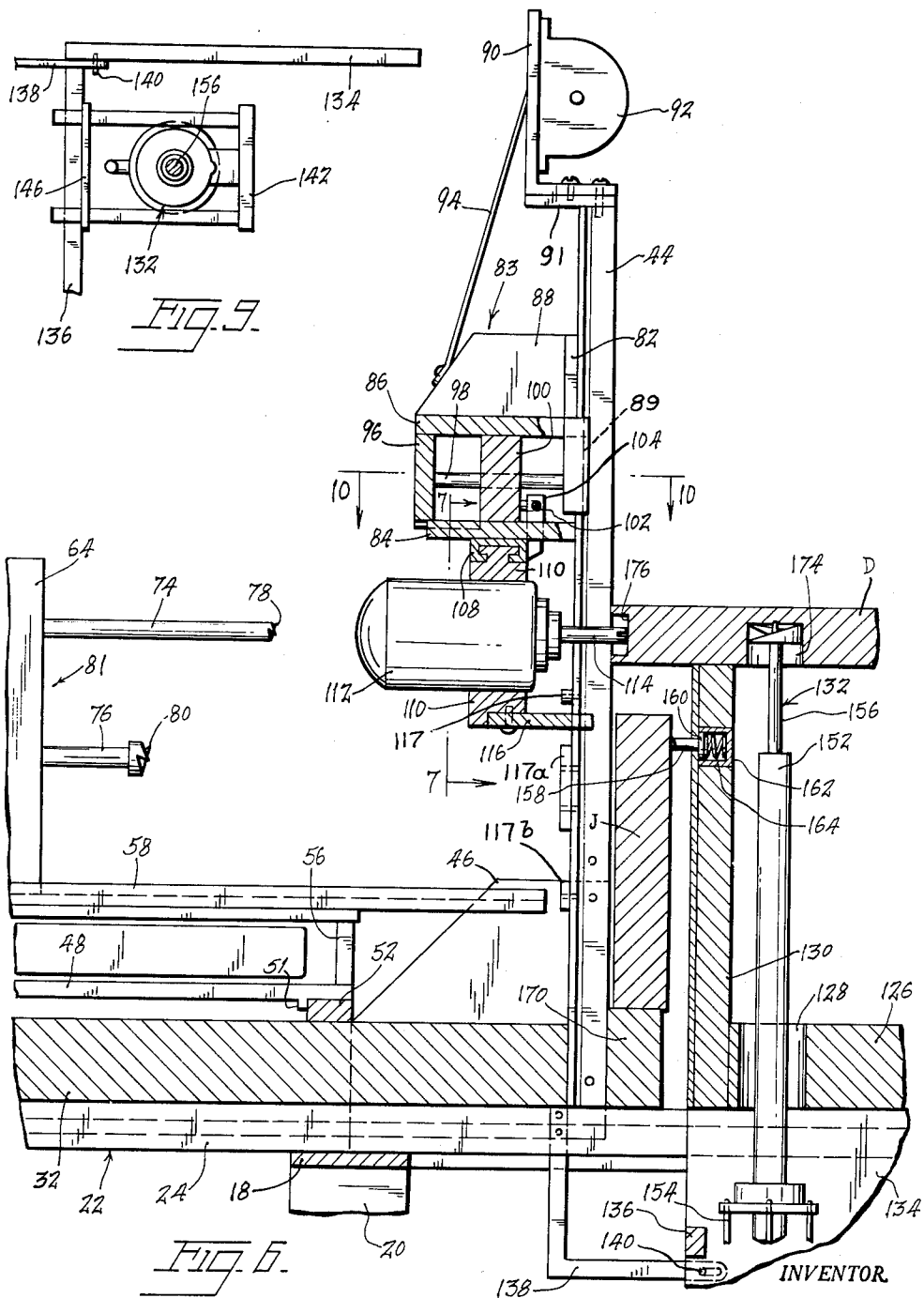
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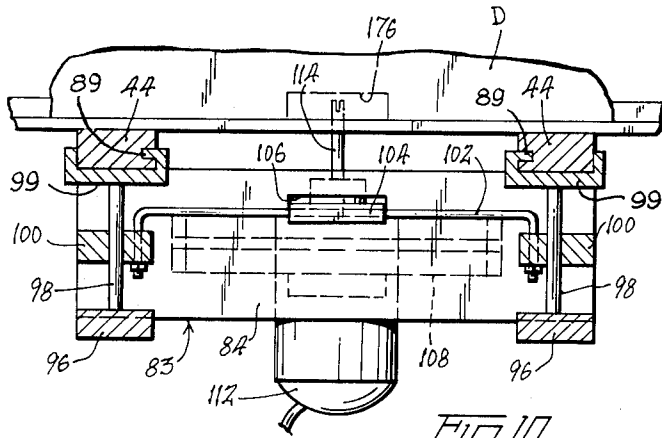


FIG. 10.

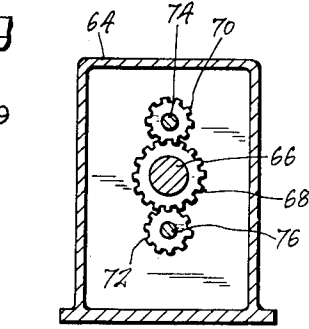


FIG. 12.

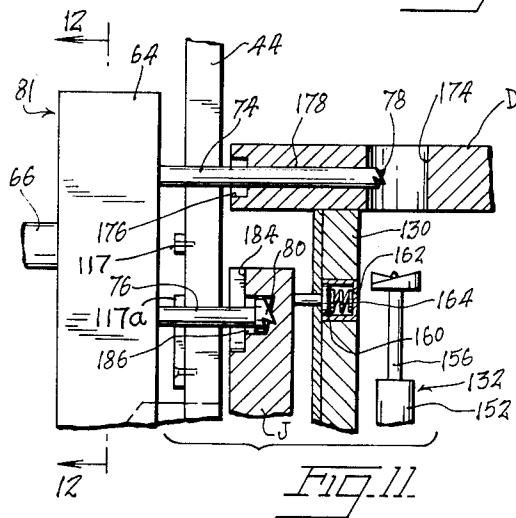


FIG. 11.

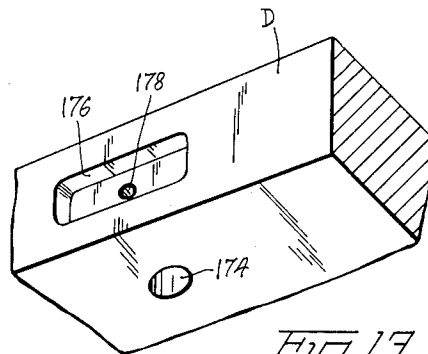


FIG. 13.

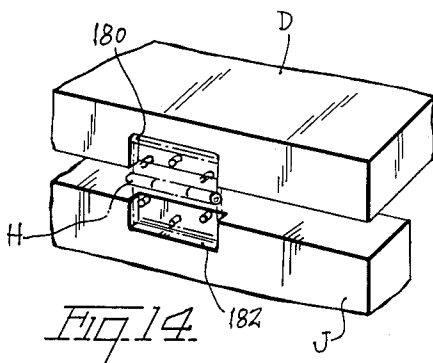


FIG. 14.

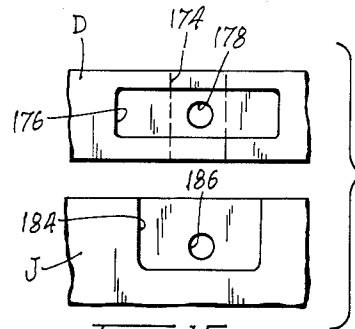


FIG. 15.

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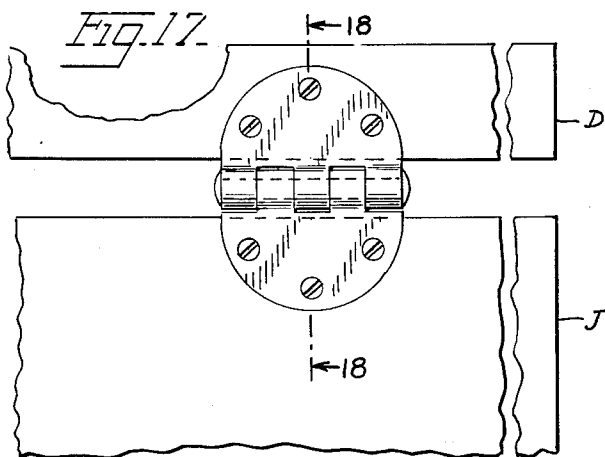
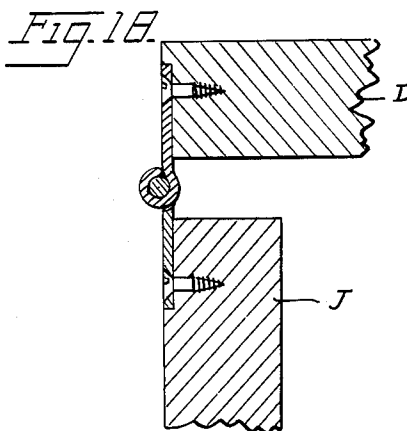
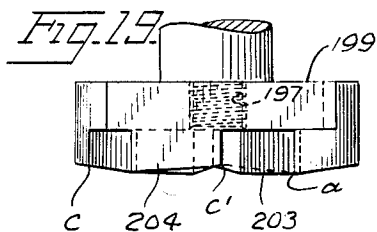
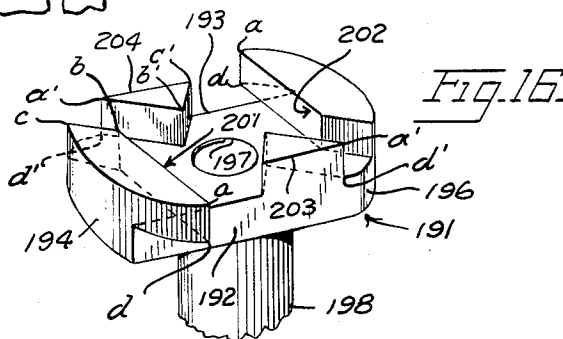
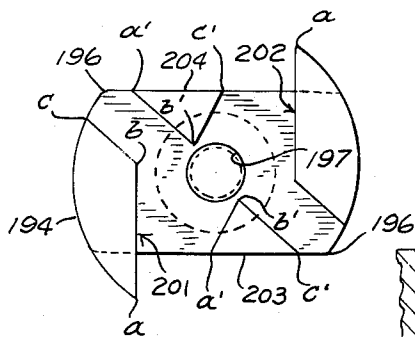
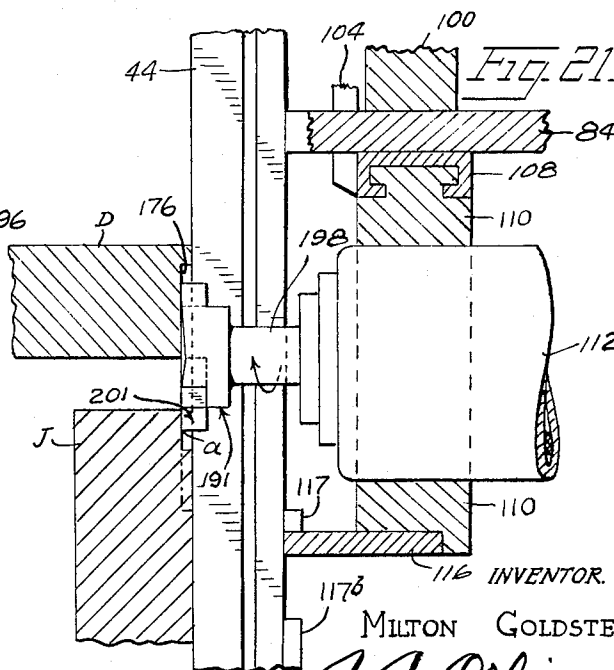
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7 Sheets-Sheet 7



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DOOR AND JAMB FINISHING APPARATUS

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Filed May 21, 1963, Ser. No. 282,044

6 Claims. (Cl. 144-2)

This application is a continuation-in-part of my co-pending application Serial No. 765,572, filed Oct. 6, 1958, and now abandoned.

This invention is that of an apparatus which holds a stock door and either and advantageously both of the jambs for it positioned in an effective relationship to one another, and comprises tools and elements for operating them to form in the door and its jambs the necessary recesses and holes for receiving the hardware items (e.g. the door lock and bolt, bolt plate, bolt and latch receiving plate, and hinges), which enable attaching these items, especially the hinges to the door and the hinge-holding jamb, all while they are held so positioned to one another. The apparatus enables repeating the same operations on successive sets of doors and the respective jambs, with each of them identically held with respect to the others, to enable forming the needed recesses and holes in proper register of them between the door and its jambs.

More specifically, the invention is that of an apparatus which holds a door flatwise on it while at the same time supporting a door jamb, and usually both side door jambs and with each, on a long edge of it and perpendicularly to the door and aligned parallel and adjacent to a respective long edge of the door.

The apparatus has also means for thus supporting the door and side jambs for it and includes elements that hold tools and have means for positioning and operating them to form in the door and jamb or jambs, while thus supported, the various recesses and cavities needed to receive the hinges and the door lock and various parts for latching it.

The invention embraces also an improved router bit that enables preparing with the barest minimum of motions a new form of hinge recess in both the door and jamb.

A further important part of the invention is an improved method of preparing jointly in the doors and their associated jambs the recesses and holes for receiving the essential hardware items. This method involves holding the door and either or both of its associated jambs in the already indicated relative position to one another and, while holding them so positioned with respect to one another, preparing on them mechanically and in proper register the various holes and recesses for receiving the necessary door and jamb hardware for hanging, latching and locking the door, and attaching the hinge butts at their respective places to the door and the jamb while so holding them relatively positioned to one another.

In current large scale building operations which involve constructing a considerable number of homes or apartments in a large housing development, a great number of identical doors is required. Heretofore, doors and their jambs generally have been made available as individual members without their having formed in them any of the various recesses and holes or cavities for receiving the essential door hardware such as the hinges, door lock, lock bolt, bolt plate, bolt end hole and engaging plate for the jamb.

Thus, the general practice has been to leave it to the individual carpenters on the job to measure off and mark on each door and its side jambs the individual locations where to rout and cut out separately the various recesses and holes, and thereafter manually to rout and cut out each of them separately, to receive the various pieces of essential door hardware.

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It has been attempted to provide apparatus for (a) holding only a door at a time and placing against certain respective areas of it separately and successively individual templates to guide different tools individually in cutting out then in the door alone the lock hole, boring the bolt hole, and routing out the lock plate recess; and (b) subsequently for allowing manually lifting the door and setting it into a framework to hold it upright with its hinge receiving edge facing upwardly and then after placing along that edge a suitable template or templates, to allow the recesses for receiving the hinge butts on the door to be routed out.

While such attempts were helpful in a measure, there still remained much to be desired, and, among other shortcomings, the individual carpenters on the job still had to mark out in the same conventional way the location for the hinge butt recesses and lock and bolt plate recess and holes, and rout and cut them out separately on the door jambs.

These and other disadvantages and shortcomings are avoided by the apparatus and method of the invention which provide a number of advantageous time and cost saving features.

An important feature of the method and apparatus of the invention is that they enable forming the various recesses and holes for the hardware items for the door and jambs at a specific combination of locations along the required edges and parts of the door and jambs, according to the needs of the specific construction job, and to form the selected combination of recesses and holes at the same locations on successive sets of a door and its associated jambs, to turn out as many such sets as are needed.

Another feature of the apparatus and the method is that it enables turning out such sets of a door and one or better both jambs in each, and having in each set of them recesses in the respective jambs accurately positioned in register with respect to the locations of the correspondingly related recesses and holes or cavities in the door.

A further feature of the method and apparatus of the invention is that they enable forming these various recesses and holes for the needed hardware items in each set of a door and its associated jamb or jambs in a minimum time interval, thereby to provide a high production rate of sets of doors and jambs, with uniform layout of the various recesses and holes from set to set so that any of the doors can be used with any of the required side jambs.

Still another feature of the apparatus and method of the invention is that they facilitate regular and easy repeated operation of the required combination of steps in the routing and cutting of these various recesses and holes for the needed hardware items, so the combination of steps can be carried out readily and efficiently by two or even one operator, or may even be adapted to automated operation.

Yet a further feature of the apparatus and method is that for the entire combination of operations which it performs on successive sets of a door and associated jambs, the apparatus requires a minimum of floor space and can be constructed at a cost low enough for the resulting savings to make the investment economically practical with continued saving in operation time and labor cost.

Further features and advantages of the apparatus and method of the invention will be seen from the subsequent detailed description of an illustrative, but not to be considered restricting, embodiment of the invention shown in the accompanying drawings wherein:

FIG. 1 is a perspective view of the illustrative embodiment of the overall apparatus embraced by the invention, showing a door and its respective side jambs supported

on the apparatus in suitable relative positions for their respective recesses and holes to be made in them in proper register in the inter-related operations on them;

FIG. 2 is an end elevation or view of the apparatus as seen from the right of FIG. 1, but with the door and jambs omitted;

FIG. 3 is a sectional view of the apparatus on the reduced scale, and taken along the line 3—3 of FIG. 2 and seen as directed by the arrows;

FIG. 4 is an enlarged transverse sectional view through the bolt hole recess forming assembly, taken on line 4—4 of FIG. 3, and seen as directed by the arrows;

FIG. 5 is a fragmentary sectional view through the bolt holes forming assembly, taken on line 5—5 of FIG. 3, on substantially about the same scale as, and normal to, FIG. 4, and seen as directed by the arrows;

FIG. 6 is an enlarged vertical sectional view on line 6—6 of FIG. 3, and showing a fragment of a door and of the jamb adjacent that part of the door;

FIG. 7 is a detail sectional view, on the same scale as FIG. 6, through the bolt plate recess forming assembly, substantially on line 7—7 of FIG. 6;

FIG. 8 is a detail sectional view, on an enlarged scale, through the lock-handle hole forming assembly, substantially on line 8—8 of FIG. 3, and showing a fragment of the carriage plate of the apparatus;

FIG. 9 is a plan sectional view of the lock-handle hole forming assembly, taken on line 9—9 of FIG. 8;

FIG. 10 is a horizontal section through the bolt plate recess forming assembly, taken on line 10—10 of FIG. 6;

FIG. 11 is a fragmentary sectional view on the same cutting plane as FIG. 6, showing a door and jamb at a later stage in the finishing operation;

FIG. 12 is an enlarged sectional view through the gear box, taken on line 12—12 of FIG. 11;

FIG. 13 is an enlarged perspective view of the part of the door showing its lock and bolt hole, and bolt plate receiving recesses;

FIG. 14 is an enlarged fragmentary perspective view showing part of the finished door and a jamb with their respective hinge-receiving recesses in register;

FIG. 15 is an exploded, side elevational view of part of the finished door and the other jamb showing the respective bolt holes, and bolt plate and latch plate receiving recesses;

FIG. 16 is a perspective view of an illustrative, but not restrictive, embodiment of the improved router bit of the invention;

FIG. 17 is a fragmentary side elevational view showing part of the finished door and a jamb, similar to FIG. 14, but with a hinge whose butt plates are semi-circular in their outer boundary, inserted and fastened in their respective hinge recesses having semi-circular inner boundaries;

FIG. 18 is a vertical sectional view on the line 18—18 of FIG. 17, and seen as directed by the arrows;

FIG. 19 is an elevational view of the improved router bit with its cutting teeth or cutters depending;

FIG. 20 is a bottom plan view of FIG. 19; and

FIG. 21 is a fragmentary partially sectional view through the hinge recesses cutting assembly 118 of FIG. 2 and paralleling its plane thereof, with the operating motor carrying the improved router bit, and showing the latter in operating position within the corresponding recesses already routed in part of the door and the adjacent part of the hinge-carrying jamb.

The apparatus includes a rectangular table (large enough to support a door placed horizontally) having corner legs 16 which may be secured suitably to the shop or factory floor. Securely supported atop said legs is a horizontal, rectangular table top or platform frame 18, advantageously formed as a rectangular frame (i.e. having the entire inner enclosed area left open, as best shown in FIGS. 1 and 3). Intermediate legs 20 can be provided

for additional support intermediate the ends of the two longer sides of the frame 18.

When holes and recesses are to be made in a set of a door and its jambs by the apparatus, they are supported from the upper surface of frame 18, as hereinafter more fully described.

Lock and bolt holes and plate recesses making assembly

A trackway designated 22 (as a whole) extends (see FIGS. 1 and 3) horizontally transversely across the long sides of platform frame 18 intermediate its ends and at a location embracing the approximate position along the proximate part of the door and its accompanying jamb, wherein holes and recesses for the lock, its bolt, bolt plate and strike plate are to be made. Trackway 22 includes elongated side rails 24, 24 which project on that side (conveniently called the lock and bolt working side) a substantial distance horizontally outwardly from the adjacent long side of platform frame 18.

Outwardly facing grooves 26 extend longitudinally along the outwardly facing sides of rails 24; and correspondingly extending confronting grooves 28 extend along their opposing respective inner sides. A few separate cross bars 30 with their ends fixedly engaged in the opposed inner grooves 28 are spaced apart longitudinally along trackway 22 to reinforce it and provide a support for the lock side motor and tool carrying assembly 81.

In that assembly, freely slidable upon the outwardly projecting portion of trackway 22, and in a direction normal to platform frame 18, is a carriage 32 (here illustrated, for example, as a wide, generally flat block). An internally threaded bore extends from its opening located substantially medially in the outermost vertical face wall (normal to trackway 22) of carriage 32 to receive in tight engagement the corresponding external threads along the outer end of shaft 34 which extends outwardly from the (inside) piston of 2-way air cylinder or air motor 36.

Air cylinder 36 is mounted on base plate 38 which is selectively locatably slidable along elongated runway 39 having along its sides inwardly turned longitudinal flanges presenting opposed engaging grooves 41 slidably embracing the side edge portions of base plate 38. A series of longitudinally spaced apart anchoring holes 40 is provided in the vertical wall of each of the engaging grooves 41 to provide a longitudinally spaced apart series of pairs of directly opposed such holes. These serve, after adjusting base plate 38 to a suitable selected working location, to receive against each of its ends an outer holding or stop bar 42, one of which is inserted in and extends through the oppositely aligned holes 40 of its respective pair of them (see FIG. 5).

Fixedly secured to the opposed corners at the inner (or platform frame) end of carriage block 32 are upwardly projecting standards 44, the securing of which to block 32 is reinforced by side brace plates 46, the lower end of each of which has an inturned flange slidably engaged in an outer groove 26.

Supported atop of carriage 32 for transverse adjustment across it is tool carrier plate 48, the outer end of which is slidably carried on upwardly projecting lip 50 extending transversely along the upper outer end of block 32 (see FIGS. 1, 3 and 5). The inner end of plate 48 similarly is slidably supported upon transversely extending spacer bar 52 extending from side to side of carriage 32 and parallel to lip 50. Guide flanges 51 depending from the underside of plate 48 adjacent the inner vertical sides of lip 50 and spacer bar 52, guide carrier plate 48 and hold it on top of said lip and spacer bar. Tool carrier plate 48 remains by its own weight at whatever location along them it is moved.

A positioning motor, conveniently the air-motivated piston-bearing cylinder 54, is mounted on plate 48, at each of whose four corners are fixedly secured upwardly projecting, short posts 56. To their upper ends are secured

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a trackway, here composed of horizontally spaced apart elongated guide bars or tracks 58 having confronting grooves and extending parallel to the line of movement of the carriage block 32.

A tool operating motor 60 is disposed upon its support plate 61, slidably mounted in the grooved guides 58. The shaft of motor 60 projects toward platform frame 18 and extends through a bearing 62 into a gear box 64 (detailed in FIG. 12).

As seen in FIG. 12, shaft 66 of motor 60 extends into gear box 64 conveniently centrally thereof. Secured to shaft 66 is gear 68 in mesh with pinions 70, 72 disposed above and below it. Shafts 74 and 76 are secured to the pinions and project forwardly out of the gear box. Exteriously of the gear box, shafts 74 and 76 are provided with drill bits 78 and 80 respectively. The shafts 74 and 76 of drill bits 78 and 80 respectively are of such length to give the required depth to both bolt holes when motor 60 is advanced by operation of air cylinder 54 the length of its advancing stroke.

From FIGS. 1, 2, 5 and 6, it is seen that, with the door and both jambs supported as shown in FIG. 1, carriage 32 (as a unit with its standards 44, motor 60 and gear box 64, being designated 81) is moved to adjust it to a conveniently practical operational starting location on trackway 22, and fixed there by inserting a stop bar 42 in each of the two separate pairs of opposed openings 40 adjacent the ends of plate 38. Then, by opening a treadle-operated valve controlling a compressed air source (all not shown) to enter the advance-motivating port of air-cylinder motor 36, motor and tool assembly 81 can be adjusted as a unit toward platform frame 18 to clamp the jambs in place relative to the door (as more fully explained much further below) and set drill bits 78 and 80 in longitudinal position for use.

The bolt-hole forming assembly including air-motivated cylinder 54 and motor 60, all generally designated 81a, then can be adjusted transversely along carriage 32, by being slid over lip 50 and spacer bar 52, to position drill bits 78 and 80 at the location opposite the position along the long edge face of the door where they are to be operated to form the bolt holes in the door and that jamb respectively. Thus, with the door and that jamb in the same lengthwise relationship to one another as they are to have when finally assembled for use, drill bits 78 and 80 can drill out the separate bolt holes in the door and jamb respectively in the precise relative positions they will need to be in when the door is to be mounted in the assembled door frame.

Bolt and strike plates forming assembly

The bolt plate and strike plate recesses forming assembly 83 (seen in FIGS. 1, 2 and 6) includes a vertical guide plate 82 slidably along and extending transversely across from one to the other of standards 44, adjacent their upper ends. A horizontal plate 84 is slidably supported in relation to plate 82 and projects horizontally outwardly as to it. A second horizontal plate 86 is spaced above plate 84 and fixedly secured to vertical plate 82 and reinforced thereto by side brace plates 88, 88.

Assembly 83 includes means to enable imparting to an operating tool motion vertically, for example, to rout out the height of a recess, as well as outwardly (i.e. into the door and/or jamb) to provide the desired depth of the recess. In addition, where necessary or desired, such means also can allow moving the tool in either direction parallel to the length of the door or jamb to give a recess a desired width great than the diameter of the tool.

FIGS. 1, 2, 6 and 10 best show an illustrative combination of means, and their operation, of assembly 83. It is vertically slidable as a whole along standards 44 by the provision of the tongue and groove connections between standards 44 and tongues 89 of assembly 83.

To brackets 90, carried on and fixedly secured to out-

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wardly (i.e. away from frame 18) horizontal extensions 91 from the upper ends of standards 44, are secured spring balance housings 92 which house coiled elongated flexible springs 94. The latter extend downwardly from slots 93 (one in each housing) and with their outer lower ends secured to brace plates 88. The counterweighting effect of spring balances 94 facilitates the up and down movement of assembly 83 (to an operating level and also during the routing of the bolt and latch plate recess in the door D and the strike plate recess in the jamb J) as well as that to and away from the operating level for operation of its tool, and also enables leaving the assembly at a selected out of the way level, when not in use (FIGS. 1, 2 and 6).

FIGS. 6 and 10 show outer corner posts 96 extending between plates 86 and 84 and fixedly secured to horizontal plate 86. Vertically spaced away from both plates 84 and 86 and extending horizontally from posts 96 to shoes 99 are guide rods 98 which extend through horizontal bores through respective slide blocks 100. Thereby the latter can slide toward and away from shoes 99 (and thus also from the door and jamb to be worked on).

In a horizontal plane intermediate that of rods 98 and lower plate 84 and parallel to the latter, extends rod 102 having at its outer ends rearwardly turned extensions, each passing through its own corresponding bore in its respective block 100 and secured against motion relative to them by nuts threaded onto the outer threaded ends of these extensions. Intermediate its ends, rod 102 extends through a horizontal bore in the upper end of a tongue 104 which depends vertically through an opening 106 in lower plate 84 to shortly below its underside.

Opening 106 is substantially, and even to about fifty percent, wider than tongue 104 is thick, depending on the depth for the recess, thereby to permit correspondingly limited forward and rearward movement of blocks 100 and tongue 104 during the routing of, and thus to predetermine, the depth of the bolt plate and strike plate recesses. For example, on starting the routing of such recess, tongue 104 is positioned as in FIG. 10, and as the router bit advances into the work, tongue 104 also advances toward standards 44. Then when tongue 104 contacts the thus forward limit of opening 106, it is stopped and so halts the advance of the recess router bit to the thus controlled depth.

Tongue 104 terminates rigidly secured to the forward wall of a horizontal guide track 108 (FIG. 6) rigidly attached to the underside of lower plate 84 and longitudinally paralleling platform frame 18. A downwardly open dovetail groove in guide track 108 slidably receives a correspondingly formed tongue extending similarly along the top of motor-support block 110 embracing motor 112 from which forwardly projects shaft 114 with the router bit at its outer end and extending between standards 44 toward the door and jamb to be worked on.

Recess size guide 116, fixedly horizontally secured to the underside of support block 110, extends parallel to and toward the adjacent long side of frame 18, and advantageously to the extent of part of the thickness of standards 44 (FIG. 6) except at notch 116a cut out of guide 116 to let it extend lengthwise and terminate at the outer end of notch 116a beyond one of the standards 44 (conveniently the left one as seen in FIG. 1).

For guide 116 to limit the extent of the recess routing in the vertical direction (as in FIG. 6), recess size stops 117 and 117a are secured to the outer face of a standard 44 (the one seen in FIG. 6, in view of the above chosen location of notch 116a). Accordingly, in routing a bolt plate recess 176 in door D, one can start routing with the upper surface of guide 116 touching the underside of stop 117 and in later completing the routing work with the underside of guide 116 contacting the upper surface of stop 117a. Thus, recess 176 will be given its selected (actual width) cut in the vertical direction as seen in

FIG. 6 (corresponding to its actual width when the door is later placed upright in the door frame).

To rout a strike plate recess in jamb J, motor 112 carrying router bit 114 is retracted by drawing back support 110 (as it is suspended from plate 84 and in turn from slide blocks 100 as they slide along guide rods 98). A third stop 117b is provided. Support 110 is lowered to a level where the upper limit for the recess can be set by then pushing support 110 toward the jamb and working with the upper surface of guide 116 contacting the underside of stop 117a and continuing the routing downwardly and finally completing it with the underside of guide 116 contacting the upper surface of stop 117b. Thereby the width of the strike plate recess (184 as seen in FIG. 15) in jamb J is controlled.

When certain improved door and door frame hardware, for example, the improved hinge of FIGS. 17-18, is going to be used, one then also can operate with an improved router bit of FIGS. 16, 19 and 20 (as shown by FIG. 21). The apparatus can be used advantageously to form the required recesses then by operating the routing bit in only two directions. One of them necessarily will be to rout the depth, followed then by routing in one other direction such as vertically from the door down to the jamb (e.g. as they are held in the apparatus).

However, for the bolt and strike plate recesses of FIGS. 13 and 15 (and likewise for the hinge recesses as of FIG. 14), the routing also is operated in a third direction, i.e. horizontally parallel to the length (actually the height) of the door and jamb as held in the apparatus. For that latter routing operation, support 110 is moved horizontally parallel to the long side of frame 18, for example, starting with the right hand end of notch 116a of guide 116 contacting the grooved face of the adjacent standard 44, and working the routing along to later finishing with the outer end of notch 116a contacting the opposite face of that standard 44.

The foregoing description of major operating assemblies relate to operations primarily conducted on what may be referred to on the lock side operations of the apparatus.

Hinge recess forming assemblies

At the opposite side of platform frame 18, are mounted hinge-recess-forming assemblies generally designated 118 (FIGS. 1-3). They serve for forming the generally similar pairs of hinge recesses in a door D and jamb J, for receiving butt hinges H (FIG. 14). There can be included as many of these recess-forming assemblies as are needed for the number of hinges planned to be used along the length (or height, in use) of the door as attached (or hung) in its frame.

Ordinarily and advantageously all of the hinge-recess-forming assemblies are identical. Generally, they are composed and constructed substantially identically to bolt plate and strike plate recesses-forming assembly 83 including its standards 44, and are operated similarly to the operation in forming recesses by assembly 83. Therefore, no particularized and extensive description need be given of assemblies 118 and their operation. They do not include any assemblies 81 and 81a, base 32, air motor 36, or runway 39. Standards 44 are fixed to supports on their own side.

However, for making a pair of matching hinge recesses with one in the door in register with the other in the jamb, whether like those of FIG. 14 or those of FIGS. 16-17 and 21, assemblies 118 need no recess stop 117a, and both recesses for the pair are made in one continuous operation. Such continuous operation then does not require withdrawing the router bit on shaft 114 by retracting support block 110 after making the recess in the door, before lowering and then advancing it again to make the recess in the jamb.

Instead, that continuous operation merely involves advancing block 110 to begin routing the recess in the door and while still conducting the routing moving it sidewise

to complete the recess in the door and then continuing and moving it down till the underside of guide 116 contacts the upper surface of stop 117b for starting routing the recess in the jamb and going on similarly to complete the recess in the jamb. That provides a pair of recesses as in FIG. 14.

As already described above, to prepare a pair of recesses as those in FIGS. 16-17 and 21, no sidewise operation employing notch 116a is used. It is formed only by advancing the router into the work, starting with the upper surface of guide 116 contacting the underside of stop 117 and moving block 110 downwardly while routing and until the underside of guide 116 contacts the top of stop 117b. It is necessary only to continue that routing while raising block 110, or to continue routing while again lowering it, if the first routing of the area did not rout out the whole required depth of cut.

Thus, the repeated coverage from the door to the jamb or back is needed only till the advancing face of tongue 104 meets the edge of opening 106 nearer vertical plate 82, but all without any sidewise movement of block 110.

Jamb clamping and door supporting assembly

Referring now to FIG. 3, pairs of tracks 120 are fixedly mounted on platform frame 18 adjacent opposite ends thereof, one pair of tracks being provided adjacent each end of it. These tracks conveniently extend fully from one to the opposite longitudinal edge of frame 18.

Slidably mounted upon each pair of tracks 120 is its own separate pair of blocks 122 spaced apart along the tracks and rigidly connected by a connecting rod 124 extending between them. Each pair of blocks 122 and connecting rod 124 constitutes upon each pair of tracks 120 separate guide means for an elongated carriage plate 126 extending in a plane paralleling and disposed below the plane of the door to be held in the apparatus. Carriage plate 126 serves as a base from which is suspended the lock-hole boring assembly referred to below.

Carriage plate 126 thus is mounted for slidable adjustment transversely of platform frame 18. In carriage plate 126, intermediate the ends and nearer assembly 83, is formed an elongated slot 128 extending longitudinally of plate 126. The outer side wall of slot 128 is defined by an upwardly projecting abutment wall or plate 130 providing an abutment for one side of a jamb J to be clamped against it on the key side.

Door lock-hole forming sub-assembly

Depending from carriage plate 126 is a door lock-hole forming assembly generally designated 132 (FIGS. 2, 6 and 8), supported between depending vertical curtain walls 134 fixedly secured to carriage plate 126 and abutment plate 130. Fixedly connected between walls 134 are vertically spaced apart, horizontal track bars 136.

An L-shaped arm 138 (FIG. 6), fixedly connected to track 22, and having a slot receiving a lug 140 carried by one of the curtain walls 134, allows limited transverse adjustment of carriage plate 126. This serves to locate lock-hole forming assembly 132 a selected distance inwardly from the adjacent edge of a door to be worked on, for formation of the lock-hole at a desired location in said door D.

Assembly 132 includes a frame 142 (FIG. 8) having vertically spaced apart arms 144 at each side thereof. Frame 142 also includes a vertically disposed outer or front plate 146 receiving the outer end portions of arms 144. Beyond the plane of plate 146, arms 144 have depending extensions 147 confronting upwardly projecting extensions 148 rigidly secured to plate 146 to cooperate with the arm extensions 147 in forming slot openings receiving track bars 136.

This above arrangement supports frame 142 depending from carriage plate 126 for adjustment longitudinally as to platform frame 18, so that the lock-hole can be formed at its selected location along the length of the door.

A frame 154 (FIG. 8) is disposed vertically in frame 142, and a motor 150, with its shaft 152 extending upwardly from it, is slidably mounted upon frame 154 for adjustment in a vertical direction, by means of rods 155 slidably engaged in openings formed in frame 154 and secured to the motor casing. Means can be employed, such as a foot treadle, not shown, for shifting the motor upwardly to provide a corresponding upward movement of drill bit 156 secured to the upper end of motor shaft 152.

Jambs and door supporting means

Abutment wall 130 holds means for bearing against the adjacent surface of door jamb J (see FIG. 6) which is to have a bolt hole and striker plate recess, and to hold it in place against standards 44. That means includes one or more plungers 158, each having a head 160 slidable in a housing 162 mounted in abutment wall 130, and backed by a spring 164 held under compression within the housing and bearing against the plunger head normally to urge the plunger outwardly from the abutment wall against the jamb J.

Means also is provided to support the other side jamb (for receiving hinge recesses) for the door frame, along the side of the platform where the hinge recess forming assemblies 118 are mounted. This means (seen best in FIGS. 2 and 3) includes relatively short, vertically disposed abutment plates 166 spaced apart longitudinally adjacent the long side of platform frame 18 and secured by side braces 168 to plates 169 which are fixed to respectively adjacent blocks 122. Abutments 166 thus are interconnected to carriage plate 126 for unitary movement with it, thereby to set the space between both of the side jambs for the door frame. Such interconnection can be fixedly adjustable to the width of different doors.

Extending longitudinally on opposite long sides of platform frame 18 are elongated support bars 170 and 172 (see FIG. 2). These support the opposed jambs J for the door frame while the operations are being performed on them. Bars 170 and 172 are relatively narrow in width, so as to permit a vise to clamp the jambs to the respectively adjacent standards 44, if at all desired.

In using the apparatus, one jamb J is placed with a long edge resting on bar 170 and with its header frame-receiving slot facing outwardly (i.e. toward the outside of the apparatus) with the vertical yet shorter arm of the L-shaped stop 173 engaged in the upper part of said header frame-receiving slot and with the extension from the upper outer end of that arm of stop 173 resting on the surface of the top of the end portion of that jamb beyond that slot.

The other jamb is placed similarly on bar 172 along the opposite side of the apparatus, with its header frame-receiving slot directly opposite that slot of the first jamb and also facing outwardly (from its own side) and with another stop 173 similarly inserted in the upper part of its slot with the upper outer end extension of the stop similarly resting on the corresponding part of that second jamb. The door then, is supported flatwise (shown about the distance of the outside diameter of the door hinge pin sleeve) above the jambs and on top of abutment wall 130 and plates 166, and with its end which is to be its top abutting against the upright ends of the outer extensions of stops 173, all as shown in FIG. 1.

The jambs and door then are held fixed in suitable working position relative to one another, by operating the compressed air-motivated positioning cylinder 54 (as explained in the second paragraph before the description of the "Bolt and strike plates recess-forming assembly") to advance standards 44 of assembly 81 to clamp the jambs and also the door in such position.

While FIG. 1 shows only one stop 173 (i.e. on the side adjacent assembly 83), it is desirable to have a corresponding one on the other long side of the apparatus (as seen in the lower right hand corner of FIG. 3). The upper outer end extensions of stops 173 position what is to be the upper end of the door (when installed) in proper rela-

tion to what is to be the underside of the header frame. While stops 173 are used at one end of the apparatus for finishing left-hand doors, by providing corresponding attachments for them, they may be transferred to the other end for use when finishing the right-hand doors.

With the jambs and door so supported, the knob-lock hole, bolt hole, bolt plate recess, and hinge recesses of the door D can be formed by suitable operation of the corresponding respective tool-operating assemblies of the apparatus; and with substantially concurrently routing out of the striker plate recess, bolt hole recess, and hinge recesses on the respective jambs.

For performing these various foregoing operations, the several individual drill bits and router bits can be located selectively at such particular positions, and be made of such respective shaft lengths, suitable to enable producing the particular specifications for these various holes and recesses by the operation of these tools over their movement distances respectively provided by the settings of the different forming size guides included in the apparatus.

There is a certain flexibility in the order in which the various tool operating assemblies of the apparatus can be used, influenced in a measure by whether two operators, one for each side, or only one operator, will be used, or some of the operations are automated. In any event, it is seen that drill bits 78 and 80 cannot be run by tool-operating assembly 81a at the same time as assembly 132 is operated to form the knob-lock hole.

Thus, for example, it may be advantageous first to form the knob-lock hole. For that, assembly 132 is shifted longitudinally of carriage plate 126 relative to the location along the length of the door selected for the lock hole. Carriage 126 then is adjusted transversely of the door to position drill bit 156 the required distance inwardly from the adjacent long edge of the door. Then, by starting motor 150 and raising it (e.g. by compressed air motivated cylinder), drill bit 156 is advanced from its lower position toward the door and will pass upwardly through it (see FIG. 6) to bore through it lock hole 174.

While lock hole 174 is being formed, another operator could be operating hinge-forming assemblies 118 to rout out of the opposite long edge of the door and its adjacent jamb pairs of hinge recesses (e.g. with one recess 180 in the door, FIG. 14, and its associated recess 182 in the hinge receiving jamb for the door frame). Then, while this operator proceeds to insert the leaves of the butt hinges H in their respective recesses and to screw-fasten them to the door and jamb, the first operator, on completing boring the lock hole, can be occupied on the lock side of the apparatus with tool assembly 81a.

There by his operating the treadle which opens the treadle-operated valve connected with the compressed source (not shown), compressed air enters the advance-motivating port of air-cylinder motor 54. At the same time the switch is closed to start motor 60 and thereby, through gear box 64, set in operation drill bits 78 and 80 to bore out simultaneously the bolt hole 178 to communicate with lock hole 174 in door D and the bolt-end-receiving hole 186 in jamb J (FIGS. 2, 11-13 and 15) until bits 78 and 80 reach their respective positions seen in FIG. 11. The treadle-operated two-way valve then is reversed to allow the compressed air to enter the assembly-retracting port of air-motivated cylinder 54 to withdraw drill bits 78 and 80.

As assembly 81a is being withdrawn, an operator can be lowering tool assembly 83 (from an elevated out of the way position), so that when drill bits 78 and 80 are out of the way, bolt plate or latch-mechanism recess 176 can be routed in that long edge of door D by router bit 114. For that, assembly 83 is adjusted to set router bit 114 to its proper elevation and then manipulating motor support 110 upwardly and downwardly sufficiently while motor 112 operates router bit 114 to rout out recess 176 to the selected depth and width in door D, with

the assistance of guide 116 and stops 117 and 117a (as described above). Support 110 can be adjusted longitudinally of the door as may be needed to give that recess any desired greater length (see FIGS. 2, 6 and 13).

Motor support 110 then is retracted to withdraw router bit 114 from recess 176 and lowered for the top surface of guide 116 to be able to contact the under surface of stop 117a. Then bolt plate recess 184 is routed out of the adjacent jamb J (FIGS. 6 and 15).

Alternatively, the treadle which operates the two-way valve controlling the air flow to the air-motivated cylinder for raising motor 150 of tool assembly 132 toward the underside of the door, can be arranged also to close a switch for operating motor 150, and be located with its operating pedal near enough to the hinge side of the machine to be operated by foot from that side. Then a single operator can operate that treadle by foot to raise tool assembly 132 and start motor 150 to operate drill bit 156 to bore out the knob-lock hole, while at the same time operating tool assembly 118 to rout out hinge recesses on the hinge side of the door and its adjacent jamb.

When knob-lock hole 174 is completed, its tool assembly 132 can engage a limit switch to close a circuit to energize a solenoid to operate the two-way valve (all not shown) to admit compressed air in the port of the withdrawal-activation part of the air-motivated cylinder to retract assembly 132.

Retraction of assembly 132 then can set a switch which closes the circuit to energize a solenoid to operate the treadle which operates the two-way valve (all not shown) for controlling the air supply to air-motivated cylinder 54, to allow compressed air to enter the port of its advance-motivating part. At the same time that circuit can energize motor 60 so that as tool assembly 81a is advanced drill bits 78 and 80 can bore out the bolt holes 178 and 186 respectively in the door and adjacent jamb. In the meantime, the operator has been completing operation of hinge recess tool assemblies 118 in routing out hinge recesses on the hinge side of the door and its adjacent jamb, and has been inserting screws in, and screwing down, the hinges in their recesses.

When bolt hole drilling tool assembly 81a has advanced the distance for which its piston advance is set, drilling of the bolt holes in both the door and its adjacent jamb is completed. At that moment, assembly 81a can close a limit switch (not shown) in a circuit which excites a solenoid to turn the two-way air valve to allow compressed air to enter the retraction port of air-motivated cylinder 54 thereby to withdraw tool assembly 81a.

The operator, then finished with installing the hinges, can come around to the lock side of the apparatus and operate tool assembly 83 (in the manner earlier above described) to rout out the bolt plate recess in the door and the striker plate recess in the jamb.

Routing of the various hinge recesses need not be limited to being done by use of the ordinary drill bit 114 as heretofore commonly used. Instead, hinge recesses can be routed out in shorter time by use of the special router bit which is a part of this invention (FIGS. 16, 19 and 20) as shown by FIGS. 17, 18 and 21. This new router bit provides the advantage of enabling eliminating a motion in the hinge recess routing with accompanying reduction in operating time as well as reducing the time the tool is in use.

The special router bit

The special, improved router bit (seen in perspective in FIG. 16, in elevation in FIG. 19, and bottom plan view in FIG. 20) includes primarily

(i) A short, stubby cylindrical, rather disc-like cutter head body 191 (taken as a whole) with two diametrically opposed segments cut away from along each of two parallel chords (each being spaced advantageously somewhat more than half a radius from the body axis), whereby the peripheral cylindrical surface of the cutter head body consists of the two opposed substantially flat surface

192 and 193, each end of each of which respectively joins an adjacent end of each of, so as to be continuous with, the two diametrically opposed substantially circular peripheral portions 194 and 196 of the cutting head body 191;

(ii) Mounting means for enabling connecting the router bit with means to rotate it, which mounting means in this embodiment is an internally threaded central bore 197 (and into which can be securely tightly threaded the threaded shorter diametered portion of the stud 198 with its shoulder abutting against the under surface 199 of body 191); and

(iii) On the outer or cutting face of the router, cutting teeth including outer annular ring (advantageously identical) teeth 201 and 202 (which conveniently may be called circular-edge teeth because each of them has a circular edge) and inner annular ring (advantageously identical) teeth 203 and 204 (which may be called inner or triangular teeth).

The views of the special router bit (FIGS. 16, 19-21), show that to rout with this router bit (as shown in this illustrative embodiment) it must rotate counter clockwise (as one looks at the outermost surfaces of the teeth and directly at the axis of the tool). Thus, the leading or first cutting corner of each tooth must be the first point or corner of a tooth that is to touch the plane surface of the door or jamb to be routed. That will be the respective corner *a* of each of the two circular teeth (i.e. which corners are at the outer ends of the diameter *a-a* of the largest circle which can be traced by any two diametrically opposed points of any of the teeth).

So also, the leading or first cutting corner of the triangular teeth is the respective corner *a'* of each of them (i.e. at the outer ends of the diameter of the largest circle which can be traced by any point of any inner tooth).

Thus, the leading planar surface area, or flat, cutting edge of the circular teeth must be the cutting edge along the line *a-b* of each of them, and of the inner teeth is the line *a'-b'* of each triangular tooth. All of the flat cutting edges of both sets of teeth fall in the same flat plane.

To provide an adequate clearance, from beyond the leading planar cutting edge *a-b* of each circular tooth, each point along the edge arced line *b-c* as well as along the long straight line *b-c* is progressively lower and lowest at the point *c* (i.e. in the direction toward the rear or under-surface of the router body). Thereby the plane *abc* slopes thus downwardly (as in FIG. 16) from the line *a-b* to the point *c*. Similarly, each of the points from the line *a'-b'* along the line *a'-c'* and also along the line *b'-c'* of triangular teeth is progressively lower and lowest at the point *c'*, so that the plane *a'b'c'* inclines downwardly from line *a'-b'* to point *c'* an adequate amount to provide a sufficient clearance.

The leading or first depth cutting edge (i.e. parallel to the axis of the router bit) of each circular tooth is its vertical edge line *a-d*; and so also for each triangular tooth is the vertical edge line *a'-d'* of each of them.

The angle between each flat cutting edge *a-b* and the diameter drawn through the axis of the router and the two leading points *a* must be adequate to provide a sufficient angle of rake with respect to those cutting edges.

The circle drawn through the points *a'* of the inner teeth at least should touch, but preferably merely sufficiently should overlap, the circle drawn through the points *b* of the outer or circular teeth to assure giving the recess a clean planar surface. The spacing between the closest two vertical faces of any two of the adjacent teeth should at least be adequate to provide sufficient egress of shavings resulting from the routing. Also, each element along the outer cylindrical surface of each cylindrical tooth from its vertical edge *a-d* to the element drawn through the point *c* is progressively further radially inwardly removed (i.e. from a regular circular cylinder drawn through the diametrically opposed elements *a-d*) to provide sufficient relief against cutting friction as the bit

rotates. The angle $a-b-c$ of each circular tooth need not be obtuse (as seen in FIGS. 16 and 20). It may be right or even acute, so long as each of these teeth has sufficient material to have adequate strength under its continuing work load, and so long as there is sufficient area of egress for the shavings produced by the routing.

Likewise, it does not matter what is the specific shape of the line $b-c$, or $a'-c'$ or $b'-c'$ of the inner teeth.

Each of the lines $a'-b'$ does not lie on a diameter of the bit. Instead in going from the point a' to its end b' , such line $a'-b'$ is offset in a direction away from a diameter drawn through the line $a'-a'$ (i.e. toward the point c') and to an adequate amount to provide a sufficient angle of rake for such inner tooth. The teeth of each set advantageously should be laid out diametrically opposite one another. Then a tooth of each set should be spaced from one of the other set to provide substantial balance during rotation, thereby during routing to avoid any unnecessary vibration or strain on the router bit in its continuous rotation over long periods of service.

The diameter taking in the opposed points $a-a$ of the special router bit can be equal to twice the difference between (i) the thickness of the door and (ii) the practical thickness (i.e. reliability to resist easy breakage in handling) of the flange between the outer edge of long side of the door and the nearest tangent to the semi-circular shape of the recess produced by the special router bit parallel to that edge of the door. Such flange thickness can be from one-eighth to about a quarter of an inch. Hence, for a door of one and three-eighths inches thickness, the greatest diameter across the special router bit can be from about two and one-quarter inches to perhaps at most two and one-half inches.

Such a special router bit can provide complementary recesses (i.e. a pair having one in the door and the other in the correspondingly adjacent position in the jamb) of a length of from about two and one-quarter inches to perhaps at most two and one-half inches along the length of the door.

In routing such a pair of complementary recesses, the special router need only be moved repeatedly in a single direction (i.e. from and to a door and jamb and back) and advanced into them only far enough to provide the required recess depth. In other words, no motion in either direction along the length of the door or jamb is needed with this special router. Thereby it provides semicircularly shaped recesses to accommodate butt hinges with each leaf having a semi-circular outer periphery.

Stud 198 is not an absolutely essential part of the special router bit, for in its essential requirements it is complete without the stud. The stud serves only as a convenient connecting link to facilitate ready attachment of the bit to a motor by engagement of the stud by a chuck or collet at the operating end of the driving motor shaft. However, use of a stud is of considerable convenience because whenever the router bit teeth are sufficiently worn down to require changing, it readily can be removed from the stud and another such router bit head body substituted for it.

The expression a "building door" used herein in the appending claims embraces any door to be mounted in a door frame and for use in any part of any building, through the doorway of which door a person can walk.

While the invention has been explained by detailed description of certain specific embodiments of it, it is understood that various modifications and substitutions can be made within the scope of the appended claims which are intended also to include equivalents of the specific embodiments.

What is claimed is:

1. Apparatus for use in preparing in a building door and in a side jamb for a door frame wherein such door is to be hung, adjacently positioned hinge leaf recesses so aligned in pairs with a leaf recess in the door adjacent one

in the jamb, thereby to enable fittingly inserting in each such pair of adjacent recesses the leaves of a butt hinge; which apparatus comprises a table having a platform frame;

5 means engaged with said table for supporting a door flatwise with its length over the length of the platform frame and one long edge of the door adjacent a long edge of the platform frame;

10 means engaged with the table for supporting a door jamb on one long edge of the jamb and adjacent said long edge of the door and with the outer surface of the width of the jamb positioned perpendicular to the door and in alignment with the respectively adjacent long edge surface thereof and also adjacent the same long edge of the platform frame;

15 a mechanism enabling routing hinge leaf recesses in the aligned long edge surface of the door and outer surface of the adjacent jamb, said routing mechanism including

20 a motor;

a router bit operatively connected to said motor;

a carriage for carrying said motor relatively movably connected to it;

25 supporting means engaged with said table for supporting spaced standards adjacent said long edge of the platform frame; spaced standards supported by said supporting means and extending adjacent said long edge of the platform frame and vertically outside of the vertical projection of the door when it and the jamb are aligned as aforesaid, and serving as a vertical guideway for said carriage;

30 said carriage being slidable vertically along said guideway to any selected elevation thereon;

35 means to enable moving the carriage selectively within a separately selected vertical distance along the guideway as the routing is being carried out;

40 mounting means for carrying said motor relatively movably connected to said carriage to move vertically with it as it moves along said guideway, said mounting means including means to hold the motor so positioned relatively to the carriage that the routing end of the router bit extends horizontally from the motor toward the door and jamb and for horizontal movement toward and away from the door and jamb, thereby to enable the routing bit to rout recesses in the edge of the door and the aligned adjacent surface of the jamb.

45 2. Apparatus as claimed in claim 1, wherein the mounting means for carrying the motor relatively movably connected to the carriage further includes means enabling shifting the motor in either direction sidewise parallel to the long edge of the platform frame.

50 3. In combination with a platform for supporting a door flatwise thereon and for supporting a door jamb on one long edge of the jamb and perpendicularly to the door and adjacent a long edge thereof, with the outer surface of the jamb positioned in alignment with its respectively adjacent long edge surface of the door, and adjacent a long edge of the platform;

55 a mechanism which enables routing recesses in the aligned long edge surface of the door and adjacent outer surface of said jamb, said routing mechanism including

60 a motor;

a router bit operatively connected to said motor;

a carriage for carrying said motor relatively movably connected to it;

65 supporting means borne adjacent said long edge of the platform for supporting spaced standards adjacent to the adjacent long edge of the platform;

70 spaced standards supported by said supporting means and extending adjacent said long edge of the platform and vertically outside of the vertical projection of the door when it and the jamb are aligned as aforesaid,

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and serving as a vertical guideway for said carriage, and also serving as well as a means whereby to enable aligning said door and jamb as aforesaid; said carriage being directly slidable vertically along said guideway to any selected elevation thereon; holding means to enable moving the carriage selectively within a separately selected vertical distance along the guideway as the routing is being carried out; mounting means for carrying said motor relatively movably connected to said carriage to move vertically with it as it moves along said guideway, said mounting means including means to hold the motor so positioned relatively to the carriage that the routing end of the router bit extends horizontally from the motor toward the door and jamb and for horizontal movement away from the long edge of the door and jamb to miss them when the carriage is at a level which places the bit at an elevation opposite either of them; and said mounting means also including means enabling directly shifting the motor and its routing bit operatively connected to it horizontally toward and away from the door and jamb, thereby to enable the routing bit to rout recesses in the edge of the door and the aligned adjacent surface of the jamb.

4. In combination with a platform for supporting a door flatwise thereon and for supporting a door jamb on a long edge and perpendicularly to the door and adjacent a long edge thereof, with the outer surface of the jamb positioned in alignment with its respectively adjacent long edge surface of the door, and adjacent a long edge of the platform; a mechanism which enables routing recesses in the aligned long edge surface of the door and outer surface of the adjacent jamb, said routing mechanism including a motor; a router bit operatively connected to said motor; a carriage for carrying said motor relatively movably connected to it; supporting means borne adjacent one long edge of the platform for supporting spaced standards adjacent to the adjacent long edge of the platform; spaced standards supported from said supporting means and extending adjacent the ends of said long edge of the platform and vertically outside of the vertical projection of the door when it and the jamb are aligned as aforesaid, and serving as a vertical guideway for said carriage, and also serving as well as a means to enable aligning said door and jamb as aforesaid; said carriage being directly slidable vertically along said guideway to any selected elevation thereon; holding means to enable holding the carriage selectively at a separately selected elevation along the guideway as the routing is being carried out; mounting means for carrying said motor relatively movably connected to said carriage to move vertically with it as it moves along said guideway, said mounting means including means to hold the motor so positioned relatively to the carriage that the routing end of the router bit extends horizontally from the motor toward the door and jamb and for horizontal movement away from the long edge of the door and jamb to miss them when the carriage is at a level which places the bit at an elevation opposite either of them; and said mounting means also including means enabling directly shifting the motor and its routing bit operatively connected to it horizontally toward and away from the door and jamb, thereby to enable the routing bit to rout recesses in the edge of the door and the aligned adjacent surface of the jamb.

5. In combination with a platform for supporting a door flatwise thereon and for supporting a door jamb on a long edge and perpendicularly to the door and adjacent a long edge thereof, with the outer surface of the jamb positioned in alignment with its respectively adjacent long edge surface of the door, and adjacent a long edge of the platform; a mechanism which enables routing recesses in the aligned long edge surface of the door and outer surface of the adjacent jamb, said routing mechanism including a motor; a router bit operatively

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connected to said motor; a carriage for carrying said motor relatively movably connected to it; supporting means borne adjacent one long edge of the platform for supporting spaced standards adjacent to the adjacent long edge of the platform; spaced standards supported from said supporting means and extending adjacent the ends of said long edge of the platform and vertically outside of the vertical projection of the door when it and the jamb are aligned as aforesaid, and serving as a vertical guideway for said carriage, and also so extending from below to above the levels of the door and jamb and thus to serve as well as a means to enable aligning said door and jamb as aforesaid; said carriage being directly slidable vertically along said guideway to any selected elevation thereon; holding means to enable holding the carriage selectively at a separately selected elevation along the guideway as the routing is being carried out; mounting means for carrying said motor relatively movably connected to said carriage to move vertically with it as it moves along said guideway, said mounting means including means to hold the motor so positioned relatively to the carriage that the routing end of the router bit extends horizontally from the motor toward the door and jamb and for horizontal movement away from the long edge of the door and jamb to miss them when the carriage is at a level which places the bit at an elevation opposite either of them; and said mounting means further including means enabling shifting the motor in either direction sideways parallel to the long edge of the platform, and also including means enabling directly shifting the motor and its routing bit operatively connected to it horizontally toward and away from the door and jamb, thereby to enable the routing bit to rout recesses in the edge of the door and the aligned adjacent surface of the jamb.

6. Apparatus as claimed in claim 1, wherein the router bit has on its outer face perpendicular to its axis of rotation,

(i) a pair of diametrically opposed similarly shaped and similarly outer positioned substantially triangular cutting teeth with the leading cutting edge of each of them parallel to said axis being based in the periphery of the circle of longest diameter outlined by the outermost point on said face, and the trailing outer face of each of which teeth recedes backwardly from said leading cutting edge away from a cylinder traced by the rotation of said edge to provide adequately practical clearance; the inner cutting edge perpendicular to said leading cutting edge at the leading cutting point forming a sufficient angle of rake with the diameter passing through the leading point of both of said outer positioned teeth; and the face bounded by the outer face and inner cutting edge and the trailing edge joining them also receding toward said first mentioned outer face in a direction backwardly from the leading cutting point to provide an adequate practical clearance; and

(ii) a pair of diametrically opposed inner teeth triangularly shaped alike and being similarly positioned relative to one another with each of them spaced apart from both of the outer pair of teeth to alternate with them; and with the body of each of the inner teeth being positioned within and spaced away from the periphery of a circle traced by the diametrically opposed leading cutting point of each of them, said circle being at least coincident with the circle traced by the inner end of the inner cutting edge of each of the outer teeth and at most only overlapping it by a distance radially significantly less than half of the largest thickness radially of an outer tooth; the leading cutting edge of each of the inner teeth being located as to the rest of such tooth in the same way as the leading cutting edge of each outer tooth is located as to the rest of the outer tooth; the inner cutting edge of each inner tooth being perpendicular

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to its leading cutting edge and being spaced away at an acute angle from the outer end of a radius through its leading cutting point adequate to provide a sufficient angle of rake for its inner leading cutting edge; and the trailing plane through said last cutting edge and extending away from it receding progressively further away from the plane traced by rotation of said edge sufficiently to provide adequate practical clearance.

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