Entry Doors

Frame-and-panel construction is sturdy, handsome

by Ben Davies

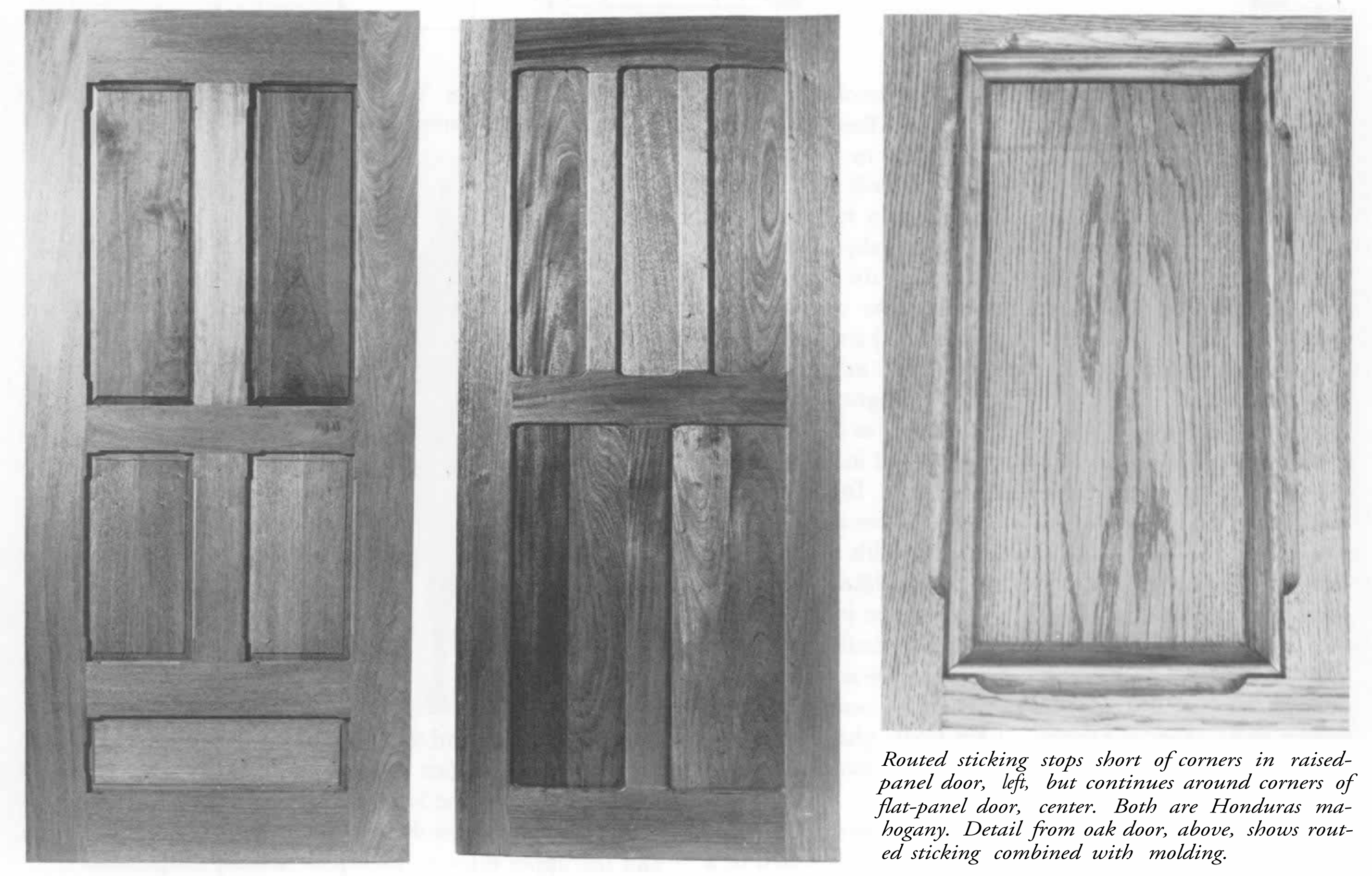
Exterior doors are the problem child of architectural design. They are required to perform three functions: seal off an opening from the exterior air, open to allow passage and then reseal, and be attractive. All this from wood, a material that can change in size as much as an inch over the width of a typical opening. While each of these functions might be separately accomplished with ease, their combination into one design creates problems.

Single-panel board-and-batten constructions of edge-glued lumber are generally too unstable for exterior doors. They cast or wind unless great care is taken in the selection and seasoning of the lumber. They also expand and contract so much with the seasons that sealing against the weather is impossible. These shortcomings can be overcome by using frame-and-panel construction and, in fact, most doors are made this way. The style is relatively stable and offers great flexibility of design. Even the familiar commercial veneered doors are a variation of the frame and panel—the panel is reduced in thickness to veneer and glued over the frame rather than inserted into grooves, and cardboard honeycomb or wood cores support the veneer. These doors succeed admirably in the first two functions a door must perform, but fail miserably at being attractive.

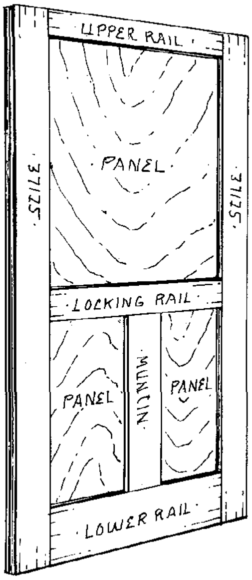
The frame-and-panel door has been in use for so long that its construction is well understood, and variations on its designs have been thoroughly explored. When any construction method remains dominant for hundreds of years it can mean only that it works quite well.

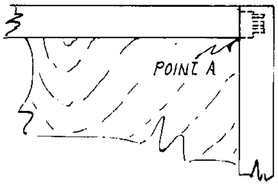
The standard size for entrance doors of new construction in the United States is 3 ft. wide by 6 ft. 8 in. high. A walnut door of this size can weigh 80 lb. to 100 lb. or more, depending on the thickness of the panels and the amount of glass. This is considerably heavier than a softwood or hollow-core door of the same size, and great care must be taken to ensure that the joints are well designed and well constructed.

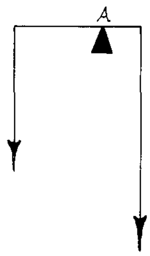
I have seen a number of doors fail that were constructed



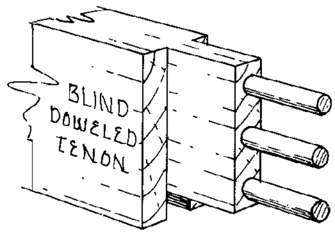
Routed sticking stops short of corners in raised-panel door, left, but continues around corners of flat-panel door, center. Both are Honduras mahogany. Detail from oak door, above, shows routed sticking combined with molding.



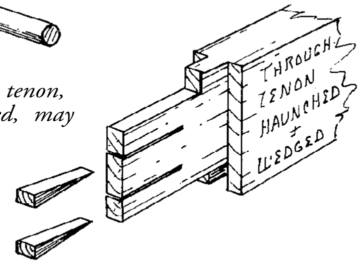




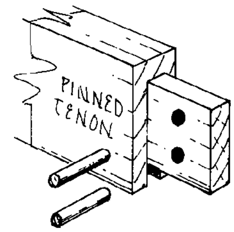
Left, the parts of a door; right, a diagram of the forces involved. In effect, the entire weight of the door is transmitted to the hinge stile through point A. *Every pound of door weight adds five pounds of strain to the tenon on the hinge side.*



Machine-made tenon with blind dowels, left, is as strong as traditional haunched and wedged joint.



Handmade through tenon, haunched and wedged, may eventually protrude.



Seasonal movement and stress may split pinned tenon along grain, making holes into slots.

with a mortise-and-tenon joint pinned through the cheek with dowels. A stronger joint is one with blind dowels inserted into the end of the tenon and bottom of the mortise. I use a 3-in. deep mortise and tenon with three or more 1/2-in. diameter blind dowels to join the stiles with the rails. Interior parts of the frame, such as muntins, are joined to the rails with smaller tenons, usually made to fit the groove cut for the panels, and are also blind-doweled. For flat panels I ordinarily use a 1/2-in. deep groove in the rails and a 3/4-in. deep groove in the stiles. This difference is to compensate for the greater shrinkage that occurs across the grain of the panels.

Several factors make blind dowel pins preferable to through-the-cheek pins. The first is visual. Dowels through the cheek are often chosen because they give the same sense of rigidity to frames as dovetails give to casework. While they do make a door look sturdy, the time will surely come when that particular effect is not wanted.

More importantly, I believe the blind-doweled tenon to be stronger than one pinned through the cheek. A tenon with blind dowels need not be haunched because the dowel pins not only make the tenon effectively longer, but also transform a stub tenon into a haunched tenon. Thus the glue area of the tenon becomes about one-third greater. And a stub tenon can be made more quickly than a haunched tenon.

Dowels perform two main functions. One is to prevent the tenon from sliding out of the mortise and the other is to counteract the bending moment of the weight of the door about the point where the tenon enters the stile. The lever arm through which the through-the-cheek dowel must act is necessarily about 3/4 in. shorter than that of the blind dowels. In a 3-in. tenon this difference translates into 25% greater strain on the pins. It is very important to understand that on a 36-in. door with stiles 6 in. wide, every pound of door weight adds about 5 lb. of strain to the dowels on the hinge side of the door. The wider the door and the narrower the stiles, the more intense the leverage. The maximum length of a through-the-cheek dowel is the thickness of the door, while the blind dowel can be twice as long as the width of the stile minus the tenon length. The extra dowel length is significant because part of the glue line between the dowels and their holes is end grain joined to long grain.

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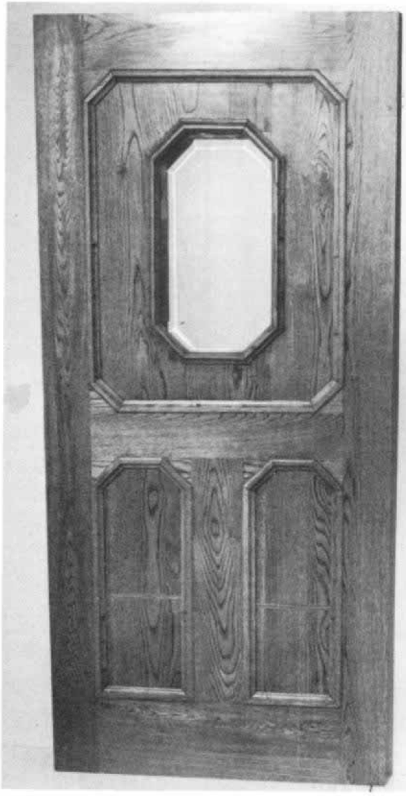
I have not discussed the through wedged tenon because this joint must be made by hand, a relatively time-consuming operation. However, the joint is strong, although in the long run the tenon will protrude slightly from the stile.

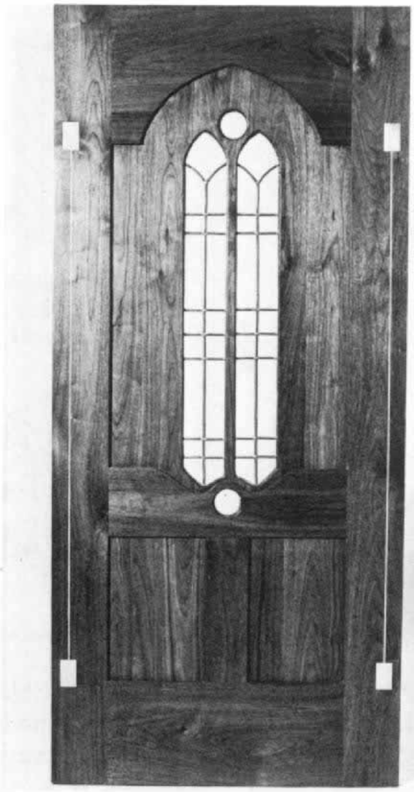
The total strength of a blind doweled mortise-and-tenon depends on two factors: the shear strength of the glue line that joins the cheek of the tenon to the wall of the mortise, and the lesser of the tensile strength of the wood in the dowels and the shear strength of the glue line around the dowels. The dowel joint is strongest when the outside dowels are as far apart as possible without getting so close to the end that the tenon is split by hydraulic pressure from the glue.

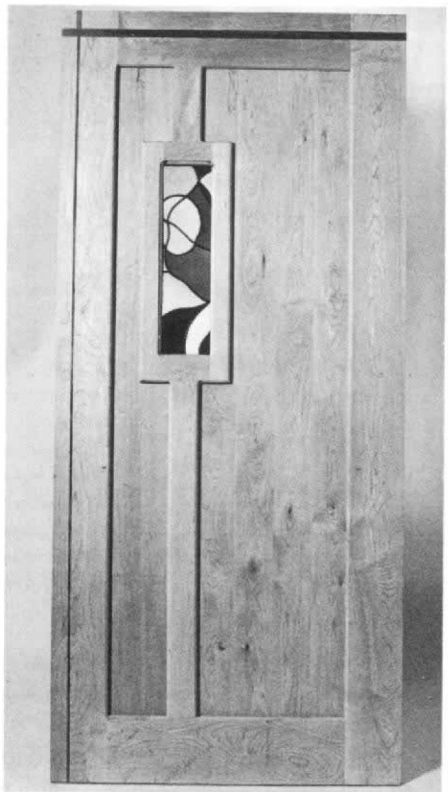
A mortise and tenon can be strengthened by increasing the size of the tenon, thereby increasing the glue area. The thinness of the glue line is also quite important—the thinner the better. The smoother the walls of the mortise and the sides of the tenons, the better the adhesion of glue to wood. I use a chain mortiser to make the mortise, and for the tenons, either a tenoning jig on the table saw or a single-end tenoner, which cuts with a cylindrical head like a jointer. But the tools used are not as important as getting a close fit.

While the decline and fall of Western civilization is widely anticipated, these things do take time, and until the event actually occurs there are few circumstances in which a door will be exposed to moisture other than that which is in the air. Therefore I generally use aliphatic resin (yellow) glue on doors that will be protected by a porch. This glue has worked out well in practice. In order to be classified "waterproof," a glue joint must withstand boiling water for some hours without losing strength. If you plan to boil your doors, phenol resorcinol glue is what you want. No matter what glue is used, be sure to seal both ends of the door with polyurethane varnish, even if the door is to be delivered unfinished. This is often neglected by the painter.

Wooden panels for a door can be flat or raised. Raised panels are somewhat easier to fit, because with flat panels the fit







Federal law requires manufacturers to use tempered glass, but permits leaded glass panels as long as no single piece of glass is larger than 30 sq. in, and no opening is large enough to pass a baseball. Beveled octagonal glass, left, is a framed panel within a panel.

must be precise—very nearly tight enough to split the stile or rail but not so tight as to actually do it. Something can be gained by slightly tapering the edge of a panel by a hand plane or belt sander but this requires a very light touch. Any irregularity or dip left by the plane will show up distinctly where the panel enters the frame. When using panels of glued-up stock, it is a good idea to design the door so that no panel is wider than about 12 in. This is particularly true where there is a cutout in the center for glass. If the panel and glass fit tightly, the wood of the panel may split at its narrow point when contracting, rather than moving in its grooves. Of course, don't fragment a design just to obtain narrow panels.

If a wide panel is necessary, flat-cut veneer over plywood will give great stability. Or large panels themselves can be made up as another frame within the frame of the rails and stiles, if the changing grain directions do not do violence to the design. A number of coats of polyurethane varnish on the door will inhibit the transfer of moisture from wood to air and reduce the shrinkage-expansion oscillations.

Often an integral part of the doors I design is a piece of stained glass that is curved or in some other way not rectangular. Installing the glass in the irregular opening can be a problem. The easiest solution is to let the glass into a groove when gluing up the door, in the same manner as for a wooden panel. This is quick and convenient, but impossible to repair. It is best to avoid this method unless the door is going to lead a quiet life in the interior of a mausoleum. Gentle curves can be glazed with moldings of steamed wood. First, a rabbet is cut with the router, then the glass is bedded in glazing compound, and finally the molding is steamed and put into place. I sometimes make a virtue of the necessity for fasteners to hold the molding and work brass screws into the design. Silicone caulk is excellent and long lasting, but it is also a glue and the window will have to be cut loose with a razor blade if it has to be removed. If curves are too acute for steam-bent wood, an extremely flexible brown plastic panel retainer can be used. It is available from Minnesota Woodworkers Supply, Rogers, Minn. 55374.

If neither steam bending nor plastics is appealing, you can use the band saw or sabre saw to cut a molding out of solid stock to fit the line exactly where glass and wood meet. This works well, but is time-consuming. Leave the stock 1/2 in. or more thick, make the cutout, then fashion some detail on the edge complementary to the sticking (the shape cut into the inside edge of the frame) on the door.

The sticking on all commercial doors is done so that the detail runs the full length of the stile. Its mirror image, called the cope cut, is then made on the shoulder of the tenon. The corner resulting when the door is assembled is a crisp line, much like that made by mitered molding.

The most economical way for a small shop to make these cuts is with matched coping and sticking cutters for the shaper. Knives can be purchased with standard copes and stickings already ground and many companies will grind a set to your specifications. I use a single-end tenoner with cope heads, which is somewhat more cumbersome to set up than the shaper but has the advantage of easily cutting a tenon as long as 3 in. and making the cope at the same time. Also, matching beading and coping bits are available for the router, and one could fashion a set of wooden hand planes to do the job. Skill and patience with hand tools can make a joint as well as a ton of machinery can, and also will lead one in the direction of simpler, less cluttered designs.

Relying on sticking to provide the detail on the inside edge of the frame works well if the panel design is rectangular and raised panels are used. However, when the design includes curved or flat panels, it is often better to eliminate crisp corners by cutting the sticking with a router after the frame is clamped up without the panels. The effect is to soften the corner, draw the eye away from the frame and emphasize the shape of the panels. Although subtle, the difference is important to the overall feeling of the door. Attention is diverted from the outline to the interior, for the most part unconsciously. Generally, soft corners are best suited to less formal designs, although this is not a hard-and-fast rule. Making use of this detail can be a powerful tool for the designer in trying to achieve a desired effect.

Moldings around the panels give a similar effect to conventionally cut sticking, but far more depth and detail are possible. The door can be made up with everything square and the moldings then glued into place. There is a problem here of wood movement, best solved by fastening the molding to the frame, leaving the panels free to expand and contract. Silicone-type glues will stretch a great deal while still holding their bond. Better yet, put the molding around the panel like a picture frame, with a channel or a tongue on its outer edge to fit to the door frame. No glue is needed to hold the panel or the molding in place.

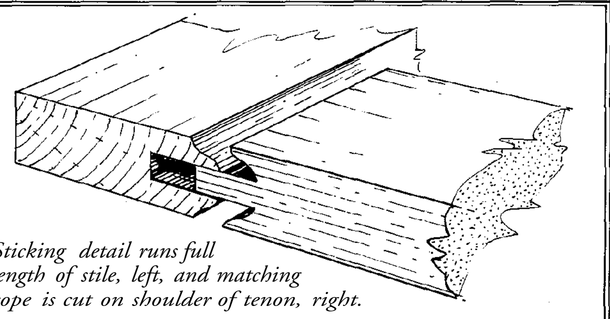
Lately I have been experimenting with a molding that is H-shaped in cross section, with excellent results. The open ends of the H are cut to fit the stiles and rails on one side, and to fit the thickness of the panel on the other.

It is difficult for me to say anything really useful about design because only its superficial aspects can be discussed meaningfully. Much nonsense is spoken and written in an attempt to intellectualize style and lump it together with technique. More often than not, good design is a matter of trial and error combined with the designer's ability to recognize those combinations of color and form that succeed and, just as important, those that do not.

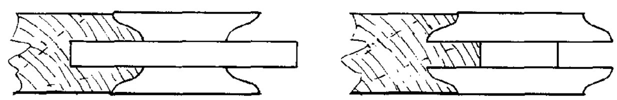
A number of design techniques, although they will not generate successful designs all by themselves, are nonetheless helpful from time to time. One of these techniques is to use a geometric form where possible rather than a free form.

Beveled glass takes on a multifaceted gemlike appearance when used in openings that are regular or irregular polygons. These same polygons around a free-flowing piece of stained glass give a visual reference that controls the curves on its interior. I suspect this explains why Art Nouveau was less successful in architecture than it was on a smaller scale. Its paintings were bounded by rectangular frames and its small objects and furniture by rectangular walls. Its architecture had no regular boundary and consequently appeared grotesque. Descriptions of space will go where they will but the human mind is Euclidean. And why should these geometric devices not succeed? Much of the diversity and beauty found in nature has as its foundation the geometric, crystalline structure of inorganic materials. A designer can do a lot worse than to mimic nature. At least it helps avoid appearing contrived.

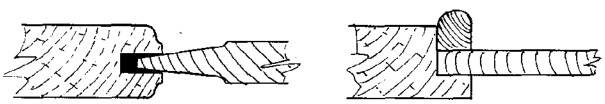
Another interesting tool comes from the arithmetic series 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, and so on. These are called Fibonacci numbers and each number in the series is the sum of the two preceding numbers. After the series has progressed for a while, the ratio between any two adjacent numbers stabilizes at 1.618. All this would be only of academic interest if someone had not noticed that the Parthenon fits neatly into a



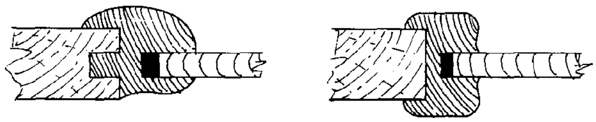
Sticking detail runs full length of stile, left, and matching cope is cut on shoulder of tenon, right.



Matched sets of shaper cutters make coping and sticking.



Panels are commonly held by grooves in rails and stiles, left, or in rabbet by applied molding, right.



Moldings with more depth and detail may be tongue-and-groove, left, or H-shaped in cross section, right.

rectangle whose width is 1.62 times its height; that the exquisite, logarithmically spiralled shell of the chambered nautilus can be generated with this ratio; that the proportions of some of Leonardo da Vinci's paintings, as well as those of Mondrian, seem to be determined by this ratio. A rectangle of this proportion, known as the golden rectangle, is frequently used in art and architecture. It has obvious applications to both doors and casework. Of course we do not want every rectangle to have these proportions, but it can be helpful to know the relationship.

These examples do not begin to scratch the surface. They are from one category of one mode of our awareness. That is, they are visual and oriented toward form. Within the visual mode there are also techniques for generating color and texture. And most often neglected are the other senses: smell, touch and hearing. The interplay and blending of techniques with a material as diverse in its nature as wood allows limitless possibilities for design.

And yet, when a door or piece of furniture succeeds, it is due to the designer's sensitivity rather than to manipulation and awareness of techniques. In much of the work where the golden rectangle has been found, the designer was unaware of the mathematics involved; the proportion just *looked* right. No doubt it is very easy to do a perfectly hideous piece based on the golden rectangle, or on any geometric figure for that matter. Techniques are just toys with which to play—they do not guarantee good design. Good design is simply done, not generated by formula.

The Right Way to Hang a Door

by Tage Frid

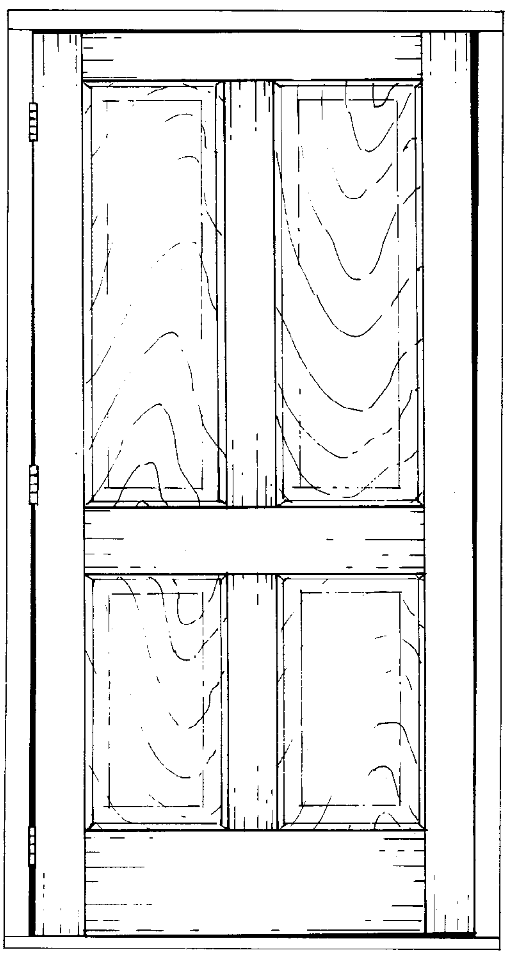
When I make a door I first make the doorcase (frame). I make the inside of the doorcase 3/16 in. larger in height and width than the door itself. If the door is to be painted, I allow a little more for the paint. I bevel the edges of the door a little toward the closing side, so that if dirt or paint should fill up the corners of the frame, the door will still close tightly.

If I am using two hinges, I place them approximately one-sixth of the height of the door in to the center of the hinge. With three hinges, I center one and move the other two out closer to the top and bottom. The hinges should be mortised half into the door and half into the frame. Here is where the mortising plane *(Fine Woodworking,* Fall '77, p. 18) comes in handy, as it will fit into the lip of the frame.

When fitting the hinges to the jamb, inlay the top hinge so that the door will fit tightly against the jamb when it is closed. But inlay the bottom hinge a little less, so there will be a gap of 1/8 in. or so in the back. Setting the hinges this way will leave the whole door cocked at a slight angle, which is much exaggerated in the drawing. The space will not be the same the whole way around. I do this because as a hinge starts wearing the door will begin to droop down. Hinges set as described will allow for this droop and the door will fit much better throughout the life of the hinge. It is especially necessary to do this with modern stamped and rolled hinges. You can see in old doors that haven't been hung this way the extent to which drooping occurs.

When I install the door frame I have all the hardware—hinges, locks, latches—already installed in the frame. I use wood shingles as shims to level the frame and fasten the hinge side first. Then I hang the door into the frame, close it and shim it until I get the spacing I want all the way around the door. Then I fasten the rest of the frame to the studs on the wall.

If I really want to do it right, I use a door-frame dovetail on all four corners, with the pins in the horizontal pieces. The joint is designed so that when you fit the door you can make the frame narrower or wider without a gap showing. Also, if the door should shrink or expand, I can take the outside molding off and wedge in or shim out the door frame to fit the door without getting a gap and without having to plane the door and refit the hardware. And this joint is much stronger than the usual method of nailing the corners together.



Door hung askew, here exaggerated for clarity, allows for droop as hinges wear. Door-frame dovetail makes opening adjustable without ugly gaps. Drawing at right shows joint in widest position; three sections below show joint going together, fully closed and fully open. Bottom sketch shows how sloping tails on vertical pieces fit undercut between pins.