



BUILDING THE CALIFORNIA ACADEMY DRAWER to house pinned entomological specimens

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This paper details everything one needs to know in order to build the California Academy Drawer, including costs, purchasing, sawing, glass-cutting, assembly, wood-filling, sanding, varnishing, installing pinning bottom, and installing hardware.

The California Academy Drawer has some advantages over the other common sizes of drawer used for storing insect specimens in the U.S. (the Cornell drawer and USNM drawer). It is $\frac{1}{2}$ " thinner than the Cornell Drawer and $\frac{3}{8}$ " thinner than the USNM drawer, and is $\frac{1}{2}$ " wider front-to-back than the Cornell Drawer, so can accommodate more specimens in less space, at less expense, than those other drawers. The California Academy Drawer is much more commonly used than the USNM drawer. (The other drawers have a few advantages. The Cornell drawer and USNM drawers are thicker, and can accommodate unit trays with their own pinning bottoms, or a gigantic Goliath Beetle on a #7 pin, and the Cornell drawer has the slight cost advantage that 50% more of its hardboard bottoms can be sawed from a 4 X 8' sheet.)

I tried numerous methods of making drawers, including the tongue and groove method, router bit methods, pattern-routing methods, the foam O-ring method, etc. All of these methods work to some extent, but all also produce some flawed drawers.

The present article details another method I found which is relatively simple and nearly foolproof, and is the best low-tech method to produce a perfect-fitting drawer every time, even if the wood sides used to construct the drawer have major flaws (the top fits tightly on the bottom on all four sides, to greatly discourage the entry of pests such as dermestid beetles).

This paper goes into great detail about the procedures. The reader might think that this tedious detail is excessive, even "anal-retentive" as the slang expression states. But woodworking involves a set of detailed skills, rather than exciting intellectual theories, and the better you master those skills, and the more meticulous you are, the better your drawers will be. The little details of the procedures make the difference between a mediocre and an excellent result. Learning and sticking to perfected efficient procedures actually saves time and effort in the long run; proper procedures lessen the time spent searching for parts, trying to remember what you are doing, and the time spent sanding, wood-filling, repairing, making replacements, cleaning up glue, and fixing all the other mistakes that happen when you use poor techniques. Good saw blades and sawing techniques make nicer cuts that require less sanding and wood-filling and finishing. Good tools and jigs etc. greatly increase productivity. Ideas and theories are useful in woodworking, but only to design procedures and jigs and tools; once you have developed a procedure, you must perfect it and memorize it so you can repeat it flawlessly without wasting time thinking. When you start making drawers and inevitably encounter problems, you will appreciate these detailed procedures.

Materials and Expenses

Glass. The glass should be single strength, 16 X 18" or a little larger in size.

1/8" Hardboard. The hardboard bottom should be sawed 16 X 18" or a little larger in size. There are dozens of kinds of hardboard, and hardboard stated to be 1/8" actually varies enormously in thickness. Hardboard that is smooth on one side and fuzzy on the other, about 0.123-.131" thick, and non-tempered, will work. However, hardboard that is smooth on both sides is better, because it warps less, and thus is slightly less bothersome to fit into the hardboard groove during box construction (although you quickly learn to deal with warping), and it sheds fewer fibers during painting (the paintbrush transfers some fibers to the rest of the drawer where they have to be wiped/scraped off). Tempered hardboard is harder and more waterproof. Hardboard that is 0.140" or even thicker can also be used, but adds a bit more weight, and the hardboard groove may have to be sawed wider. The preferred hardboard would be about .131", smooth on both sides, and tempered.

5/8" Baltic Birch Plywood. This plywood is made in 5 X 5' sheets, which should be sawed into sixths (about 20" X 20"), which should be sawed into pieces 2.72" X 20". Those pieces are trimmed to 2.64" width, dado-sawed to make a recess for the flange, sawed to make a glass groove, sawed to make a hardboard groove, then miter-sawed into approximately 17" and 19" lengths. The drawer is then assembled.

1/4" Baltic Birch Plywood. This plywood also is made in 5 X 5' sheets, which should be sawed into thirds, each third should then be sawed almost in half, and these should be sawed into flanges measuring 20" X ~21/32". These flanges are rounded a tiny bit using a corner-rounding router bit. After the drawer is sawed apart, these flanges are individually sawed to length and glued into the dado recess of the bottom of the side, to form the flange that fits into the recess on top of the side.

Plastazote. Plastazote is currently considered to be the finest pinning bottom for entomological drawers, because it has a fine cellular structure, is easy to pin into, holds the pin well, and withstands many repeated pinnings at the same spot. The plastazote used is LD33, white, 3/8" thick.

Brass Drawer Pull/Cardholder Fixture. This fixture is 3 17/32" X 1 15/32" in size, and consists of a brass frame into which a card can be slipped from above, and the bottom of the frame is curled forward to form a pull tab. The fixture is screwed onto the front of the drawer using two small brass screws.

**Cost for Baltic Birch and Plastazote Drawer with Brass Pull/Cardholder Fixture
(wholesale prices, July-Dec. 2000)**

Glass, \$2.22 apiece.....	\$2.22
1/8" Hardboard, \$6.48 per 4 X 8' sheet.....	\$0.65
5/8" Baltic Birch plywood (four pieces), \$23.80/sheet.....	\$1.51
1/4" Baltic Birch plywood (four pieces), \$10.38/sheet.....	\$0.19
Plastazote, ~\$13.31 per 41 X 61" sheet.....	\$2.22
Brass Drawer Pull/Cardholder, \$9.60/dozen.....	\$0.80
Silicone, \$4./tube.....	\$0.20
Glue (Tightbond II), \$12./gallon.....	\$0.05
Nails, ~3¢/drawer.....	\$0.03
Polycrylic finish, \$24./gallon.....	\$0.22
Total per drawer.....	\$8.09

Dimensions (see Figures, and Table 1)

The finished drawer (ideal dimensions) is 19" wide, 17" front-to-back, 2 1/2" high. The top is 1" high, the bottom is 1 1/2" high on the outside, but inside a flange 1/4" thick and 1/4" high rises up to fit into a recess of the same dimensions in the top. The sides are 5/8" thick. Single-strength glass 16 X 18" is recessed 1/8" into a groove 3/16" deep that is 1/8" from the top of side. Hardboard 16 X 18" is recessed 1/8" into a groove 5/32" deep that is 1/8" from the bottom of side. Inside the drawer the height is 2" from glass to hardboard, and 1 5/8" from glass to the 3/8"-thick plastazote pinning bottom.

The hardboard can be sawed more precisely than glass can be cut, so the hardboard groove can be shallower, with less space reserved for glue, to make the hardboard fit more tightly and keep the drawer square.

The actual dimensions of the drawer are a little different from the above, because of technical specifications of the wood (actual Baltic Birch plywood averages only .582" instead of 5/8"), fine tuning of the flange height and top height, etc. Table 1 gives exact dimensions for five different options for the drawer. The depth of the glass groove and hardboard groove must be coordinated with the size of the glass and hardboard and the thickness of the sides. If 16 X 18" glass is used with sides that are less than 5/8", then the outside drawer dimensions should be less (about 16.96 X 18.96"), to permit the narrower .582" Baltic Birch sides to grasp the glass sufficiently. Flange height affects how tightly the top fits onto the bottom, and ranges from .25" in tight-fitting drawers (the dimension I use) to 3/8" in drawers so tight they must be pried apart with a putty knife (a flange height I use only in boxes without glass intended for storage of insect specimens inside envelopes). And height of the top may be lessened a bit to recess insect pins more into the bottom.

Before making your drawers, you should calculate the dimensions you want, because different materials have different dimensions. And buy the glass first, because it may be miscut, and then to use it you must adjust the other dimensions of the drawer.

The depth of the glass saw groove should be calculated together with the size of the glass and the thickness of the sides, because these all affect each other functionally. If you are sawing, jointing, and planing the wood sides out of rough lumber yourself, then make the sides 5/8" thick. If you are buying already-planed side boards, you must measure the thickness of the side boards you are using, because they will probably not be exactly 5/8" (the tradition in the lumber industry is to cheat on every thickness dimension, for instance the infamous 2 X 4 is only 1.5 X 3.5".) Now determine the depth of the glass groove you want to have (3/16" seems fine), and determine how far into this groove you want the glass to extend (1/8" seems fine); the remainder of the groove (1/16") is a space for silicone, to seal the joint against entry of pests, to provide cushioning for the glass, and to provide room to accommodate glass pieces that have been cut either too large or

too small. Now designate the outside dimensions of the drawer that you want (17 X 19"). For sides mitered at a 45° angle, the inside dimensions of the drawer are the outside dimensions – 2(thickness of sides). Using Baltic Birch, the sides are .582" thickness on average, so inside dimensions are 17" – 2(.582) = 15.836", and 19" – 2(.582) = 17.836". Now, if any of these measurements were non-standard, calculate the size of glass and hardboard that you need. The glass length = the length of the drawer side – 2(side thickness – glass groove depth + silicone space width). Using Baltic Birch and a glass groove depth of 3/16" and a silicone space of 1/16", the glass size (lengths) should be 17" – 2(.582" – .1875" + .0625") = 16.086", by 19" – 2(.582" – .1875" + .0625") = 18.086". The same equation applies to hardboard, so the hardboard length = length of the drawer side – 2(side thickness – hardboard groove depth + glue space width). With Baltic Birch and a hardboard groove depth of 5/32" and a glue space of 1/32", the hardboard length should be 17" – 2(.582" – .15625" + .03125") = 16.086", and 19" – 2(.582" – .15625" + .03125") = 18.086".

You could saw the hardboard that size yourself, but a glass company might not want to cut glass to that odd dimension, so we could let them cut glass to 16" X 18" size, and similarly saw the hardboard to those dimensions, and adjust the drawer side length and glass groove dimensions to accommodate that size glass and hardboard and the .582 side thickness of Baltic Birch. We can rearrange the above equation, and compromise and use a glass groove depth of .13" and a silicone space width of .03". The drawer side length = glass length + 2(side thickness – glass groove depth + silicone space width). So, drawer side lengths should be 16" + 2(.582" – .13" + .03") = 16.964", and 18" + 2(.582" – .13" + .03") = 18.964". The equation for hardboard is the same, and we can use a hardboard groove depth of .10" and a glue space of .03". Drawer side length = hardboard length + 2(side thickness – hardboard groove depth + glue space width). So, drawer side lengths should be the same as for the glass, 16" + 2(.582" – .13" + .03") = 16.964", and 18" + 2(.582" – .13" + .03") = 18.964". The inside lengths of the drawer sides are the outside lengths minus twice the thickness of the sides, or 16.964 – 2(.582) = 15.80", and 18.964 – 2(.582) = 17.80". Now, assess the glass-holding capability of this groove by calculating three distances that represent how much the glass can move or escape from the drawer. The minimum distance between opposite glass gooves is the inside lengths of the sides, 15.80" and 17.80"; the glass is 16 X 18", much larger than this minimum, so no problem here. The maximum distance between opposite glass gooves is the distance between the maximum depths of the glass groove on opposite sides, which is the inside lengths of the sides plus twice the glass groove depth, or 15.8 + 2(.13) = 16.06", and 17.8 + 2(.13) = 18.06"; these distances are plenty large enough for this size glass and even for miscut glass that is .06" too large. The gap misfit is the distance from the inside of one side to the depth of the glass groove on the other side, which indicates whether the glass can slide so far into one groove that it comes out of the opposite groove; this distance is the inside lengths of the sides plus the depth of the glass groove, or 15.8 + .13 = 15.93", and 17.8 + .13 = 17.93"; thus the glass would have to be miscut to less than 15.93" or 17.93" for this problem to occur.

You could compromise and use Baltic Birch .582" thick, but have the glass cut larger to 16 1/16" X 18 1/16", and use a silicone space of 1/16", in which case the glass groove depth calculates with the above equation to .17575" (a bit less than to 3/16" = .1875"), so we could just saw the glass groove to almost .18". Likewise, we could saw the hardboard to 16 1/16" X 18 1/16", and the depth of hardboard groove, if we use a 1/32" glue space, then calculates to .1445", so we could saw it to a bit more than .14. (Table 1.)

Better still, if you could get the glass cut to 16 3/32" X 18 3/32", you could use a silicone space of 1/16" and glass groove depth of .19", hardboard 16 3/32" X 18 3/32" and a hardboard glue space of 1/32" and hardboard groove depth of .16" (Table 1).

Calculate all these things for the thickness of the wood sides and the size of the glass you want to use, and if you don't like the glass-holding capability of your glass groove, estimate another glass groove depth or change the sizes of your sides or glass, until you find the dimensions you want to use. Calculate the depth of the hardboard groove, for the side board thicknesses and hardboard and drawer dimensions you want.

Methods of Making Drawers

The goal in making entomological drawers is to produce a tight-fit, with no spaces around glass or between top and bottom that would allow pests to enter or fumigants to exit. The Ceylon Dermestid has recently spread to museum collections, a very small beetle that can enter drawers that formerly were good enough to keep out pests. More than ever before, a tight fit, rather than ease of production or slickness of varnish, must be the goal.

The main discovery that I made in making drawers is that the four-piece-side method is greatly superior to the eight-piece-side method in producing a tight-fitting drawer. **Four-piece-side drawers** are nailed/glued together from four sides (plus glass top and hardboard bottom), and are then sawed apart to create a top and a bottom, and then a flange is made to create a press fit between top and bottom. This method produces a virtually perfect tight fit of top onto bottom on every drawer, because the alignment of top and bottom is nearly identical. (The alignment is identical because top and bottom share the same alignment before being sawed apart.)

Eight-piece-side drawers, in contrast, are nailed/glued together from eight side pieces (the top and bottom of each of the four sides) (plus glass top and hardboard bottom). These drawers often work satisfactorily, but often do not fit perfectly, because it is very difficult to align the top pieces with bottom pieces while simultaneously gluing and fitting them onto glass and hardboard and gluing all the corners together, and one slight misalignment on one corner amplifies itself all

around the drawer until the result is an ill-fitting second-class drawer whose top fits a little loosely onto the bottom, and may allow pests to enter. These drawers are a little simpler to make, and can be attractive cosmetically, so this is by far the commonest method used to make drawers, and is the only method used for commercial drawers.

The four-piece-side method has numerous advantages, including tightness of fit, and the ability of this method to make perfect drawers despite numerous flaws in the parts and construction of the drawer. Because the top is sawed off the bottom, they fit together nearly perfectly. The top would be completely identical in fit to the bottom if the saw blade width were zero and if the top and bottom boards had zero warping after the box is sawed apart. However, the saw blade is roughly 1/8" wide, creating a tiny bit of misfit if the side is not perfectly vertical (if you saw through a cone-shaped tower, the sawed place on the top will be a bit smaller than that on the bottom). And if the board had uneven stresses, and sawing it apart caused the top to warp a bit differently than the bottom, the fit would become slightly imperfect. However, the flanges installed in the bottom force the top to fit onto the bottom, and overpower any tiny misfit that might exist.

The four-piece-side method makes perfect drawers despite bad parts or poor construction. The top and bottom will fit well even if the sides are not the standard thickness, even if the sides are thin on one end and thicker on the other, even if the sides are thicker on the top and thinner on the bottom or vice-versa, even if the sides are warped concave or convex, and even if some of the corners are not perpendicular (because the drawer is not square either due to bad assembly or due to non-square glass or hardboard bottom). With all of these flaws, the top will fit well onto the bottom, simply because the top was sawed from the bottom. The four-piece-side method is also very tolerant of poorly-installed flanges: the top will fit on the bottom too tightly, but that is easily fixed by scraping/sanding the outer edge or top of the flange (my first few drawers sometimes had to be fixed this way, but now only ~2% of my drawers need to have a flange scraped). Thus the four-piece-side method is "foolproof"; I have made more than 500 drawers with the method, without a single failure or loose-fitting drawer; not one drawer has had to be junked (in contrast, I have trashed/recycled numerous drawers using other methods). It is a nice feeling to place the lid onto a drawer bottom for its first time, and have it fit perfectly and tightly.

With a lot of effort, the eight-piece-side method can be made to work. The first step should be to glue/nail only the bottom four pieces of the sides together with the hardboard. This task requires joining only four pieces (plus hardboard) together, which is much easier. Then, use the bottom as a template on which to build the top, by placing the four lid pieces (with the glass) onto the bottom as you glue/nail them together (remove the lid and excess glue after construction so the lid will not dry stuck to the bottom). Even better, you could even saw the top pieces to length only after you fit them onto the bottom and mark where to saw, which would help to prevent one slight goof magnifying around the drawer in the usual eight-piece procedure. Using this modified procedure, you should be able to match the corner joints of the top pieces with the bottom better, which should produce better results. Also, once the glue in lid and bottom dries, you can sand the outside until top matches bottom perfectly, and paint the entire drawer, inside and out, which will increase tightness of fit if the lid was a little loose, then if the lid is too tight you can scrape the flanges/recesses and repaint them until the fit is correct. Jack Harry (pers. comm.) paints the inside of drawer this way and uses the eight-piece-side method, and tells me he gets nice results, with a lot of work.

Other Methods of Making Drawers. The **tongue-and-groove** method often produces good drawers, but is not meant for producing really tight drawers, because the metal tongue and groove cutters available (inexpensive molding cutters from Craftsman, better molding cutters from Delta etc., shaper cutters) seldom match each other perfectly, and are generally sized for wood 1"-1 1/2"-wide rather than the 5/8" wood that entomologists use. And the sides of the tongue and groove are inclined instead of vertical, so that a slight warp allows top and bottom to separate and permits pests to enter. This method is unsatisfactory.

The **router bit** method works fairly well, using a cove router bit to shape the underside of the top of the side, and a matching-radius corner-rounding bit to shape the top of the bottom of the side; these milled edges are very pretty when the drawer is opened. But the top must be placed accurately onto the bottom for a tight fit, or the top may rest a bit ajar and thus create a space for pests to enter.

Using a **shaper** to form the recess and flange would also work fairly well most of the time. However, a shaper is expensive (\$1200. for a good one, and \$300. or more for each cutter), and it is difficult to find cutters that would work well because manufacturers do not make their cutters for this purpose.

Those tongue-and-groove/router bit/shaper methods are eight-piece-side methods, so all suffer from the problem of trying to assemble eight side pieces into a tight-fitting drawer. One can try to fit the top of side tightly onto bottom of side before those are joined to the adjacent side pieces, then proceed around the drawer until all is connected. But too often a little misalignment on one corner means that the next corner cannot be made perfect, and so the errors continue or even magnify all around the drawer, and the drawer lid then knocks a bit on the bottom because it is loose, and one wonders whether the dermestid beetles will enter and chew the specimens to dust.

Examination of the most popular U.S. commercial drawer reveals that it is apparently constructed using a four-piece-side method, using sides that have had a groove molded that later forms the recess around the inside of the top. The drawer is then glued and fastened (with bottom and glass) using V-nail fasteners, then the drawer is sawed apart using a special offset dado-like shaper cutter (that has a wide cutting face beside a narrow cutter that sticks out another 1/8") that

simultaneously forms the recess around the top of the bottom of drawer and cuts into the previously-molded groove a little to split the drawer apart. Then the bottom of the top appears to be sanded a little, so the whole method leaves cutter-edge marks on the top of the side, but not as much on the bottom of the top. That method works fine for quick commercial construction, but a V-nailer is expensive and the cutter and shaper are even more expensive, plus the splitting operation removes nearly 3/8" from the side of the drawer, so it wastes more wood and results in the wood grain not matching up too well on top and bottom. And if you practice and are careful, you can make drawers just as tight as those or even tighter using this paper's methods.

A promising method is to use a **router bit guided by metal patterns** made by a milling machine. In this method, an expensive (\$60,000.00) computerized (CNC) milling machine is used to machine two metal patterns: one pattern is used to make the recess on bottom of top of side (the pattern is clamped to the upper part of side, and a 1/2"-inch-diameter top-bearing router bit is used to make the recess, while the bearing on the router bit rolls against the metal pattern to guide the router bit), and the second pattern is used to make the flange on top of bottom of side (this pattern is clamped to the lower part of side, and the same router bit bearing rolls against metal pattern). When adjusted well, this method makes very fine drawers; however it is too sensitive to the diameter of the router bit, because the same router bit is used to cut the top and bottom and thus a variation in router bit diameter is magnified double in the final fit of the top to bottom, and this diameter varies between router bit manufacturers an astonishing amount (from .493" to .499 in router bits that are labeled "1/2"). Also, it is difficult to find router bits whose flutes are short enough to work, so one has to grind the existing ones down with a diamond wheel, or custom-order router bits. And if this special router bit hits one nail, it is ruined, which is quite aggravating. And the method is very sensitive to where you clamp the top and bottom onto their respective metal patterns, because a slightly mispositioned clamping means that the top recess still fits well onto the bottom flange but the outer walls of top and bottom are mismatched, producing an overhang or lip on the outside of the drawer that requires a lot of sanding to remove. Also, to clamp the bottom to the metal pattern you must drill four holes through the hardboard of the bottom for bolts to fit through, then clamp the hardboard to the metal pattern using wing nuts; these four holes must then be wood-filled and sanded. To avoid splintering the wood, all router bit methods require the use of the "climbing the walls" technique, moving the router the opposite direction that the books claim is safest, so the cutting edge moves toward the interior of the wood, which is more strenuous than the splintery direction. The safer easier method is not satisfactory because the cutting edge of the router bit moves from the interior to the edge of the wood, and knocks large splinters off the edge.

A better method than the pattern method would be to place the drawer itself directly into a **CNC milling machine** to mill the flange in bottom of drawer and mill the recess in top of drawer. This would work fine for the top, but the bottom would be a problem in clamping the drawer to the bed of the machine, because about 4 clamps would have to be used, one on each side, and each clamp would have to be removed to mill that side and then would have to be reinstalled before milling the next side. Or a vacuum clamping system or gigantic electromagnet would have to be developed to clamp the bottom to the machine. Time on these machines is expensive.

A **molding cutter method** might make excellent drawers. A molding cutter would be used to place a 3/8"-wide drawer-top recess groove, glass groove, and hardboard groove, into the inside surface of boards that would become the sides. (I am not sure that a molding machine is capable of making narrow sharp saw-like grooves such as a glass groove, however.) The molding machine would cut all three of these grooves at the same time, which would save a lot of time and labor. Large rubber wheels press the wood down in the molder as it runs through the machine, so the grooves would be a constant distance from the outside surface of the wood, even if the wood is warped outside the machine. The recess groove would be cut 3/8" from the outside of the board, a distance I will call A; and all three grooves would be at a constant distance from the outside of the board, making the width of the side boards less critical. Then the drawer would be nailed/glued together, making this a quality four-piece-side method. Then the drawer would be cut apart using a 3/8" wide dado-saw (two outside cutters and one 1/8" chipper make a 3/8"-wide dado cut) or shaper cutter (the same width cutter as used for the top recess), whose cut would also form the recess on bottom of drawer, with the depth of cut (distance B) being 3/8" plus .01", so that the dado saw/shaper cutter would simultaneously barely cut into the top recess groove to cut the drawer apart and would make the flange on bottom of drawer fit into the recess on top of drawer with .01" space between. To keep the depth of cut constant even if the board warped after removal from the molding cutter, a domed-up table saw insert could be used for the 3/8" wide dado saw blade that would perfectly cut even concavely-warped drawer sides; warped sides could be cut equally well with a shaper using a "rub collar" below the cutter, instead of a rip fence, or a convex rip fence below the cutter. And this groove would rise up into the top recess groove by .075", so that the top recess would be sawed down to .30" height and the flange on bottom of drawer would become .30" also. This method theoretically should work great. The fit of top to bottom of drawer would depend critically on the precise depths of both the top recess groove (A) and the shaper cutter groove (B), but one should be able to adjust these depths to perfection, and the use of a convex table saw insert/convex rip fence/rub collar should be able to fix misfit caused by warping of a side board. Perhaps one could use a 3/8"-wide shaper cutter to cut the bottom recess groove and watch the process through the glass top and somehow continuously adjust the cutting depth so that the cutter barely cuts through the side.

Schmitt boxes are often made by using a four-side-piece method with 3/8"-thick sides to build the box, then saw it apart, then install a 1/4" flange all around the inside of box (fastened to the lower part of side) that extends from bottom to top. This method would not work with a glass-topped drawer, because thicker side boards are needed on the top to provide enough strength after sawing the glass groove.

Another promising method is the **foam O-ring method**. The top of the drawer is merely a piece of glass, perhaps edged by some protective rim (tape or wood perhaps, because aluminum moldings are incredibly expensive), and this glass merely lays on top of the side, and all around the top of the side is a piece of very soft foam. The glass presses down on the foam to seal the drawer. An angle-iron flange on opposite corners of the bottom would serve to keep the glass in place. With the proper soft foam, the seal may be superior to any other kind of box. I tried this method using stiffer foam, and it did not work because the glass is not heavy enough to compress anything stiffer than soft foam.

Perhaps the most promising method is a plastic tray the size of a Schmitt box, manufactured by the million from a plastic injection mold, which is a steel contraption that would be created the usual way by using a CNC milling machine etc. The mold fits into a large machine, and melted plastic is injected into the mold, then the finished tray is ejected. The lid of the tray would be either a clear plastic rectangular sheet, or would be the bottom of a second identical tray, both of which would fit flat onto the top of the first tray to create a tight seal. Thus one could stack these trays and dispense with tops, and place a clear plastic top only on the topmost tray. Such plastic trays would cost only about 10¢ to manufacture, once the plastic injection mold was made, and the foam pinning bottom would cost another 20-50¢. The trays would serve as unit trays also, and would replace all the current storage devices now in use (California Academy Drawer, Cornell Drawer, USNM drawer, Schmitt Box, etc.). They would be so cheap that they would be disposable, and inexpensive 20-cent foam bottoms could be used since the tray is not required to last for hundreds of years. This system is what entomologists everywhere should have. But making the injection mold would cost me \$10,000.00+, and entomology is not a lucrative or popular pursuit, so sales of these trays would not be guaranteed.

Corner joints. There are many methods that could be used to join adjacent sides together. The box joint is time-honored, in which the end of each side has wood fingers that interdigitate into the next side to greatly strengthen the joint. Similar is the dovetailed joint, which has tapered fingers that are designed to make them difficult to pull out from the recesses in the adjacent side, that make an even stronger joint. The simplest method is to use a butt joint, and merely right-angle the ends of the boards and glue one to the other, which is strong enough for entomological drawers. The most common method is to miter the joint, angling each board 45° and then simply nail/glue them together. The miter joint is preferred for entomological drawers because it is simple to make and is pretty, and great strength is not needed for these lightweight drawers.

Obtaining, Cutting, and Cleaning Glass

The easiest way to obtain glass is to buy it in quantity from a commercial glass company. Glass cut by robotic machines at wholesale glass companies is best, because it promises to be more accurate. If one calls many glass companies listed in the yellow pages of the telephone book, one can eventually find a good price for large quantities (such as 300 pieces) of glass, a price only half the price for single pieces. However, purchased glass cut by humans may be cut too large or small by .11" sometimes, and may be non-square by that amount also. And you must tell them to cut it to the exact measurements you specify, or they may cut it 1/16" too small and assume that you will install it into a frame of the size you specified. Small quantities of cheap glass can be gotten inexpensively by recycling discarded glass, or buying ugly picture frames with glass at yard sales for \$1 or less. However, these recycled pieces are generally the wrong size, so one must cut them down, which is a skill that requires a lot of practice to perfect. Beware of glass in cheap picture frames that is thinner than single-strength glass and is unusable; cheap picture frames with narrow plastic or metal frames are often sold in 16 X 20" size using this too-thin glass. Avoid any glass stamped in the corner with "tempered" or "herculite" (including all glass from aluminum screen doors), because this tempered glass shatters into a million pieces when one attempts to cut it; occasionally tempered glass will not be marked at all. Glass a century old flows and becomes rippled, and is a little harder to successfully cut than newer glass.

Cleaning Glass. Commercial glass arrives covered with oily cutting fluid, dust, gummy adhesive from duct tape used to bind the sheets together, etc. Lacquer thinner is best for cleaning a big buildup of gummy adhesive. For ordinary grease and grime, the following formula has been published for decades in books by Heloise, and later by Consumer Reports, and works great. Use 1/2 cup sudsy household ammonia, 1 pint of 70% isopropyl alcohol, 1 teaspoon liquid dishwashing detergent, and enough water to make a gallon (the ammonia can be replaced by vinegar for less-dirty glass). Windex cleans glass fairly well also, but is expensive and probably is made using the same formula, with a bit of blue color added. Glass cleaner irritates the lungs when inhaled in airborne droplets from aerosol spray, so you should pour glass-cleaning fluid into a bottle with a single bent tube as dispenser, because the single stream of fluid minimizes airborne droplets (nice nalgene bottles with the squirter tube can be bought from chemical supply companies, or you can make your own by just forcing a hole into a polyethylene bottle cap with an awl/hole punch and then forcing a 1/4" copper tube into the hole, bending the tube, and pinching the tip of the tube mostly-closed with pliers to reduce the flow sufficiently). One can use detergent to remove grease, then an equal mixture of vinegar and water to remove streaks.

Place the glass onto a pile of half-a-dozen large newspaper sheets on a flat table. Squirt the fluid onto the glass, wad up a large sheet of newspaper, wipe the fluid over the glass, then rub it across the glass until the glass squeaks and is clean. The newspaper absorbs the fluid and dries off the glass, and absorbs the grime, so throw away the newspaper after a few pieces of glass and wad up the sheet from the top of the newspaper pile directly under the glass. Wipe off newspaper lint and remaining fluid with a towel. Turn the glass over and clean the other side. Wipe newspaper lint off the surface and edge of the glass with the towel.

Cutting Glass. To cut glass, one should buy an expensive (\$31.00) glass cutter which has a cutting wheel made of carbide that has a very sharp edge (cheap two-dollar cutters have a very rounded edge when examined with a magnifying glass, an edge that works poorly), and a reservoir of lubricating fluid in the straight handle above the cutting wheel. This reservoir is filled with ordinary motor oil (5W-30W, WD40, etc. is used by many professionals) or fluid containing ethylene glycol (the main ingredient in antifreeze) that is sold in an expensive little bottle with the cutter; these lubricating fluids evidently serve only to keep the shaft of the carbide cutting wheel turning freely. Wear safety glasses. Place the glass on a cushioning surface (newspapers work well) on a flat table. Clean the glass first, because it must be perfectly clean to successfully etch the line; run your finger over the line to be cut to make sure it is clean. Inspect the glass for cracks and scratches and chips. Use a drywall square to find a square corner you can keep in the finished piece, and mark that corner with a felt-tipped pen. Try to position the glass so that the finished piece will be square and the flaws in the glass will be cut off and discarded. Mark the ends of the cut with an accurate ruler and narrow felt-tipped pen. Mark the long width of the glass first (18" for instance), so that if you ruin that cut you can still cut it to the shorter length (16"); after you make the 18" cut; then mark and cut the shorter length (16") later. You can make the cut merely with a straightedge such as a long piece of plexiglass or a drywall square, but the cut will happen away from the edge of any straightedge, by a distance about half the width of your cutter tool, so you must take that into account. And when using a straightedge, your cutter might inadvertently wander away from the straightedge and ruin the cut (a problem that presumably seldom happens to experts, but it happened to me when I was learning). So you should make a straightedge jig out of 3/8"-thick clear plexiglass, 32" long X 7" wide, constructed out of four pieces of plexiglass, so that there is a slot exactly the width of the cutter tool about 2" from one edge. Two long plexiglass pieces hold the cutter between them, and two short pieces are glued to the ends of the long pieces to hold them in position. Place the cutter in the slot while you clamp the pieces to glue them, to make sure the slot is the right width. Special glue is needed for plexiglass, although acetone-based clear household glue seems to work okay. When your jig is made, place the jig over the glass, so that your felt-tip-pen marks are in the middle of the slot, place a large very heavy weight on the jig near you to keep it in place (I use a foot-long piece of railroad track) and press down on the far end of the jig with your hand to keep it in place, run the wheel of the cutter on the newspaper for a few inches to clean it (this is important, as the cut sounds and feels sharper with a clean wheel), hold the cutter like a pen and place the cutter wheel at the edge of the glass on the far end of the cut, and press down on the cutter with moderate force as you quickly and evenly run the cutter along the glass and straightedge. The cutter should make a slight scratching/hissing sound as it etches the glass, and make an etched line that is easily visible. If you press too hard, the etched groove will be a noticeable valley with cracked slivers of glass running along it, which will not make as perfect a break as if you pressed lighter. However, pressing too hard is a little better than pressing too lightly and missing some spots, which might cause the glass to break away from your desired line. Clean the etched line with rag/paper tissue and inspect the etched line to see if it is complete. If you miss a spot you can carefully redo that spot, but do not roll the wheel on an already-etched groove. You must not try to make a cut that is less than two glass thicknesses from the edge of the glass, or the attempted cut will wander over to the edge (an expert can often make this cut). Some people then go over each end of the cut with the cutter to make sure the ends are etched, but this does not seem necessary. Now, place the glass on a solid table with a sharp edge, place the edged groove directly above the sharp edge of the table, with one hand press down on the glass near the etched line to hold it onto the table, with the other hand grasp the glass in the middle of the edge to be removed, and snap the glass quickly down, to snap off the unwanted portion. There are many other methods of breaking the glass: You can place your hands at one end of the cut, using both thumbs on top and both index fingers on the bottom, and snap the glass apart, by forcing the glass downward on both sides of the crack. You can use a hard object (such as the ball of a cheap glass cutter) to tap the underside of the glass directly under and all along the etched line to make the glass crack nearly through (keep tapping until you see the crack go through the glass). Starting at one end of the etched line, you can use the 4"-wide sheet-metal-bending vice grips or wide pliers to grasp the excess glass and bend it downward sharply until it breaks off along the line. If the glass did not break cleanly all along your line, you may be able to save the piece; the wide pliers can be used to pry off protruding glass, and a small jagged point that still sticks out can be ground off with a 4" grinder (use safety glasses to keep the glass bits out of your eyes of course, and a dust mask to keep the glass out of your lungs), although the grinder generally leaves ragged spots. A skilled professional glass cutter can produce a nice sharp edge of the cut piece; while a beginner using a cheap cutter cannot etch the whole line fully, and has to re-etch parts of it, and the glass breaks along part of the line and then wanders astray, and then wide pliers are required to try to rebreak the bad parts along the line, and the rest of the cut is rather jagged, and the garbage can fills with ruined pieces, etc. If you ruin a piece of glass, use it for a dozen more practice cuts to improve your skill.

If you successfully cut a piece of glass to the proper 16 X 18" size, clean it and store it for use. To stack glass on top of glass, place a piece of newspaper or a sprinkle of corn meal etc. between the glass pieces, or adjacent glass pieces will stick to each other too tightly.

About 5-6 minutes are needed to clean, inspect, square, mark, cut, and stack a piece of glass, when you become proficient.

Instead of a glass top in your drawer, you can use plexiglass (acrylic plastic), which works well in place of glass. Plexiglass can be cut by untrained persons merely with a drywall square and a scoring knife/awl/metal point (score the groove, place the line over a table edge, and bend the plastic excess down to break the plastic along the scored line), and can even be sawed with the table saw (preferably using a triple-chip saw blade). Acrylic is much less breakable also, and may even absorb ultraviolet that fades insect specimens. The only problems with acrylic are that it is more expensive, and it is easily scratched, so one cannot remove silicone or varnish from it with a chisel (a major drawback for entomological drawers). Never touch or rub anything on acrylic, not even a soft cloth, because hard dust on the acrylic or cloth will be forced across the surface and will plow ugly furrows into it; merely blot up stains with soapy water, and vacuum dust with the nylon brush attachment of your vacuum. I have made several drawers with acrylic and found it to be excellent, but removing silicone from it with hard rubbing and isopropyl alcohol is a nuisance.

Sawing the Hardboard Bottoms

Hardboard is manufactured only in 48 X 96" (4 X 8') sheets, which can be sawed into only 10 pieces 16 X 18" in size. (If the hardboard were 48 1/2" wide, it could be sawed into 15 pieces, as it can be when Cornell Drawers are made.) One can use a variety of saw blades on hardboard: the Freud LU98M010 10" laminate/chipboard/plywood 80-tooth triple-chip-grind teflon-coated laser-cut carbide blade works well, as does a Sears Industrial 10" 72-tooth crosscut/miter carbide blade. Most saw blades with a high tooth count should work well. Set the rip fence on the table saw for 17" in the middle of the blade, and run the sheet lengthwise through the table saw twice, to make two pieces 17 X 96" in size, and one scrap piece (this scrap piece can make ten Schmitt box tops/bottoms). Set the table saw rip fence to 19.2" in the middle of the blade, and saw each piece four times, to produce ten rough-sawn pieces each 17" X 19.2" in size.

Use a **squaring sled** (see cabinet construction paper) to find one straight edge on the piece (place hardboard against angle-iron of squaring sled and see if the wood is straight). If no straight edge is found, saw one edge straight. Then saw a bit off an adjacent edge until you have a squared corner. Mark that squared corner with a penciled L.

Set rip fence for 18" exactly, and finish-saw all the pieces to this length. Of course you must saw an edge opposite to that sawed during the squaring operation, and the penciled L must be adjacent to the table saw rip fence.

Set rip fence for 16" exactly, and finish-saw all the pieces to this width. Of course you must saw an edge opposite to that sawed during the squaring operation, and the penciled L must be adjacent to the table saw rip fence.

The hardboard should be sawed precisely to the right dimensions, because later you will use the hardboard bottom as a ruler to see if the glass has been miscut.

Choosing Wood for the Sides

Various woods were tried for making drawers. Some woods have been highly touted as the best (basswood, poplar, etc.), and certainly some woods can make fine drawers, but actually I found that no single species of wood is best. A good piece of wood will make a nice drawer, regardless of what tree species grew it. In contrast, a flawed board (cracked, warped, twisted, knotty etc.) will produce a bad drawer, even if it was grown by an expensive high-status tree such as walnut. Even the softest woods such as redwood produce nice drawers, although their softness allows them to mar easily and permits nails fastening the flanges to occasionally knock out the wood a bit opposite the insertion point of the nail. So the harder woods are better to prevent those problems. Dense hardwoods such as maple and walnut produce nice drawers, but are heavy and expensive, and dull the expensive saw blades and router bits faster. Basswood and poplar are nice woods. Availability, cost, and appearance may affect your choice of wood. I have made fine drawers out of birch, poplar, walnut, maple, cherry, fir, hickory, oak, cedar, pine, and redwood.

Thus, to make a nice drawer, unflawed wood and good sawing/construction techniques are much more important than the species of wood that you use, although you should choose a reasonably hard wood.

However, there is one kind of wood that is outstanding, because of its combination of ease of use, price, hardness, stability, and appearance. I found that 5/8" Baltic Birch plywood is quite excellent for making drawer sides, because it is already manufactured to almost the proper thickness (avoiding the onerous chores of ripping, jointing, and planing)(although the thickness is .582" on average rather than 5/8"=.625"), it is fairly hard so resists marring and denting and 1/2" flange nails do not blow out the wood opposite the insertion point, it has 11 plies so is less prone to warping and twisting and cracking than solid wood, it can be sawed/milled/sanded precisely (making it a favorite for woodworkers for making precise wood parts), the 11 plies are rather pretty on the top of the drawer sides, its color matches the color of the most available good wood filler, and it is comparatively inexpensive (costing about the same as poplar). Making drawers is the most common use for Baltic Birch Plywood. Baltic Birch also smells very nice; one entomologist likes to use it for drawers that hold stinky beetles, in the hope of masking the smell.

Sawing the Sides from 5/8" Baltic Birch Plywood

5/8" Baltic Birch plywood comes in sheets 5 X 5' in size, that have 11 plies of birch wood compressed/glued together with immense force, totaling slightly less than 5/8" in thickness. The log is rotated into a knife that peels off a continuous ply, so the pattern is repeated every foot or two on the finished plywood as the knife reaches the same point on the log. Baltic Birch is imported from Scandinavia, and is used for quality woodworking because of its strength and resistance to warping and cracking. The BB quality is less expensive and works well; it has a few lenticular insertions here and there on each sheet, which can be placed in inconspicuous positions that do not mar the appearance of the drawer. Each sheet can be sawed into 63 drawer side pieces.

First, sand the manufacturer's ink stamp and other sandable blemishes off of each sheet. I have found that the best electric sander—for every sanding task on the drawer—is the rotary random-orbital sander (the Makita is fine, and Makita and DeWalt have a model with variable speed that could be used at low speed on the top edge of an installed flange without taking off too much material; when you turn this sander off, it continues to rotate for a long time, so to avoid wasting time holding it, make a wood stand with a fork into which to hang the spinning sander), which has a 5"-wide rotating velcro-hooked rubber base with 8 holes, onto which one presses felt-backed sandpaper discs with 8 holes. All other sanders are basically useless (a whole lot o' shakin', but not much sanding—except stationary belt sanders, which are very nice for heavy-duty sanding).

Now, each sheet should be rough-sawed across the grain, by setting the table saw rip fence at 20" in the middle of the blade, and sawing the sheet into three pieces ~20 X 60" in size. Stack these pieces flat, and clean the floor and the pieces before you stack them, because the heavy weight of this stacked wood could drive dirt such as sand grains into the wood and create a flaw in the surface; a sand grain near the bottom of the pile would be pressed into the wood by almost the entire weight of all the boards above it.

One should use a quality saw blade to make the remaining saw cuts in Baltic Birch Plywood. The Systimatic 1960 Laminate/Veneer 10" LV 80-tooth, alternate-top-bevel-negative-K-Land-grind .085"-width/.131" (.132" in MDF in my measurement)-kerf carbide saw blade works very well to make nearly perfect edges of the wood. One must adjust the height of this blade to minimize chipping (try the blade 1/32" above the wood), and push the wood slowly into this saw blade.

Each of these 20 X 60" strips should now be sawed into three parts. You could saw them fairly crudely by keeping the table saw rip fence at 20" in the middle of the saw blade, and sawing each piece along the grain (ripping parallel to the outer ply or veneer) into three parts. But a better job would be gotten by using the quality squaring sled described in the cabinet paper; if you make a straight saw cut you might be able to skip the next step. The resulting pieces are about 20" X 20" (more precisely, approximately 19.934" X 19.934"), and each makes seven sides (seven pieces 2.632" wide, plus seven saw cuts .132" wide, totaling 19.348", leaving .586" extra for rough-sawing).

The next task is to saw the finished-width sides out of these boards. If you are a meticulous expert woodworker, and your saw cuts were excellent when sawing the 20 X 60" pieces into three 20 X 20" pieces, you could skip a step and saw the finished 2.64"-wide sides without first sawing them to 2.72" width. However, if your last saw cuts were a bit concave or convex or scorched by faulty lateral movement of the wood into the side of the saw blade, you should rough-saw them to 2.72" width, as follows. I have found too often that when one tries to saw a piece perfectly the first time, errors will happen, and pieces will be ruined or flawed that end up too small after sanding/sawing off the blemishes.

Each of the ~20 X 20" pieces must be sawed along the grain into seven sides, each side about 2.72" X 20", so the wood grain runs lengthwise along each. The 2.72" width is a little wider than the intended finish width, in order to allow fixing the sides that were sawed imperfectly or had saw-scorching on the edge, etc. (The intended finish width of each side piece is 2.5" plus the laminate-veneer saw blade kerf width .132", or 2.632", rounded to 2.64". Then later, after the drawer is assembled, each side is sawed through the dado groove with the laminate-veneer saw blade .132" wide to separate the drawer into top and bottom; when the finished drawer side becomes 2 1/2" in width, the final height of the drawer.)

To saw these 20" X 20" pieces, inspect both edges that are parallel to the grain, and put the best edge of those two edges against the rip fence, because the manufacturer uses a crude saw blade to trim the edges of Baltic Birch, and the edges are often angled as much as 10° away from being vertical. And if one end is convex, and the other end concave, put the concave end against the rip fence, because it may be easier to make a straight first saw cut when the wood against the rip fence is concave than when it is convex. Saw all the Baltic Birch to this 2.72" width. After sawing each of the resulting seven side pieces, you will have a good idea whether that side piece has both edges imperfect, or has only one imperfect edge or none. Set the bad pieces (with both edges imperfect) in a separate "bad" pile, the good pieces in a "good" pile. One need not clean the pieces before stacking them, because the weight on the bottom of the pile is only the pieces directly above. Stacking them 25 sides high seems to work well, as half of the 25 are a convenient load for sawing, and the whole 25 are about the right amount for sanding.

Now, finish-saw all the sides to final width. Bring a pile of sides to a table next to the saw, and place them edge-upward in a row on the right side of the table. Brush the dust off the edges with a nylon brush, so the boards will fit precisely against the rip fence. Take the leftmost side of the bunch, brush off its right side and brush the dust off the table saw top in

front of the blade, saw the board, then place it on edge on the left side of the table, place the next on edge beside it, etc. until you finish the pile of sides. Then grab the pile, rotate it counterclockwise 90° upright (edges to the side), and haul it to your storage area, and grab another pile of sides. This meticulous trivia may sound ridiculous (anal retentive) here, but this identical procedure should be done later in sawing the dado saw groove, hardboard groove, and glass groove, when it will help prevent a mistake by sawing a groove on the wrong position on the board. With this procedure fixed in your mind, you can daydream about birdwings in New Guinea instead of worrying about positioning each board.

If you saw only a small amount off the edge of the wood, and raise the saw blade above the 5/8" height of the wood, a few narrow chips will come off the top edge of the wood, mainly where the wood fibers are angled toward the oncoming saw blade. To eliminate these chips, you can use a sneaky finish-sawing trick. Raise the saw blade only partway through the 5/8" Baltic Birch, say to the top of the sixth ply (which is 55% of the thickness of the wood, about 0.33"). Saw the edge of the piece, then turn it over and saw the remaining 5 plies. With this trick of sawing only partway through the wood, chips cannot form at the tips of the saw blade, and the edges of the finished piece are nearly perfect. (With this trick, you can make fairly good-looking edges even with a fairly bad saw blade.) This trick works even better than the commonly-used manufacturing technique (on expensive sliding table saws etc.) of using a conical scoring blade preceding the regular saw blade, or of using a TCG (triple-chip grind) saw blade in which longer conical teeth alternate with flat-tipped regular teeth. This operation may cause fatigue/strain in the thumbs or back, so one should alternate which hand leads and which follows, and one can also make a side push stick to avoid using the thumbs (this push stick is about 4" wide, 2" tall, 23" long, and is basically a long board, which a stop on the back that pushes the rear of the side piece, and a long stop along one side that pushes against the side of the side piece; as usual, one can router the bottom of a single 2 X 4" board to make this push stick, or use a thinner 3/4" board and glue 1/2" boards to the bottom for the two stops; never use nails on any push stick, because the saw blade will go astray and ruin itself on the nail). Such a push stick works very well and is a little safer, but takes a little more time to use than merely using the hands.

Now reset the rip fence to narrower width, about 2.67" (wider than the finish width of 2.64"), and resaw the pieces on the bad pile. Find the prettiest or straightest edge on each one, place that edge against the rip fence, and resaw the worst edge so it is good. Place these in another pile and keep the bad side on the left (or right if desired) to make sure you next saw the other side. Inspect all the pieces in the "good" pile also, to pick out pieces that are flawed on both edges, and resaw the worst edge of them also and place them on that same pile.

Now, reset the rip fence to the final width of 2.632" (use a ruler measuring in 1/100th of an inch to set it the best you can—erring a little too wide at say 2.64" is better than erring too narrow, and sanding may remove some wood, so set it at 2.64" or even 2.65" —of course this width equals 2.5" plus the thickness of the saw blade you will use to saw the constructed drawer apart, plus whatever you sand off), and resaw all the side pieces. Inspect each side piece before you saw it, and trim the worst edge remaining on each.

Sawing the Dado Recess into Sides

A dado groove is sawed into the inside wall of each side, to make a space where the flange is later installed. After the drawer is sawed apart through the dado groove, the flange is glued/nailed into the dado groove on drawer bottom, and the flange fits up into the dado groove on the top of the drawer to create a tight fit of top to bottom.

The Freud SD208 carbide stacked dado saw works very well; it has 12 teeth on each outer blade and two teeth on each of the five chipper blades, and costs about \$94. (More expensive dado saws such as the Systimatic 1775 have up to 42 teeth on each outer blade and 6 teeth on each chipper, and cost much more.) Install all seven blades of this dado saw set on the table saw, so that the saw cut swath is 13/16" wide. (Some shims may be necessary to achieve this full width [the five shims are width .020", .012", .012", .008", and .004"], but you can just ignore the shims and accept whatever width you get such as .798-.802"). You may need to replace the washer on your saw blade shaft with a thinner washer to enable the nut to grasp the shaft sufficiently when you tighten these blades onto the shaft. Use a dado saw insert on the table saw.

The dado saw should be set to make a groove about the depth of the almost-1/4" Baltic Birch plywood (actually about .225" wide) that is used for the drawer flanges, plus the very thin layer of glue that helps fasten the flange into the dado groove. So test some 1/4" Baltic Birch in the groove to set the depth properly.

The edge of the dado saw groove should be set to be about 3/4" (actually .69") from the top edge of the side of the drawer. The top edge of the sides should be pressed against the rip fence during all operations (sawing of the dado groove, glass groove, and hardboard groove), in case all the sides are not absolutely identical in width, and because the top edge may be better than the bottom edge (if there is a flaw on one edge, it should be banished to the bottom where the flaw will not be seen). so the rip fence should be .69" from the edge of the dado saw blade cut.

Before you saw the dado groove, inspect each side piece, and decide which surface would look best on the outside of the drawer, and which edge would look best on the top of the drawer. Ugly blemishes in the wood can be placed in the path of the dado saw to be removed, or can be placed at the bottom of the inside edge where the hardboard will prevent anyone from seeing them. The best side should be placed outward, the best edge upward. (Some people might want to place the prettiest side inside the drawer, but most people want the best side on the outside.)

To saw the dado groove, bring a pile of sides from the storage area, and place them on the right side of a table beside the saw, top-edge upward. Brush dust off the exposed edges with a nylon brush. Pick up the leftmost side of the bunch, brush the dust off of it and off the top of the table saw in front of the blade, inspect the side, and place the best edge against the rip fence, and the best surface upward, and see if fits exactly against the rip fence (is straight). If it is not straight, you might want to consider placing the other edge against the rip fence and use that edge as the top. Place the side push stick described above on top of the side piece so that the side is inside the recess of the push stick, and push the piece very slowly over the dado saw, as a considerable amount of material is removed. This side push stick works well for the dado cut, and will greatly cut down on fatigue/strain in your thumbs/hands /forearms, especially if you install a wood block or two (toward the end of the top of the push stick) that fit into the palm of your forward hand. When you finish sawing each piece, place it on the table to the left of the group, in the same orientation (on edge, top upward, groove to the right), then place the next sawed side beside it, etc., until you finish the pile of sides and they are now on the left side of the table. Then grab the pile, rotate it counterclockwise upright (edges to the side), and haul it to a storage area, inspecting the ends of the boards along the way to make sure you sawed them all. Use the same procedure for every saw groove operation on each side, to simplify searching for the right position of each board, and to help prevent the mistake of sawing the wrong spot on the board.

Remove the sawdust frequently, because a day of dado-sawing will produce more than a bushel (1/8 m³) of sawdust.

Before you dismantle the rip fence/dado saw, inspect all your completed sides. Make sure they all were dado-sawed, and if there is a knothole in the upper ~.30" of the dado saw groove, set them aside (a hole in the middle and lower part of dado groove does not matter because that area will be sawed away or covered by the installed flange). Wood fill the holes, let them dry, and dado-saw them again to remove excess wood filler.

Make a dado groove in three or more trial pieces of good fine-grained wood (Baltic Birch, or MDF=medium-density fiberboard) now; you will need those pieces later for making the flanges.

Sawing the Hardboard Groove into Sides

Make trial cuts using your saw blades, and fit your hardboard into them, to choose a saw blade that makes the proper width cut. If the saw cut is too tight, time and effort will be wasted trying to force the hardboard into the groove, and if the hardboard is a little warped the task may be impossible, and excess glue will not be able to ooze out of the groove, and the rotating work table described below will not be able to square the drawer well. If the groove is much too loose, the glue may run out of the groove, and the hardboard may sag and not glue very well in spots. A groove that is about .01" wider than the hardboard seems to work well. "1/8" hardboard is manufactured in many thicknesses, from unsatisfactorily thin 1.10" to as much as 1.40" or even 1.50", and is commonly .131" thick.

The width of groove needed is wider than the kerf of most acceptable saw blades (except for some ripping blades mentioned below that might work), so you must make one saw cut, then change the rip fence a little to saw the groove a little wider so that the hardboard fits into it loosely.

A triple-chip-grind saw blade leaves a deeper rounded shallow trough in the center of the groove, which is probably a better place to hold the glue than a sharp-rabbit-eared groove made by an alternate-top-bevel saw blade; the triple chip grind saw blade makes a right-angled edge in the groove also, which is less likely to split the wood. The Freud LU98M010, 10" laminate/chipboard/plywood 80-tooth triple-chip-grind teflon-coated laser-cut saw blade with .127" kerf (.126" in Baltic Birch) saws a hardboard groove wide-enough for hardboard about 0.123-0.125" thick to fit tightly into the groove. However, the groove is too tight for the same hardboard that is warped a little, and is too tight for other bottoms made from the same manufacturing lot of hardboard that are a bit thicker at .127". The DeWalt 10" 80-tooth alternate-top-bevel finish/miter saw blade cuts a groove .128" wide in MDF, but saws a groove much thinner (.121 sometimes) in Baltic Birch, too tight for comfortable fit with the hardboard. So, the groove must be widened with a second pass with both of these saw blades, to about .14" for .125-.131" hardboard.

Some few-toothed saw blades are wider in kerf (a .138"-kerf Craftsman 10" blade with 48 teeth for instance). A ripping blade (which have few teeth) with flat-top (raker) teeth saws a perfectly flat-bottomed groove that matches the hardboard, and would be perfect if its few teeth do not splinter the edges of the groove (the splintering might be minimized by pushing the wood very slowly over the saw blade). Systematic makes four rip blades with .145" kerf that have 10 & 24 teeth in flat-top grind, and 30 & 40 teeth in triple-chip grind, including the Systematic Glue Joint Rip Blade #1625 10GR40-095 10" 40-tooth triple-chip-grind blade that is recommended for glue joints in hardwoods etc., so this blade might be the best of all. Amana sells 10" ripping blades with .150" kerf (20 teeth), .145" (30 teeth) and .135" (24 & 50 teeth).

As always, the top edge of each side should press against the rip fence during sawing. The saw groove should be placed 1/8" from the bottom of the side, so use trial pieces to set the rip fence. (The distance from rip fence to the most-distant side of saw blade is the 2.64" width of the boards, minus the 1/8" that the side extends below the hardboard, or about 2.515".) Then move the rip fence a bit closer to the saw blade to saw the groove to the necessary wider width.

The depth of the hardboard groove can be calculated using the same procedure described below for the depth of the glass groove, because the depth of the hardboard groove depends on the thickness of your side boards, the size of your hardboard and how precisely you sawed them, and on how much you want the hardboard to extend into the groove and how much

space you want in the back of the groove for glue (Table 1). For Baltic Birch sides of .582" thickness, and hardboard cut rather precisely to 16 X 18", a hardboard groove .13" deep works well, which allows a space of .03" in the bottom of the groove for glue (the outside dimensions of the drawer sides are 16.964" X 18.964"). The .03" glue space is small because you should be able to saw the hardboard much more precisely than glass is cut, and then the hardboard can fit nicely and serve to keep the drawer square.

To saw the groove, bring a pile of sides from the storage area, and place them on the right side of a table beside the saw, top-edge upward, and dado groove to the right. Brush dust off the exposed edges with a nylon brush. Pick up the leftmost side of the group, brush the dust from its right side and table saw top, rotate the side clockwise 90° and place it on the table saw, and saw the groove. When you finish sawing each piece, place it on the table to the left of the group, in the same orientation (on edge, top upward, grooves to the right), then place the next sawed piece beside it, etc., until you finish the pile of sides and they are now on the left side of the table. Then grab the pile, rotate it counterclockwise upright (edges to the side), and haul it to a storage area, inspecting the ends along the way to make sure you sawed each one. Use the same procedure for every saw groove operation on each side, to simplify searching for the right position of each board, and to help prevent the mistake of sawing the wrong spot on the board.

Before you dismantle the rip fence/saw blade setup, inspect the hardboard groove on all of your sides. Set aside the boards you forgot to saw, and the boards that have a knot hole beside the groove. Wood fill the holes, let them dry, and resaw the groove to remove excess wood filler.

Sawing the Glass Groove into Sides

One must use a thin-kerf saw blade to saw the groove for single-strength glass. The Systimatic 1420 thin line 10" triple-chip-grind 80-tooth .099"-kerf (.102" in MDF in my measurement) saw blade works well, and produces a groove with a slight rounded depression in the bottom (from the conical teeth), which might provide a good place for the silicone, and might make the wood less likely to crack than an alternate-top-bevel saw groove. The Marathon/Irwin 14074 10" 60-tooth thin-kerf saw blade works well, and cuts a groove .098" wide. Other saw blades will work well also, such as the Systimatic 1235 thin line 10" alternate-top-bevel 80-tooth .099"-kerf saw blade, etc.

The groove should be placed 1/8" from the top of the side, so the rip fence should be set 1/8" from the saw blade. As always, the top edge of the side should be pressed against the rip fence during sawing.

The goal in making a groove for glass is to have plenty of room for the glass, to account for miscutting of the glass, and for thermal expansion and contraction of the glass at different temperatures, while not allowing the glass to come completely out of the groove on one side. On an ideal drawer with 5/8" sides and 16 X 18" glass, the glass groove should be about 3/16" deep, and the glass should fit 1/8" into the groove, leaving a space of 1/16" on each side that is filled with silicone (1/8" total space when adding both sides), to allow for inaccuracy in the size of glass or sides. Table 1 lists these dimensions along with others you might want.

In practice, glass measurements may vary somewhat, because the person cutting the glass may not have been very careful (the 16 X 18" glass that I bought averaged 15.97" X 17.98" in size, and varied from 15.91-16.06" X 17.89-18.06", and was sometimes non-square by 1/16"). And the thickness of the wood sides may be a little less than 5/8" (Baltic Birch averages .582"). So, to minimize problems during construction (the glass being too big for the grooves, the glass being too small so that the glass comes out of the groove on one side), measure the size of your glass, and measure the thickness of your side pieces, and carefully set the depth of the saw groove to permit silicone to help center both small and large pieces in the groove and seal the groove. The silicone seals the crack against pests such as dermestid beetles, helps equalize the glass within the rectangle formed by the four grooves, and excess silicone oozes out and can later be removed by running a sharp chisel and razor blade over the glass. (Silicone also helps cushion expansion and contraction of glass due to temperature changes, although this benefit is mainly needed with much larger [giant] pieces of glass exposed to outside weather variation.)

Table 1. Alternative critical dimensions of drawer sides, glass, and hardboard.

Item	Ideal Drawer: exactly 5/8" sides, 17 X 19" drawer	Baltic Birch sides, 16 X 18" glass and hardboard	Ideal for Baltic Birch sides, 17 X 19" drawer	Baltic Birch sides, 17 X 19" drawer	Baltic Birch sides, 17 X 19" drawer
Side Thickness	.625" (5/8")	.582"	.582"	.582"	.582"
Drawer Outside Dimensions	17 X 19"	16.964 X 18.964"	17 X 19"	17 X 19"	17 X 19"
Drawer Inside Dimensions	15.75 X 17.75"	15.8 X 17.8"	15.836 X 17.836"	15.836 X 17.836"	15.836 X 17.836"
Glass Size	16 X 18"	16 X 18"	16.086 X 18.086"	16 1/16 X 18 1/16"	16 3/32 X 18 3/32"
Glass Groove Depth	3/16"	.13"	3/16"	.176"	.191"
Silicone Space	1/16"	.03"	1/16"	1/16"	1/16"
Hardboard Size	16 X 18"	16 X 18"	16.086 X 18.086"	16 1/16 X 18 1/16"	16 3/32 X 18 3/32"
Hardboard Groove Depth	5/32"	.13"	5/32"	.144"	.160"
Glue Space	1/32"	.03"	1/32"	1/32"	1/32"

(See the Dimensions section above for similar calculations.) The depth of the glass saw groove should be calculated together with the size of the glass and the thickness of the sides, because these all affect each other functionally. Measure the thickness of the side boards you are using, then estimate the depth of the glass groove you want to have, and estimate how far into this groove you want the glass to extend (the remainder of the groove is a space for silicone). Now calculate the outside dimensions (lengths) of the drawer sides, which are 16" plus 2(thickness of side minus glass extension into groove), and 18" plus 2(thickness of side minus glass extension into groove). With Baltic Birch, the sides are .582" thick on average, and using a glass groove depth of .13", and inserting 16 X 18" glass .10" into the groove (leaving .03" for silicone), the outside lengths of the drawer sides are $16 + 2(.582 - .10) = 16.964$ ", and $18 + 2(.582 - .10) = 18.964$ ". For sides mitered at a 45° angle, the inside dimensions (lengths) of the drawer sides are the outside dimensions minus twice the thickness of the sides, or $16.964 - 2(.582) = 15.80$ ", and $18.964 - 2(.582) = 17.80$ ". Now, assess the glass-holding capability of this groove by calculating three distances that represent how much the glass can move or escape from the drawer. The minimum distance is the inside lengths of the drawer sides, 15.80' and 17.80"; the glass is 16 X 18", much larger than this minimum, so no problem here. The maximum distance is the distance between the maximum depths of the glass groove on opposite sides, which is the inside lengths of the drawer sides plus twice the glass groove depth, or $15.8 + 2(.13) = 16.06$ ", and $17.8 + 2(.13) = 18.06$ ", plenty large enough for this size glass and even for miscut glass that is .06" too large. The gap misfit is the distance from the inside of one side to the depth of the glass groove on the other side, which tells us whether the glass can slide so far into one groove that it comes out of the opposite groove; this distance is the inside lengths of the drawer sides plus the depth of the glass groove, or $15.8 + .13 = 15.93$ ", and $17.8 + .13 = 17.93$ "; thus the glass would have to be miscut to less than 15.93" or 17.93" for this problem to occur. Calculate all these things for the thickness of the wood sides and the size of the glass you want to use, and if you don't like the glass-holding capability of your glass groove, estimate another glass groove depth or change the sizes of your sides or glass, until you find the dimensions you want to use.

Ideally, you should try to get glass that is cut precisely by a giant robot machine, but unfortunately the glass you buy will probably have pieces cut by a human up to 1/10" too small, or almost that much too big, and some of the corners may be 1/16" out of square, which all means that you should develop a strategy for using these miscut pieces of glass. (The glass that I cut myself is much more accurate than the glass I purchased.) Calculate the depth of glass groove and the thickness of sides that permit most pieces of glass to be used successfully, without coming out of one groove or being too large inside the grooves for the drawer corners to come together tightly for nailing.

An ideal strategy for using miscut glass is to measure some of the pieces of glass that you obtained, and see how many pieces are too small, how many are too large, and how many are just right (count an obtuse-angle non-square corner as being larger on those two sides, as your groove must be deeper to accommodate that obtuse angle if your drawer corner is square). Now, saw the same percentage of your sides with a .02" shallower glass groove than usual (for example, saw 31% of them .11" instead of .13"), and saw the proper percentage of sides with a .02" deeper glass groove than usual (for example, saw 9% of them .15" instead of .13"). After you saw each of these special sides, mark the lower part of the bottom of the dado-saw groove with a green felt-tipped pen if the groove is shallower than normal (do not mark it at either end of the board that might be cut off by the miter saw), and mark the bottom of the dado groove in the middle of the board

with a red felt-tipped pen if the groove is deeper than usual (mark the dado groove because it is much wider than the glass groove thus easier to mark visibly, and the lower part of the groove will be filled in by the flange so the mark will not show on the finished drawer). Keep these special boards in different piles, then when you construct a drawer, you can lay the glass onto a board that is the size you want the glass to be, and if it is too small or too large you can use these special sides. If the glass is a little big, you can use only one deeper-groove side; if it is way too big you can use two deeper-groove sides (one opposite the other). If the glass is a little small, use only one shallow-groove side; if it is way too small, use two shallow-groove sides. This scheme will let you make nice drawers even with the badly-cut glass pieces.

Another strategy for using poorly-cut glass is to wait until you assemble each drawer to saw the glass groove. Place the glass over the ideal-size-glass board—such as a hardboard bottom if you sawed it precisely and square--and see whether the glass is too small or large or non-square, and saw the glass groove to the proper depth to fit that miscut glass piece. You could even raise the saw blade on the saw on one part of a side if the glass bulges out there.

Still another strategy for using poorly-cut glass would be to miter the sides longer for too-large glass, and shorter for too-small glass. However, you presumably sawed the hardboard rather accurately, and these odd-length sides would make the hardboard fit worse, so this method is not very good, unless you saw the hardboard bottoms larger also, and that is too bothersome.

To saw the groove, bring a pile of sides from the storage area, and place them top-edge upward, dado groove to the right, on the right side of a table beside the saw. Brush dust off the exposed edges of the group with a nylon brush. Pick up the leftmost side of the group, brush the dust off of its right side and off the table saw top, rotate it clockwise 90⁰ and place it on the table saw, and saw the groove. When you finish sawing each piece, place it on the table to the left of the group, in the same orientation (on edge, top upward, the grooves to the right), and place the next beside it, etc., until you finish the pile of sides and they are now on the left side of the table. Then grab the pile, rotate it counterclockwise upright (edges to the side), and haul it to a storage area, inspecting the edges along the way to make sure you sawed each one. Use the same procedure for every saw groove operation on each side, to simplify searching for the right position on each board, and to help prevent a mistake by sawing the wrong spot on the board.

Before you dismantle the rip fence/saw blade setup, inspect all your sides to see if the glass groove is there and has good margins. If there is a knothole etc. on the margin, wood fill the blemish and groove there, let it dry, and resaw the groove to remove excess wood filler.

Filling and Sanding the Edges of Sides

Most of the flaws in Baltic Birch are on the edges (the 5/8" surface with the 11 plies), where there may be knotholes that need filling, and there may be bluish-gray smudges caused by rubbing against an aluminum rip fence, or there may be red-brown scorching caused by faulty sawing. Any holes that appear in one of the plies (where a knot fell out, etc.) should be filled using wood filler (see Wood-Filling tips, Appendix II).

You must sand before mitering the ends of the sides, because the sander can damage a mitered end.

If you sand the 5/8" surface of only one piece with the random orbital sander, too much wood will be removed and the edges will become rounded or splintered too much, so you should wood fill and sand the edges while the pieces are ganged 25 or more (even 100 if your clamps are long enough) at a time, all pressed together with the edges upward (wood filling and sanding is much faster this way anyway). Place the 25 or more sides, edge upward, on a hard flat surface such as your table saw top, align the ends in a line, and clamp them together (two 36" Quick Grip Bar Clamps work very well, one clamp on each end, as you can just move the black bars of the clamps against the ends to align them, and quickly clamp and unclamp them). If you see holes (caused by knots etc.) in one of the plies, fill it with wood filler. You can sand essentially immediately if you use the rotary random orbital sander. Sand the wood filler with 60-grit sandpaper, lightly at first, because the sander quickly removes some of the excess wood filler and makes the air flow very rapidly over the filler that remains to speed its drying. Do not let the sandpaper overlap the edge of the gang by more than a few centimeters, or it will round the edge too much. Then complete sanding the remaining excess wood filler and the blemishes, and sand the rest of the wood a bit. You can tilt the sander up a bit to sand a small spot more intensively than when the whole base of the sander is pressed against the wood.

Unclamp them, turn over the gang, reclamp, then wood-fill and sand the opposite edges.

Miter-Sawing the Ends of Sides

A miter saw cuts the 45° angles on the ends of the sides. You should set up your saw jig to measure the inside diameter of the sides, not the outside diameter, because the critical dimensions of the drawer side (the glass groove and the hardboard groove) involve the inside of the side piece, not the outside, and the outside can be allowed to vary somewhat in width/length—due to variation in thickness of the whole side--without causing any problem. So choose the dimensions you want to use in your drawer and glass and hardboard (Table 1), to determine the inside dimensions of the sides to use to calibrate your sawing jig.

The Systematic 1255 Double Miter/Wood 10" DW 100-tooth, .098" width/.122" kerf carbide saw blade works very well for miter cuts, and produces a perfect cut on the front of the board and an excellent cut on the rear. This saw blade is

designed for the 45° cuts made in picture frames by industrial machines such as the Pistorious Double-Miter Saw, which have two saw blades running at the same time, 90° from each other, to cut both adjacent miters in a piece of molding. The Systimatic 1250 Precision Trim Blade alternate-top-bevel 10PT 100-tooth, .085" width/.131" kerf saw blade also works very well (even though the manual rates it best only for crosscuts and plywood). The DeWalt DW3218 Series 40 10" 80-tooth Precision Finish Miter Saw (.128" kerf) also works well. The thinner-kerf saw blades are said to be easier on the miter saw.

A miter saw such as the 10" Makita works fairly well, although all portable miter saws have a bit of inaccuracy in making cuts because the arm holding the motor etc. to the base is small and is hard to adjust even to make a perfectly vertical saw cut. Furthermore, the miter saw may not have been adjusted perfectly at the factory. If the saw cut is not vertical, the two bolts holding the arm to the base should be loosened and aluminum foil shims placed under one side of the arm until the saw blade becomes 90° to the base of the miter saw extension [described below], and the saw blade becomes 45° to the back of the miter saw extension, then the bolts should be retightened. This procedure takes a hour or more. You should adjust it to make a perfect miter cut while it is in the proper 45° position.

(A homemade miter jig that fits onto the table saw might work better than a miter saw. The table saw blade would be cranked to 45°, and the jig would be constructed the same as the squaring sled described in the cabinet paper, and in addition there should be 45° stops for 17" pieces and 19" pieces, and beyond that no stops for two 20" pieces. With this jig, one could miter the first end of 20" pieces, miter the second end of 17" pieces and 19" pieces, perhaps all at the same time in one pass across the table saw if one could manage to clamp or hold them to the miter jig tightly during sawing.)

A **miter saw extension** should be bolted onto the backstop of the left side of the base of the miter saw, to permit 17" and 19" boards to be cut. To do this, an aluminum angle-iron (about 3" tall on the rear wall, about 1" wide on the horizontal bottom flange, about 22-23" long) should be bolted to the backstop using recessed flat-head machine screws, so that it extends to the saw cut when the saw is angled to the right and set for 45°. Then a vertical aluminum stop should be bolted to that angle-iron about 23" from the saw blade. The angle-iron floor flange should be perpendicular to the saw blade, and the stop should be parallel to the saw blade. Once you bolt the extension to the miter saw, install the saw blade you intend to use, and only then slowly lower it through the aluminum to saw the near-zero-clearance 45°-angled end of the extension.

Now you need to make two **miter stops** made of ¾" MDF fiberboard or other fine-grained wood, that are to be placed against the aluminum stop on the miter saw extension and clamped against the back of the miter saw extension. One stop is for making ~17" sides, the other stop is for ~19" sides. Each MDF stop is about 3" high, ¾" thick, has a squared left end that fits against the aluminum stop of the extension, and the right end is mitered 45°. Miter the end of the MDF first, then crosscut the other end to the proper length with a table saw. Use a 24" ruler graduated to 1/100" to help saw the two pieces the right length. To make a stop of the right length requires trial and error: make one stop, clamp it onto the extension, cut a trial drawer side piece and measure its length (the length of the inside of the side, not the outside), then cut the stop a bit shorter or make a longer stop, etc., until you get one that is the right length.

Making a nice vertical cut with the miter saw also requires the proper six-step technique. Position the mitered end (if there is one) of your wood piece against the mitered stop (on the left side of the machine), and squeeze the piece against the backstop there with your left hand to hold it in place. Place your right hand just to the left of the planned saw cut, and squeeze the board against the backstop there to hold it in place. Move your left hand to just left of your right hand, and squeeze the board against the backstop there to hold it in place. Move your right hand to grasp the operating handle of the miter saw, press the safety/start button in with your right thumb, and squeeze the trigger with your right index finger, to turn on the saw motor. Move the handle downward to just above the wood with your right hand and pause there while the blade is spinning, release your thumb from the safety/start button and let your thumb dangle into space, then with the rest of your hand still on the handle, move the handle straight down to saw through the wood. Do not move the handle forward or back during the saw cut, or the end of your mitered piece will not be square (the miter saw is loose enough that forward or backward pressure during the down-cut will produce a non-square saw cut). Test your pieces with a square to master this technique.

To miter the ends of the sides, first miter the nicest end on all the sides. Choose the nicest end to miter first, in the hope that the flaws on the bad end will be cut off when you miter the other end. If there is a blemish on the last three inches of a board, use that for a 17" side, because nearly 3" will be trimmed from the 20" board to cut it down to 17"; if there is a blemish on the very end of the 20" board it will be removed in making a 19" side. A warped board is better cut short—to 17"—than long.

Now, miter the other end of the boards. Look at each piece, and prepare to miter 50% of the pieces to 19" length, 50% (including the pieces with ugly ends) to 17" (set the pieces with bad ends aside for 17" length, and count the numbers of each carefully). The 19" sides must be mitered prior to the 17" sides, for two reasons: 1) a 17" side can be made from a 19" side, but not vice versa; 2) when you are mitering the second end of the 19" sides, you may find some sides that are too short for 19" sides that must be used for 17" sides. Clamp the ~19" miter saw stop onto the extension, and place the mitered end of each side against the backstop of the extension, so the mitered ends of the stop and side fit together, and the inside of the side is against the extension. (Each mitered end has an obtuse angle and an acute angle and the obtuse angle should be against back of the miter saw extension, while the stop has its acute angle against the extension. The opposite

arrangement of angles would cause wood chips to build up behind the stop, and would make the sawed board difficult to insert and remove.) Then, operate the miter saw to miter the other end of the side. The side should be the proper approximate 19" length. Miter the end of 50% of your side pieces to 19" length. When you place each piece against the backstop and miter stop, you will notice whether the mitered end is square, and whether the board is warped, and whether there is a cosmetic blemish, in which case you may want to re-miter the end, or use that board for a 17" board.

After you finish mitering 50% of the pieces to 19" length, count them again, and count the remaining sides. Clamp the ~17" miter saw stop onto the extension, and miter the other 50% of your side pieces to the proper ~17" length.

Inspecting, Wood-Filling, and Sanding Sides

You might want to inspect the wide surfaces of each piece for flaws and blemishes/ink spots/footprints etc., although this should not be necessary because those blemishes should have been removed earlier before you sawed the 5 X 5' Baltic Birch sheets. Wood fill and sand any defects you might find. Splintered spots on the edge could be sanded a bit, but most such sanding is best postponed until after the drawer is assembled.

The miter saw may have splintered the inside edge of the end of the board a little. You could inspect those ends now, and wood fill any blemishes (apply a little wood filler with the spatula to a hole at end of dado groove, then immediately use chisel to wipe off excess there).

Assembling Drawer

Before describing the assembly procedure, some aids, tools, and techniques need to be discussed.

Rotating Assembly Table. To nail the corners of the drawer, a rotating assembly table helps greatly. The top of the table rotates to bring each corner into proper position for the nail gun, two adjacent sides are vertical and square to align the drawer properly both vertically and horizontally, and the other two sides swing up and against the drawer sides to help keep them in place. I made a rotating table using the bottom of an industrial swiveling chair. This chair has castors on each of the four legs, and has a rotating vertical post that once fit onto the seat of a chair, but instead of the seat I bolted aluminum angle-irons that rise up to a flat table-top aluminum plate that forms the work surface for assembling the drawer. The work surface top of the rotating table should have bolt heads or something else sticking up to keep the hardboard 1/8" above the bottom of the drawer sides (the sides should rest on the work surface, not on bolt heads), to make it easier to insert the hardboard into the hardboard groove on the sides. Two adjacent sides of the four sides of the top of the rotating table should have permanent aluminum walls, and the other two adjacent sides should have hinged walls made of aluminum angle-irons that hang downward but can swing up and into place against the drawer. When in the up position, the aluminum walls should fit tightly against an ideal drawer exactly 17" X 19" in size. All of these four aluminum walls should touch only the middle to near-the-end portions of each drawer side, because the ends of the sides (on all four corners) must be exposed to permit the nail gun to contact the wood and insert nails. And all four corners of the work surface top, where the four corners of the drawer will rest, should be cut off (cut a triangle of sides 1", 1", and 1.41", off of each spot where the corners of the drawer will rest), to permit the fingers to lift the corners of the drawer up a bit to help insert a warped piece of hardboard into the hardboard groove, to permit the nail gun to have easy access to the corners of the drawer, and to permit excess glue at the corner to drop without messing up the table. Because drawers tend not to have ideal dimensions, use duct tape to attach a foam pad along the lower edge of the two hinged walls, so that when you swing the hinged wall up and onto the drawer side, the foam will press against the middle of the side and keep the side nicely pressed into the glass and hardboard during nailing, even if the dimensions of the drawer are a bit different from 17 X 19". The foam will tend to equalize the pressure on all sides of the drawer, to make the best of an imperfect job of construction, while you are trying to hurry as the glue and silicone start to stiffen; and if you need to force the side farther onto the glass and hardboard, you can just press downward on the hinged wall to gain leverage and exert even more lateral pressure onto the side. The four walls of the rotating work table must be perpendicular to each other of course (align them with a drywall square), to encourage the the drawer to be square too.

This rotating work table also works great for painting cabinets and drawers. Merely set a spacer onto the top to bring the top level all around, set a piece of plywood or plastic over that to catch drips, and place your support and paintable object onto that. Now you can rotate the object in order to paint all four sides without moving the paint container or yourself.

You can make drawers without the rotating assembly table, although the process gets messier at times because the pieces are sometimes hard to align with each other. Try nailing two opposite corners together first, then fit the glass and hardboard into them and then nail the final two corners. Glass fits better into a groove while it is in the vertical position. One can use a nylon strap that is placed around all four sides and clamped, although realistically, if you can get the drawer put together enough to put on the clamp you are mostly finished anyway, and some of the corners might set prematurely in the wrong position before you can get the clamp strapped on and the corners fully adjusted.

Brad Nailer. An 18-gauge brad nailer works very well to fasten the drawer (and cabinets), because the nail is inserted under high pressure (90 psi) and instantly penetrates the wood, without noticeably moving the joint if you squeeze out excess glue and hold the joint fairly tightly while nailing (in contrast, a hammer displaces a mitered joint greatly with each swing, making a perfect joint nearly impossible to achieve). The nail gun also sinks the nail head approximately 1 mm into

the wood (using 90 psi for 1" brads, or 60-70 psi for ½" brads), so the only visible evidence of the nail is a tiny depression that is easily filled with wood filler. The nails are very inexpensive also (but avoid nails that are stuck together with inadequate glue [Prebena ½"] because these shatter into little pieces that are a mess to insert into the nail gun slide). Use a brad nailer that can nail both 1" and ½" brads. The only annoyance of a nail gun is that one must inspect and refill the nail holder slide frequently to make sure the nails do not run out, because an empty nail gun still makes a little depression in the wood so it is not immediately apparent that you have been nailing nothing (one could drill a hole through the slide cover so you can see whether nails are present). A nail gun is run by air pressure, so you must have an air compressor. A 27-gallon "5.5" horsepower (actually the horsepower ratings on most small power tools sold today are phony "peak" horsepower, up to a bogus 5.5 hp, because one cannot get more than 1.7 real horsepower out of a 110-volt 15-amp circuit) oil-filled (with separate motor and compressor units connected by a V-belt) air compressor works very well, and is quiet enough for comfortable use. A tiny air compressor will also power the brad nailer, but will run and make noise more often. Oil-less air compressors (motor and compressor combined into one structure) cost a little less, but make horrible noise that is quite uncomfortable.

V-Nailer. Some popular commercial drawers are fastened using a V-nailer (except the kits for customer home assembly use flat metal splines pounded into a groove in the corner instead). A V-nail is a thin flat (non-corrugated) sheet of hard metal that is bent 90° in the middle and the edges are flared a bit so the edge is in the shape of a W (a "V" if you ignore the small flaring). The best V-nailer for small manufacturers is the ITW AMP Miter-Mite VN42, which costs \$2713.00; it is run by adjustable air pressure, inserts V-nails from beneath the wood, and has a toothed clamp and rubber foot to automatically clamp the joint. To operate this machine, you place the pieces into place against a metal corner backstop, depress the foot pedal to move the sawtooth holdfast into the corner to grasp the wood, move the bar with right hand to position a rubber foot above the nailing site, depress a button with the left thumb to make the rubber foot go down on top of the wood to hold it down, and keep holding the button down to inject the V-nail from beneath up into the wood. The AMP VN Manual is a simpler version without electricity or air pressure that is operated by a foot pedal, and costs \$1095.00. V-nails are made in various thicknesses (3, 5, 7, 10, 12, 15 mm high), but in practice, the short 7-mm V-nails are used for everything, and if the wood is thick a second V-nail is merely inserted in the same place, on top of the first V-nail, as the second drives the first one deeper so that both are equivalent to one 14-mm V-nail. V-nails are used to fasten the corners of picture frames in most large picture-frame shops, because they can be inserted all along the joint—even on picture frames that are 3 or more inches wide that are too wide for nails to reach the inside of the joint—and leave no blemish on the front or side of the frame (because they are inserted on the underside of the picture frame), whereas a brad from a nail gun is so short that it can only be placed in the outer corner of the frame about an inch or less from the corner, and the brad leaves a hole in the wood. However, V-nails are not really suited for making entomological drawers, because they make a large V-shaped blemish on top of the corner of the drawer where the V-nail went in, which must be filled with wood filler, and they produce considerable disruption to the interior structure of the wood. On Baltic Birch this wood filler would ruin the visual pattern of the plies and badly mar the appearance of the drawer top. In contrast, the brad nailer makes only a tiny hole in the wood on the side, which can be filled with cheap wood filler that closely matches the color of the Baltic Birch. Thus the brad nailer is superior cosmetically in entomological drawers, and the reason V-nails are used on picture frames (to fasten the mitered joint more than an inch or two from the corner on wide frames) does not apply to entomological drawers because those drawers have narrow-width sides so that nails can reach everywhere on the drawer frame where fastening is desired. Also a brad is probably just as strong as a V-nail, and results in much less internal disruption of the wood fibers, and the glue forms a large part of the strength of the finished joint anyway (glue fans say that glue is stronger than wood, and the brad is mostly useful only for holding the joint until the glue dries—although when I smash old furniture to recycle the wood, it usually splits at the glue joint).

Silicone Tips. Pure 100% clear silicone is used to provide a seal and cushion in the glass groove. (It is also used elsewhere in the drawer in a later stage of construction, for gluing the foam to the hardboard bottom.). Excess silicone sometimes oozes out of the caulking gun after you unsqueeze the handle, and oozes out of the glass groove when you install the glass. Do not wipe off small amounts of excess silicone, just leave excess blobs of silicone where they are, because your attempt at cleaning will only spread the mess, and it is much easier to remove silicone after it dries and turns to rubber, when light sanding removes it instantly from wood and flings it away, and a sharp chisel run over the surface of the glass removes it very quickly from the edge of the glass. If the chisel is not perfectly sharp and straight, it helps to grind it sharp with a wet fine-grit grinder (the grinding wheel rotates in a tub of water to lubricate the grinding and keep the metal cool)(of course you must grind only the beveled part of the chisel, never grind the flat side). If there is a big excess of silicone, such as sometimes oozes out of the nozzle after you stop squeezing, lift it off with a chisel and wipe it into a square of absorbent tissue and throw it away. After cutting the tip off a new tube of silicone, use a razor blade to make opposite sides of the tip narrower, in order to insert the silicone more deeply into the glass groove. One tube of silicone will last for about 50 drawers when used only on glass grooves. When not in use, store an opened tube of silicone in a freezer, because the low temperature almost completely stops the hardening process. If left out at room temperature, an opened tube of silicone will harden slowly over a period of weeks, so eventually the silicone will be too hard for the tube to be used, and the tube will go to waste. Even after one day, the silicone in the tip may have hardened enough that you will

have to stick the thin wire into it again to create a flow channel. Covering the nozzle with aluminum foil and rubber bands retards hardening a little, but not enough.

Inserting Sheets Into Grooves. To assemble the four sides, glass, and hardboard, you must fit the glass and hardboard into the sawed grooves in the sides. In general, the best way to fit any thin, flat, semi-flexible piece into a groove is not to try to get it into the whole length of the groove all at once, because warping/drooping will prevent easy insertion as the piece catches on the edges of the groove (1/8" hardboard tends to be convex on the smoother side, and single-strength glass droops in the middle a little if you hold it by the edges). Instead, insert one end first, at a slight angle. Start at one end and fit the corner of the glass/hardboard into the end of the groove, maintain pressure at that point, and then press farther on and the glass/hardboard will gradually slip into the groove, straightening itself on the way. Straightening the hardboard/glass with your hands while inserting it also helps. Angle the glass/hardboard into a groove even when an adjacent side of the glass/hardboard is already in a groove; for instance, when the hardboard is already in the groove of the first side, and you want to insert it into the second side, rotate the hardboard (or second side) a bit until the glass is closer to the second side at the corner where the two sides meet, then press that corner of the hardboard into the groove with your left hand and use the right hand to raise the middle and other end of the hardboard, then press and lower the hardboard to make it to slip inch-by-inch into the groove. Try not to force the hardboard/glass into the grooves too much, in order to leave some glue/silicone in the grooves, which will later help to equalize the hardboard/glass in the grooves on all four sides.

Nail Placement. To nail each corner, carefully align the top of the corner, hold it tightly in place, and put a nail there, wipe glue off the top and vertical edge of the corner so you can see the edge, carefully align the bottom of that corner the same as the top (if the sharp end of one side sticks out a bit on the top, then it should stick out the same amount on the bottom in order to make the sides vertical) and place a nail there, place a third nail on the adjacent board above the last, then again wipe excess glue off the corner. If the top is not tight enough, you may want to put a fourth nail there, on the adjacent board. When nailing a corner, do not press too hard on one board only, or the joint will slip out of alignment; try to press equally on both boards, unless you want to force one board into better alignment. The three nails in each corner should be carefully placed, especially the top nail, which should be placed more than 3/8" below the top of side, and closer to the outside than the inside of the recipient side, so that it ends up more than 1/8" below the glass and ~1/4" above the dado groove. A nail placed too high might possibly break the glass, although this has never happened in my experience, and the glass does not extend far into the wood so the nail is not likely to hit the glass, and if a nail hit the glass it would be an oblique blow that probably would not break the glass anyway. A nail placed too low often ends up in the dado groove, where it has to be clipped off with wire cutters and the stump pounded into the wood with a nail setter or screwdriver to get it out of the way (place the drawer top on a flat hard very stable surface such as the top of the table saw while you pound, to stress the glass the least), then the depression must be filled with wood filler, and the excess removed with a sharp chisel. The spot halfway between the glass and the dado groove is about .5" below the top of the drawer, but the aggravation of treating a nail in the dado groove is much greater than the possibility of breaking the glass, so the top nail should be placed closer to 3/8" below the top. The middle nail should be placed about 3/4" to 13/16" above the bottom, to avoid the lower part of the dado recess, and should be placed on the other (adjacent) side than the side in which the lower nail was placed. The bottom nail should be placed about 3/8" to 1/2" above the bottom, to avoid the hardboard groove (where the nail would not cause any damage, but would be useless for holding the drawer together). These desired nail positions could be marked with red lines on the outside of the aluminum walls of the rotating work table (at both ends of each side wall, next to each corner) to help place the nails correctly, although after awhile you will learn to place them in the proper positions automatically. Placing the nails in correct positions prevents time-wastage and later aggravation in fixing wayward nails and possible breakage of the glass.

Assembly Procedure. The drawer should be assembled and dried above the lowest usable temperature of the glue, which is 55° F for the best waterproof Titebond II aliphatic resin (yellow) glue, and 50° F for other aliphatic resin glues (Titebond, Elmer's). If your compressor is stored in a cold place, you could drill a hole through the wall and run the air hose indoors to a warmer place.

The assembly of a drawer, from glass-cleaning to final stacking, takes less than 15 minutes (10 min. when you become expert).

Gather all the pieces for the drawer. Inspect the hardboard for frayed edges (fix these with pliers, chisel, etc.

Clean the glass (see above), and place it onto the hardboard (or other marked board) to see if the glass is cut to the correct size, or is miscut too large or too small. If it is the correct size, pick out two ordinary 17" sides and two 19" sides. If the glass is miscut, you may want to use sides that have a shallower or deeper glass groove, to compensate. But a piece of glass that is cut to the right width and length, but is non-square by 1/16" or so, is still usable because the slop in the glass/hardboard grooves permits some inaccuracy, and the whole drawer can be non-square and still fit properly into the cabinet. Set the glass aside on a soft safe spot, and place the hardboard onto the rotating assembly table.

Dust the four sides and lay them onto a newspaper on a table, a short side followed by two long sides then a short side, all arranged with grooves upward, the tops all in the same direction. If a dado groove is splintered at the end where it will be the drawer top, fix it with wood filler. Use a caulking gun to apply a little silicone all along the glass groove, except at the very end (1/4") of the grooves, because glue—not silicone—should cover the entire mitered surface of each end. Apply

silicone to the glass groove of all four sides now. Then apply a greater amount of glue into the hardboard groove of all four sides. Apply glue to both mitered ends of a short side (you could glue only one end, but then you might forget to glue the other end later, so the best way is to get into the habit of always glueing both ends whenever you pick up a short board), being careful to not get too much glue next to the dado groove (where it will have to be chiseled out later), and place it onto the rotating assembly table in upright position, against the short upright wall. Insert the hardboard into the hardboard groove of that side (twist it to flatten its convexity and angle it into the groove, as above). Place a long side onto the assembly table against the long upright wall, about 1/4" away from the corner where both sides come near, and slide the hardboard into the groove of that side also (angle it and raise the other end, as above), then adjust both sides to make them meet well at the corner. Place a long piece of foam of the right height (~2.15" high, ~4" wide, 2 feet long) onto the hardboard to keep the glass propped up the right height for easy insertion into the glass groove (the foam is 2 feet long so you will be forced to pull it out before installing the last side—a small piece of foam could become forgotten and trapped inside the finished drawer until the drawer dries and is sawed apart). Place the glass on top of this foam, and insert it into the glass groove of the short side (angle it in), then into the glass groove of the long side (reach your fingers under the glass and lift the middle of the glass a little to counteract its sag and get it to fit into the glass groove easily)(with experience, one can start the glass into the far end of the short side, then insert the glass into the corner and long side simultaneously). Adjust the corner perfectly (it is better to align the insides of the two sides at each corner, rather than the outsides, because all the critical dimensions of the drawer involve the inside of the drawer, not the outside, and a small jutting edge on the outside of a corner can be quickly sanded off)(use a strong light here so you can see how the two sides match at the corner) and nail it with the nail gun and 1" brads. Place a long side onto the work table, press it onto the glass and hardboard (the easiest way seems to be to place the end of the long side close to the short side and angle the groove onto the hardboard for two-thirds of its length or more, then raise the middle and end of the glass a bit with your fingers and wiggle it a bit until it slips into its groove, then the side will slide the rest of the way onto the hardboard if it has not already done so), then raise the hinged wall of the rotating assembly table and swing the wall down into place against the side. Adjust the corner perfectly and nail it with the nail gun. Pull the long foam piece out of the drawer without pulling out the glass or hardboard (if it grabs, the foam is too high). Glue both mitered ends of the remaining short side, place it onto the work table, angle it a bit and press it onto the hardboard and glass (this side generally fits easily--although some pressure and slight wiggling may be needed--because the glass and hardboard are now closer to the correct height than before), and raise the hinged wall and swing the wall down into place against the side. Now inspect and adjust these two corners until they match perfectly, and nail both corners.

Rotate the drawer to make sure all four corners have been nailed. Lower the hinged walls and lift out the drawer. Move it beneath a strong light and carefully inspect each of the four glass grooves, to make sure the glass fits well into all four grooves; light reflects from the cut edge of the glass, so you can tell from the shiny reflection how deeply the edge is recessed into the groove; if the glass is not fully inserted into a groove, push it in farther with your fingers, or if this doesn't work lift the drawer vertically so that groove is downward on a table, and knock the drawer down onto the table a little until the glass slides into the groove a little more; if the glass is a bit too small, equalize the glass in all the grooves (the silicone will harden to keep it in place). Now, squeeze both opposite sides inward a little to make any excess silicone ooze out of the glass groove (this will also make the glass fit a little more deeply into the groove), rotate the drawer 90°, and squeeze those sides inward a little; this squeezing works to remove excess silicone from the glass groove that may cause the side to bulge outward a little when the silicone hardens, but is not necessary if you put only a little silicone into the grooves; squeezing a little ensures that excess silicone is removed. Do not wipe off excess silicone, except on the very top of the wood of a side, as noted above. Turn the drawer over and lay it on its top. Remove excess glue from around the bottom of the drawer. Stack the drawer onto others already assembled, upside down so falling objects will not break the glass, and place a newspaper between them to keep glue/silicone on one drawer from sticking to the next. Let the drawer rest for a day or so to permit glue and silicone to harden. Clean glue spills off the rotating assembly table with rag/chisel.

Wood-Filling, Sanding, and Silicone Removal

Use wood filler and a 3/8"-wide putty knife to fill the nail holes on the sides (the brad nailer operated at 90 psi sinks the nail heads about 1/16"), any crack along the corner joints (on outside and top and bottom edges), any holes in the Baltic Birch plys, etc. This takes about 3 minutes per drawer. Let the wood filler dry for a bit (it will be dry enough on one drawer by the time you finish filling half-a-dozen others).

Use a rotary random orbital sander with felt-backed (velcro) sandpaper to sand off wood filler, glue, excess silicone, and other blemishes. Wood filler is easily spotted as a grainy raised patch. Glue makes a yellowish smooth hard blemish. Silicone looks like a darker transparent stain on the wood. Paint will not stick to silicone, so you must remove any excess. The sander instantly removes silicone by grabbing it and flinging it away. A sandpaper grit of about 180-220 works fine to sand wood filler off the wide surfaces of the sides.

To sand the drawer, place it on a soft surface, on one side (the other sides up in the air), hold it upright with the left hand, and sand the side that faces upward lightly with the sander held in the right hand, from left to right. Do not let the sander remain anywhere for long or it will oversand that spot. Edges especially are vulnerable to oversanding, so do not let

more than the margin of the rotating sandpaper hang over the wood edge. The four 2.6" corner edges of the drawer should be sanded very quickly, as follows. When the sander is finished removing wood filler from the nail holes on the right-hand end of one side, move the sander away from you quickly so the center of the rotating disc is nearer the back of the wood and then very quickly move the sander to the right and simultaneously rotate the sander 90° down onto the adjacent side while keeping the rotating sandpaper pressed lightly against the wood, and the sander should now be centered on that side. This maneuver will fully sand the corner very nicely so the two side boards now match perfectly. (You must move the sander backward on the board before you rotate the sander onto the next side, because the orbital disc of the sander spins very fast and acts as a gyroscope, so its precession during the move forces the sandpaper harder onto the corner near you than away from you, sanding it unequally. Moving the sander backward first makes the force act on the middle of the corner. To experience this precession force, just hold the sander in the air, and quickly rotate it as you would on the drawer, and you will feel the rotating disc exert its precession force at a right angle like a gyroscope.) After the sander is pressed onto the new side, rotate and lift the drawer with the left hand (while keeping the sander on the new side) so the new side and the sander are on top, and sand that side.

Now sand the sharp edges around top and bottom by hand very briefly (about one second per edge), to remove small splinters and round the edge just a little. Use flexible cloth-backed sandpaper (do not use a sanding block or paper sandpaper, because these are likely to catch little splinters and tear them back to create big splinters torn off the wood). If you mentally count from 1 to 8 as you sand each of the eight edges, you can avoid wasting time sanding some edges twice.

Now lay the drawer down, so the hardboard is on top, and sand the wood lightly, wherever there is wood filler or glue or silicone or other sandable blemishes (usually the only thing that needs to be sanded is wood filler and glue on the corners). Corners should be sanded to make the surfaces of the two boards flush with each other, by holding the sander so the edge of the rotating disc moves from inside of corner to outside, to minimize splintering (a coarser grit of 100-120 works better here). The Makita variable-speed random orbital sander is very useful here, because it has two handles and can be held with both hands to keep the sandpaper more parallel with the wood surface to prevent damage to the edges, and it can be operated at lower speed (about half-speed, setting #3).

Place the drawer so the glass is on top, and sand the wood like you did the bottom.

Now use a narrow chisel with a nice straight sharp edge to remove silicone from the edge of the glass. Push the chisel over the top of the glass, the flat side of the chisel downward and the side of the chisel resting against the wood, to scrape off the silicone. After you are finished with the chisel, use a sharp razor blade to remove any last bits of silicone from the corners, and to scrape gunk from the glass top.

Brush off the top, and stack the drawer onto others, bottom upward to prevent falling objects from breaking the glass. Sanding and silicone removal take about 5-6 minutes per drawer.

Sawing Drawer Apart (Sawing it into Top and Bottom)

A quality saw blade with many teeth should be used to saw the Baltic Birch Plywood drawer apart. A saw blade that has both sides of each tooth ground sharp and parallel to each other makes a very smooth cut (the sides of the teeth plane the wood), such as the Vermont American #27716 Premier Plus Smooth-Cut Trim 80-tooth Industrial Dyanite Carbide 10" alternate-top-bevel saw blade (kerf ~.131). Other manufacturers make similar planing blades (Forrest makes one, and Systimatic makes the Super Finish Trim saw blade #1910 10SF60-085 10" 60-teeth .131-kerf). Non-planing blades also work. The DeWalt DW3218 Series 40 10" 80-tooth Precision Finish Miter Saw blade (kerf .128) works fairly well and produces few splinters. The Systimatic 1960 Laminate Veneer 10" LV 80-tooth, .085-width/.131-kerf carbide saw blade works, but is harder to push through the wood, and may even splinter the outside corners a bit more often.

At least three **drawer-splitting shims** must be made for proper drawer splitting. Shims can be made numerous ways, but two features must be present: 1) a strip or pin fits into the sawed groove to keep it from pinching shut; and 2) a handle holds the shim while keeping the hands above the saw blade. A shim can be made from a wooden block about 5-6" long, 1 1/2" wide, and about 1 1/4" thick. A strip of aluminum sheet metal (3" long, 1" wide, its thickness a little less than the saw groove [aluminum from recycled >3-mm highway signs with the paint sanded a bit works well for .131" saw blades]) is installed into a saw groove .131"-wide and 3/8" deep using Polyseamseal (Clear) caulking. The wood extends 1" farther than the aluminum strip on each end to keep the aluminum above the saw blade, and a stop can be added at each end of the shim to help keep the hands out of the saw blade. I made some fancy long shims that have multiple features such as a board to keep the hand from slipping into the saw blade and a side flange that keeps the bottom of the drawer from falling backward, but these fancy shims did not seem to work as well as the simple small shims just described.

A **tall rip fence** must be made for proper drawer splitting. This tall rip fence can consist of 3/4" MDF fiberboard, ideally about 15" tall (although 12" will work), and preferably longer than your table saw (44" works fine; most table saws are 27"), kept flat and rigid with a support structure behind it (a lattice of 5"-wide MDF consisting of several long boards connected by about four short boards, all glued together into a bookcase-like lattice). The purpose of the tall rip fence is to keep the drawer top perfectly perpendicular to the table saw surface while the drawer is sawed apart. The tall rip fence should have a horizontal board on the rear that lies on the table saw surface and is clamped to the table saw, and should be shaped so that you can position the clamps well on your table saw surface. Another horizontal board near the top of the rip

fence will help maintain flatness of the rip fence face. Three or four large right-angle pieces must connect the vertical board with the horizontal board to maintain the 90° angle between rip fence face and table saw surface. It is very difficult to get flat surfaces perfectly flat, so after you make the tall rip fence, place a straightedge against its face to check for warping or bulges or depressions, then use 40-grit sandpaper on the rotating random orbital sander to sand the high spots down until it is perfectly flat. My latest tall rip fence has a lattice on the back as above, which rests on a long steel square-cross-section beam, and I use two large C-clamps to clamp the MDF lattice/steel beam/table saw top together. Then I clamp large boards to the table saw behind the rip fence to make sure the setup cannot move. The tall rip fence is the most important item you must have to produce quality splits. When I had a smaller crummy rip fence, my drawers would sometimes be flawed by a gap at in a corner, but this problem never happened after I built the big 15 X 44" rip fence described above.

Set the tall rip fence about 1" from the saw blade on the right side of the blade (the exact distance depends on where the dado groove was sawed, and how tall you want your flange to be in the finished drawer; it was .96" for my last run of drawers). Adjust the rip fence front-to-back until the front of the saw blade (where the cutting takes place) is at the middle of the rip fence (this is especially important if your rip fence is short, only 27"), so the drawer can be held against the rip fence both in front of and behind the blade. Run trial pieces of wood through the saw to measure the distance. Raise the saw blade to about .45" (reaching just above the bottom of the dado groove).

One must carefully use the following procedure using the tall rip fence and drawer-splitting shims to saw the drawer apart perfectly. The goal is to keep the top (future lid) of the drawer firmly against the rip fence at all times while sawing the drawer apart, and keep the bottom of the drawer firmly away from the saw blade in the opposite direction, without either the top or bottom moving laterally into the saw blade and creating a flaw. (A badly-sawed-apart drawer typically has a noticeable ridge on a corner, where one saw cut carved deeper into the wood than the saw cut on the adjacent side, making a gap at the corner between top and bottom, which might have to be wood-filled as noted below.) A careful saw cut will result in a tight fit between top and bottom when the lid is placed onto the bottom, and there will be no gap on the corner. To make this perfect saw cut, one must place shims into the grooves already sawed to keep the saw cut from pinching shut, and hold the shims near the table saw surface, and press the shims against the tall rip fence, to ensure that the top of the drawer always remains firmly against the tall rip fence during each saw cut. (A perfect saw cut also requires that the rip fence be exactly parallel to the saw blade [see Appendix], and the face of the rip fence must be flat.)

To repeat, the drawer-splitting shims serve two functions here: 1) they press the top of the drawer against the rip fence to maintain the alignment of the saw cut (the aluminum strip fits into a saw groove already cut to press the top of the drawer against the rip fence); 2) the aluminum strip keeps the saw cut already made from pinching shut, which keeps the saw blade from chewing/scorching the bottom edge of the saw cut.

Turn on the saw and stand on the left side of the saw. Pick up the drawer, and find the long side that is prettiest (the side you want to be the front of the drawer); you should saw this side first, because the first saw cut is the least likely to chip, and if you saw a long side first then the most difficult last cut will be a short side. For the first cut, place the glassed top (not the hardboarded bottom) of the drawer against the tall rip fence, so one side rests on the surface of the table saw. Grab the drawer with both hands near the table saw top (but above the saw blade), and push the drawer to the left through the saw blade to saw the drawer apart on one side. Always keep the drawer firmly pressed against the rip fence, and push the drawer through the saw blade at a constant moderate speed (not slow). For the second cut, rotate the drawer clockwise 90° to position the next side for sawing, and insert a long shim into the groove just sawed, which is now on the left side of the drawer, and hold it into place with your hand, near the table saw surface. Now, holding the shim with your left hand and holding the other side of the drawer with your right hand, and pressing the shim/drawer against the tall rip fence, push the drawer left through the saw blade to saw the drawer apart on that side. The third cut is like the second cut: rotate the drawer clockwise again 90° and leave the shim in place that now rests on top (you can move it to the middle of the top), insert another shim into the groove just sawed (now on left side of drawer), and saw the third side, while holding the shim with your left hand near the table saw surface, and holding the right side of the drawer with your right hand near the table saw surface, and pressing shim/drawer against the tall rip fence as before. For the fourth cut, rotate the drawer 90° clockwise again, and position two shims on the left and right sides of the drawer, and another shim on top of the drawer, and saw the final side, while pressing the left and right shims in your hands against the tall rip fence. When this saw cut is completed, the bottom of the drawer will come loose and will want to fall backward a little (of course the aluminum on the shims keeps the bottom from moving sideways into the saw blade), so you should lower the whole drawer slowly down toward you almost onto the table saw top. Be careful here not to let the topmost shim come loose and bound toward the saw blade (if it hits the saw blade it will be shot off to where it could break something). Place the drawer down onto a flat surface (an extension wing of the table saw or an adjacent table). Remove the shims, while keeping the top and bottom together (do not rotate the top on the bottom).

Place the whole drawer on a table, without moving the top. Inspect both long 19" sides of the drawer again, and choose which side should be the front (the prettiest side), and which should be the back, and rotate the entire drawer to place the prettiest side in front. Turn the top upside down, while keeping the front forward, and place it on top of the bottom. Use a felt-tipped marker to write a unique drawer number on a permanent list beside the drawer (a piece of 1/4" hardboard makes a

good permanent list), and then use the same marker to write the same number on both top and bottom of the drawer, in the same position on front center (for instance, print the number 352 on the list and 352 on the bottom of the lid and 352 on top of the bottom, so that when the drawer is closed, both numbers come together). The number is necessary to keep the top in the proper position on the bottom (when you pick up a drawer lid, find the number, and place that spot onto the front of the bottom of the drawer, on top of the same number), because the drawer is not perfectly rectangular and the corners are not perfectly perpendicular (due to non-square glass and wood and slightly-warped sides and imperfect mitered joints, etc.), and without the inked number you might inadvertently place the back of the top onto the front of the bottom, and the drawer might not fit together well and might even be damaged by your attempt to force it where it does not belong. You should write the number on your list before you write it on the drawer, because if you write it on the drawer first you might forget to write it on the list, and then the next drawer will mistakenly receive the same number as the last.

Each number you assign must be unique, so the number will help you find the right lid if you later have several drawers open at the same time. And if you move your collection over bumpy highways, the glass could break and fall onto fine specimens and ruin them; to prevent this breakage you could remove the tops of all the drawers and transport the tops in separate boxes, and transport the bottoms in their regular cabinets; after the move, reinstall the tops onto the bottoms, using the drawer numbers to put the tops on their proper bottoms.

Removing Silicone and Glue from Inside of Drawer, and Fixing Flaws

Use a wider (1") sharp chisel to remove silicone from the edge of the glass on inside of top, as you did from the outside of top. The razor blade is not very useful here, because the wood walls are deep so the razor blade cannot get into the corners as well as a chisel. To remove silicone from the corners, use a small probe with a V-shaped metal tip (you could grind a surplus small screwdriver into this V shape). A strong light may reveal silicone still present, which a sharp razor blade can remove.

Use a narrow (1/4") sharp chisel to remove excess glue from the corners of the dado groove, both on the lid and on the bottom of drawer.

If you find holes in one of the plies of the Baltic Birch, now visible after sawing the drawer apart, wood-fill them and chisel/sand the excess.

Sometimes the saw blade tears a splinter off a corner of the drawer. A tiny splinter can be ignored and the spot just sanded a bit, but a large splinter may leave an unattractive edge, which you can fix with wood filler. Use a 1"-wide putty knife to apply wood filler to the space, press it down a little to minimize later sanding, let it dry, then sand both surfaces until the wood filler is flush with the wood. A variable-speed rotary random-orbital sander operating at half-speed with ~200-grit sandpaper is useful here.

If there is a noticeable gap between top and bottom at a corner, caused by faulty sawing the drawer apart (which is in turn caused by a bad tall rip fence—a quality tall rip fence and good shims and correct sawing technique will completely eliminate this problem), spread wood filler onto that corner on the top and on the bottom with a wide putty knife/chisel to cover the approximately 1/2 X 1/2" area, and a little beyond on the lower side, and sand the wood filler until its surface looks flat and the crack is eliminated (place the lid on the drawer in front of a lighted pale background and look through the crack to see where to sand). If you use Elmer's Wood Filler For Heavy Duty Use, the color of the wood filler will be too pale, but you can make the corner attractive by using two colored pencils (light-peach for the lighter plies, dark-brown for the darker plies) to color the corner the same as the rest of the drawer.

If you find a drawer in which the glass has not entered the glass groove completely on one side (caused by poor groove/glass dimensions, and your failure to inspect each glass groove before and after you nailed the drawer together), you can fix it very well with wood filler that bevels outward along the glass to fill the crack. Place lots of wood filler (For Heavy Duty Use) all along the crack, and then run a square-edged putty knife (or any rectangular piece of metal or hard plastic) along the area to bevel the wood filler to make the wood filler as thick as is needed (1-2 mm) along the glass and zero thick at the edge of the wood. To bevel the wood filler properly, the tip of the putty knife should contact the glass, and the wood should contact the putty knife along the edge of the lid. Place wood filler this way on top of the crack and on the bottom. Let the wood filler dry, then use a chisel/razor blade to remove excess wood filler that spread beyond the repair onto the glass (first use a chisel to remove wood filler on the glass away from the bevel, then use a razor blade forced down the bevel and onto the glass to remove wood filler next to the desired bevel and to trim high points on the bevel). You can camouflage the wood filler a little by coloring it with the light-peach colored pencil. This method works well; it is simple and quick and the finished repair is not very noticeable, and seals the glass crack tighter than silicone. Do not try to fill the crack with glue (clear DuPont Duco Cement etc.), or glue a tiny sliver strip of wood such as Baltic Birch along the crack beside the glass, because these procedures are messy and are cosmetically unattractive (a strip of wood beneath the glass looks okay, but would look better if it tapered away from the glass).

Now is the best time to vacuum dust from the drawer, inside and out, which is best done using the brush attachment on a quiet shop vacuum.

Making the Flanges from 1/4" Baltic Birch Plywood

Strips of wood are glued/nailed into the dado recesses on the inside of the drawer side, to form the flanges that stick up from the bottom of the side and fit into the recess on the top of the side.

1/4" Baltic Birch plywood comes in sheets 5 X 5' in size, about .225" thick, that have five plies of birch. It is imported from Scandinavia, and is used for quality woodworking because of its strength and resistance to warping and cracking. The BB quality, which has a few lenticular insertions on each sheet, is more available and less expensive and works well, because these insertions are not unappealing, and the sheet is sawed into little strips anyway so any ugly strips can be discarded.

The flanges should be made after the sides are finished, because the width of the dado groove in the sides, and the kerf of the saw blade you will use to saw the drawer apart, will both affect the width of the flanges that should be made. (The dado groove width minus the saw kerf = the flange height plus about .02" slop.)

The height of the flange affects how tightly the top will fit onto the bottom; the taller the flange, the tighter the fit. Using Baltic Birch, a flange height of approximately .24-.25" seems to work well, making the top fit rather tightly onto the bottom, yet allowing the top to be lifted off with some effort. Using pine, and a flange height of 3/8", makes the lid fit so tightly that it must be pried off with a thin putty knife; the 3/8" flange is great for boxes without glass containing insects inside envelopes, which seldom need to be opened and then can be pried off with a putty knife.

First, sand the inked manufacturer's mark and other sandable blemishes off of each sheet.

Now, each sheet should be rough-sawed across the visible grain, by setting the table saw rip fence at 20" in the middle of the blade, and sawing the sheet into three pieces 20 X 60" in size.

One should now use a quality saw blade to make further cuts in the Baltic Birch. The Systimatic 1960 Laminate Veneer 10" LV 80-tooth, .085-width/.131 (.132 in MDF in my measurement)-kerf carbide saw blade works very well to make nearly perfect edges of the wood. One must adjust the height of this blade carefully to minimize chipping (start with the blade 1/32" above the wood; for top chipping, raise the blade, for bottom chipping, lower the blade). Using this saw blade, each 20 X 60" Baltic Birch piece makes 73 flanges (plus a scrap piece .18" wide), so each 5 X 5' Baltic Birch sheet makes 219 flanges.

Now, each of the 20 X 60" pieces should be sawed roughly in two, parallel to the grain. Set the table saw rip fence at 29.59" in the middle of the blade (edges of the cut cut will be 29.52" and 29.66" using the Laminate Veneer saw blade).

All of these pieces should now be sawed into strips, each strip approximately 21/32" (actually .64") X 20", so the wood grain runs lengthwise along the strip.

The strips form the flanges inside the finished drawer, by filling the dado saw groove that was cut into the inside of each drawer side. Therefore, to set the rip fence setting for the flanges, use the trial pieces you made earlier out of good wood that you ran through the dado saw. Those trial pieces should be placed on the table saw and sawed through the dado groove using the same saw blade used to saw the drawers into top and bottom halves. The two pieces that result represent the lid and the bottom of the finished drawer, so the flanges must be cut to fit precisely into the sawed-through dado groove that now remains in those two pieces when they are pressed together. You must account for a little glue that will be used to glue the flange into the dado groove on the bottom of the side, and account for a slight mismatch in the corners when assembling the drawer, so the flange should be a bit loose within the dado groove. Use trial pieces on the table saw until you achieve a rip fence setting that produces a piece (approximately 21/32" in width, or .64") that fits properly (with the right amount of looseness) into the sawed-through dado groove on the pressed-together pieces.

Several methods can be used to saw the flanges. First, there is the usual method.

To saw the large Baltic Birch pieces into flange strips, you will need a special **flange push stick**. This stick should be approximately 3/8" wide, 3-4" high, and 21" long, and can be made out of any kind of sturdy wood. It should be rectangular in shape, but the wood should stick downward about 3/16" on the inch or two of the end of the stick near you; this downward jog of the stick catches the edge of the Baltic Birch to help push it. The 3/8" width of the stick fits between the saw blade and the rip fence. On top of the push stick you should install other pieces of wood to make it wider and to raise it up into the palm of your hand, to avoid the blisters that an unadorned stick will make in the palm of your hand across from the base of your thumb.

To help saw the flanges, a **saw-cut shim** is useful. Saw a short cut in the end of a piece of wood using the saw blade you are using to saw the flanges. Find or make a small sliver of wood that is tapered a little, and insert it into the groove until it stops (fits against both sides). Wrap electrical tape around the wider end of the sliver just above the groove, then mark and saw off the sliver below the wood and above the tape. To use this shim, start your saw cut through the Baltic Birch, and when the saw cut is about 3 inches behind the saw blade, insert this saw-cut shim into the cut, where the tape will keep the shim from falling through the crack, and finish the saw cut. This little saw-cut shim keeps the wood from pinching together behind the saw blade and thus keeps the saw blade (on the side of the saw blade opposite the rip fence) from chewing a concave fault into the straight edge of the wood; the saw-cut shim allows you to exert more pressure on the board to keep it against the rip fence, without worrying about pinching the saw cut closed. This saw-cut shim helps the most when sawing the first few flanges off of each large piece, and helps prevent occasional scorching of the edge of the pieces that is caused by errant lateral movement of the wood (wood should ideally move straight into a saw blade without

any lateral movement or twisting). This saw-cut shim can be ignored if your saw technique is good, if you hold the flange push stick with one hand to constantly force the wood against the rip fence, and use your other hand to twist the remaining wood to keep the saw cut from pinching the saw blade. Expensive table saws have a curved metal piece just behind the saw blade that keeps the wood from pinching the saw blade.

When you have finished the push stick, you are ready to saw. Place the Baltic Birch on the table saw, all of the end pressed against the rip fence, and place the flange push stick over the end of the Baltic Birch and against the rip fence. Keep one hand on the push stick, and place the other hand on the lower base of the Baltic Birch, about a third or halfway out to the end of the piece. Now move the Baltic Birch forward into the saw blade, keeping it against the rip fence, exerting most of your force on the push stick, and exerting only enough force with your left hand to keep the piece against the rip fence and keep the saw groove behind the cut uniform in width. As the saw cut progresses toward completion, less force will be needed from your other hand. And as the Baltic Birch shrinks in size with each cut, your other hand will need to exert less force, and your hand can be brought closer to the saw blade. Practice will show you how to make nice cuts.

If you have a large quality squaring sled (such as the 24 X 25" squaring sled detailed in the portable cabinet paper), you can use it to make the flanges. Simply place the sled onto the table saw, place the plywood onto the sled, and move the plywood past the line of the saw blade until it hits a stop that sets the proper width of the strip (a block clamped to the table saw that is set for distance like the rip fence above). Then, merely hold the plywood onto the sled and push the sled to saw the strip. The only problem with this method is that it becomes difficult when the plywood is nearly completely sawed, because then the plywood is difficult to hold square on the sled. The last pieces would have to be sawed using a rip fence, as above.

Rounding One Edge of Flange

If the outer upper edge of the flange is not rounded a little, the drawer lid will catch on the flange, and as a result the lid will be difficult to put on and the lid will tear the top of the flange a little. So the outer upper edge of the flange should be rounded a tiny bit, so the lid fits easily onto the bottom.

The flange needs to be rounded very little to work properly; in fact without looking closely you will not be able to see the rounding at all. The rounded area on the finished flange should be only about 1/32" wide in top view and only about 1/16" high in side view. To remove this tiny amount of wood, a 1/4"-radius corner-rounding router bit should be used, installed onto a router table. The router bit should be raised until the bottom of its ski-slope cutter is almost flush with the router table top, and then the router table fence should be adjusted so that only a tiny amount of wood is removed.

To round the flange precisely and safely, you must make a **rounding push stick**. This stick should be about 3/4" high, about 3" wide, and about 20" long. It should be used flat on the router table, and the flange should be laid flat on the router table also, so the lower rear edge of the push stick, all along the push stick except for several inches on the right end, should have a recess about 9/16" wide and 7/32" deep into which the flange fits. The unrecessed end of the push stick serves to push the end of the flange into the router bit. The recess can be made by another router bit, or can be made by gluing plywood onto the bottom of a piece of wood.

To minimize sanding/filling of flaws on the flanges, you should now perform **triage**—inspection and sorting of the pieces based on their condition--on your flanges. The goal here is to place the ugly spots and imperfections so that they will be glued into the dado recess on the bottom of the drawer and will never show on the final drawer. Grab 20 or so of the flanges, place them on a table that is positioned just to the right of your router table, and arrange them edge-upward. Inspect them for flaws such as dark knotty laminations or holes, or spots scorched red-brown by the saw blade. Pick out each ugly piece and look at the opposite edge to see if it looks better, then place the good edge upward. After all the pieces have been arranged with good edge upward, if there are still holes or blemishes, hold them together and wood-fill the holes and sand the filler and blemishes. Now place all the pieces flat onto the table, good edge to the rear, and inspect the sides. Any flange that has an ugly side should be turned over—end-to-end, placing the ugly edge beneath where it will mostly be glued into the dado groove—so that the nicer side faces upward. If the top rear edge of a piece is ragged, place it downward to be rounded. Now, your flanges are all arranged with nice edge to the back, and good side upward, just the position that they will be used on the router table.

To round the edge, move the flange to the left onto the router table, maintaining its orientation of course, so that the top of the flange—the good looking edge you just selected--is against the router fence, and the to-be-glued side—the uglier side you just selected--is facing downward. If the edge does not fit perfectly against the router fence (is chipped), try turning the flange end to end--keeping the ugly edge against the router fence—to see if the other side is straighter (the chipped edge is best treated by rounding it with the router bit). Place the rounding push stick over the flange, so the flange fits into the recessed part of the underside of the push stick. Press the flange against the router fence with both hands and quickly move the push stick to the left past the router bit, which is rotating counterclockwise from your point of view. Place a table or some other catching device to the left of your router table to catch the finished pieces.

Installing Flanges into Bottom of Drawer

Check for excess glue/splinters etc. in the corners of the dado groove, and remove any you find.

Place the flange on the table saw on a good right-angle jig (a miter-gauge or squaring sled, etc.), and trim one end of it square (it's faster to trim four flanges at one time, rounded edge downward to minimize splintering). A quality crosscut blade, such as the Systimatic 100-tooth 1250 precision trim alternate-top-bevel 10" blade with .085 plate/.131 kerf (.132" in MDF in my measurement), works very well; if you push the flange slowly past the blade very few splinters will come off. Most saw blades with a lot of teeth will work fairly well. Rotate the drawer until the left side is near you. Place the squared end of the flange into the recess on the bottom of the drawer, against the left end of the recess, and use a pencil to mark where the right end should be trimmed. Trim that end to length with the table saw (trim it a tiny bit larger rather than what appears to be exact size, because you can shorten it with the table saw later, but cannot lengthen it—if you saw it a bit too short, it will probably fit on another drawer, or if not you can even splice it with another too-short piece to create one flange out of two pieces, which works fine), and place it into the drawer to see if it fits. It should fit without a space at each end, and should fit snugly, but not very tightly because glue will be used to fasten it on both ends. If it is too long, keep sawing it a bit shorter until it fits nicely. Do the same for the flange on right side of the drawer, and insert it into place. Now trim the flange for the front of the drawer, while the left and right flanges are in place and pressed against the sides. This flange should fit more loosely, because four layers of glue will constrict its length when installed, and neither end will touch the drawer top anyway, and any space beside the end will later be filled with wood filler anyway. Trim the flange for the back the same way. Leave all these flanges in the drawer where they belong. Repeat this process for many drawers. You can stack them on top of each other—flanges still in place—up to about 25 (fewer if your wood is soft), if each is rotated a little compared with the drawer beneath, and the lid is rotated compared to the bottom (stack the lid below the bottom, so that falling objects will not break the glass). Fitting the flanges into the dado recess this way takes only a couple minutes, and is actually one of the most enjoyable tasks in making the drawer.

Now nail/glue the flanges into place. Place the drawer bottom on a table, the front forward (the inked drawer number forward). Remove the front flange from the bottom, and place it in front on the table, remove the back flange and place it in back, remove right flange and place it to the right (laid on top of the front and back flanges), and finally remove left flange and place it to the left (laid on top of the front and back flanges). Always maintain these same positions of drawer and flanges when you do remove the flanges, to avoid making the mistake of trying to install a flange into the wrong recess where it will not fit precisely. Each flange was individually sawed to fit into its own recess, and should not be placed in any other.

Now move the drawer to the work table, inspect each corner where the flanges will be to make sure that all glue/splinters are removed, and remove any dust. Place the drawer so that the left side is on the edge of the table top (so the right side is 19" up in the air). I now place the flange to be installed in the proper position just behind the drawer. Place a bead of glue all along near the front of the recess, and spread it with your finger and fingernail all over the recess, including the ends of the adjacent recesses where the ends of this flange will press, and the front and back of the recess. Pick up the flange for the left side, find the rounded edge on it, and orient that rounded edge in the proper position (toward the top and outside of the drawer), then press the flange into place. Lower the drawer down onto the table, and squeeze hard on the flange all along its length to squeeze out excess glue and make sure the bottom of the flange is fully pressed into place both toward the bottom of the drawer and especially toward the side (if the flange is not vertical, then the lid may fit too tightly and you will have to scrape/sand the outside of the flange to loosen the fit). Raise the drawer back up again and nail the flange using the brad nailer and five ½" brads, while pressing the flange into place with your fingers and the nailer. (If you have made the sides out of soft wood such as pine, the ½" nail will occasionally reach within about 3/32" of the outside of the drawer and may occasionally blow out the wood at that point to create a low little wood hill; to help prevent this, angle the nail by lowering the back end of the brad nailer so that the nail goes in at a 20-30° angle, and lower the pressure on your air compressor to about 60 psi. This blowout problem never occurs on harder woods such as Baltic Birch, which you should use, but even for this wood the best pressure may be only 60 or even 50). Wipe off any glue that appears on inside of drawer.

Rotate the drawer 180° and repeat the same process to install the right side flange. Rotate the drawer counterclockwise 90° and install the front flange, then rotate it 180° and install the back flange.

Now, remove all glue that has oozed out around the flanges where the lid will fit. Lower the drawer down onto its bottom, and push a wide (1 ½") slightly-dull chisel along the flange joint to remove excess glue. Remove glue from the right side first (because it is now on the right side on the table), then turn the drawer to remove glue from the front, the left side, then the back. Use a wide (1 ½") chisel to remove most glue because it is visually easier to align parallel to the wood than is a narrow chisel. The chisel should have a nice straight edge with no nicks, but the edge should be a little dull, because a really sharp chisel will gouge the wood. Orient the chisel with flat side downward on the top of the drawer beside the flange, the edge of the chisel against the flange, and push the chisel forward so that the front ramp of the chisel scoops up the excess glue. Wipe the glue off the chisel with a rag, or with another chisel when it becomes encrusted. Rotate the wide chisel and place the flat bottom against the vertical outside of the flange and remove the glue again. Pull a smaller (1/2") sharp chisel toward you along the joint on both surfaces to wipe any remaining glue from the joint (be careful not to tear splinters off the crosscut edge of the wood; you can prevent this by placing your other thumb there to stop the chisel from hitting the vulnerable edge). (Do not use cloth to wipe off glue, because cloth spreads glue around as much as

it removes it, and cloth sometimes catches wood splinters and tears them off; a chisel does a better job of removing glue.) Remove glue this way from all around the drawer.

Install a 1 1/2"-diameter sanding tube (the kind that fits onto a rubber cylinder that has a metal shaft, and is tightened by a machine screw at the end) into a variable-speed reversible 3/8" drill. Use this sandpaper/drill to slightly round the four corners of the flanges, where the ends of the flanges were trimmed by the table saw and thus were not rounded. To do this, place the drawer on the rotating assembly table, place your left forearm on drawer bottom, left fingers supporting the drill just basal to the chuck, right hand on drill handle, and angle the drill so that it rounds the upper outer edge of the flange ends. This process rounds the end of a 1/4" piece of plywood, so to minimize splintering, when the corner is aimed away from you, if the outer surface of the plywood is on the left, set the drill in the reverse position to avoid splintering the wood fibers at the corner; if the outer surface of the plywood is on the right, set the drill in the forward position; this procedure takes the least amount of time if you have the drill set on reverse and round the far left corner (when drawer is set on rotating assembly table with front or back forward), switch drill to forward and round far right corner, rotate drawer 180° on rotating assembly table, round far right corner, switch drill to reverse and round far left corner, then leave the drill on reverse for next drawer. A new sanding tube requires only a few seconds at low speed to sand the corner, while an old worn tube requires much longer. You can use an ordinary coarse file to round the ends of the flanges, but a file requires more time than the sanding tube.

Place the drawer somewhere to dry, the drawer top beneath it, each drawer rotated 10° compared to the next (do not fit the top onto the bottom before the glue dries, or the flanges might become dislodged or the top might become glued stuck to the bottom). You can stack other drawers on top of this one, up to 25 drawers in the pile, without damage unless your wood is soft like redwood or soft pine.

Nailing/gluing the flanges in place takes about 10 minutes.

Fitting Lid Onto Bottom of Drawer, and Final Inspection

First, make sure there are no small obstructions in lid or bottom that would prevent the lid from fitting well onto the bottom. Inspect all four corners of the dado recess in the lid, and chisel away any obstructions such as excess glue and splinters. Wood filler that is too high can be sanded or scraped down with a razor blade. Wood-fill any cracks or holes you find, and use a 1/4"-wide chisel to remove excess wood-filler.

Inspect the flanges on the bottom of the drawer. If adjacent flanges do not fit tightly together, wood-fill the crack between them, and wipe off the excess. Wood-fill other cracks beside the flanges, sand off the excess wood-filler, and fix other flaws. Run a 1/4"-wide sharp chisel lightly along the edge of each flange to remove glue balls (formed by excess glue) etc. on the flange; you can feel any bumps that occur, and then inspect and scrape off those bumps (do not pull off splinters at the end of the flange). A file that is square in cross-section, with the file grooves only on two of the four faces, is useful to smooth glue and wood filler on the outside of the flanges, because the file can work on the flange while the smooth side rests on the top of the side (such files are hard to find; I found an "O Nicholson X-F Made In USA" file at a flea market that works well). An ordinary large file with ridges also on the edge can be used.

The top should fit onto the bottom perfectly and tightly, but you should be able to pry off the lid with your fingers without too much difficulty (this excellent result will occur on ~98% of the drawers if you installed the flanges properly). Place the top onto the bottom (making sure the numbers on top and bottom are both in front of course), press it gently into place, and see if it has the proper tightness of fit. Do not force it if it does not fit readily. (If the lid becomes stuck and you cannot pry it off with your fingers, insert a razor blade or thin putty knife into a crack and work it around the drawer to pry off the lid.) If it is too tight, and you have removed obstructions such as excess glue, a too-high application of wood filler, etc., the most likely reason is that the bottom of one flange was not pressed into the recess of the side tightly, causing the flange to be angled outward beyond the vertical, so that the overhanging flange catches the lid. Find out which side is too tight by placing the top onto the bottom in all four different ways (in other words, place the left side of lid onto the left side of bottom, while the right side of lid stays up in the air, to see if the left side of the front or rear flange overhangs too much, then repeat the process on the other three sides). Or, if the lid is already on the bottom, lift all four sides of the top in turn to find out which side is too tight. If the left side is too tight for instance, it means that the left side of the rear flange or the left side of the front flange overhangs too much. Inspect the suspected flanges to see if they are noticeably non-vertical, and inspect the matching recesses to see if wood filler must be scraped down there. Scrape the overhanging flanges by pulling the edge of a sharp narrow chisel toward you to remove enough wood from the outer upper side of the bad flange, until it becomes vertical and the top fits properly onto the bottom (this is dangerous because the chisel can come off the flange and head toward your other arm, so you must wear chisel-stopping gloves on both hands and keep your other arm a foot away) (a file works less well to plane the flange, but helps on the corners). If more than one flange overhangs, fix them all until the top fits well.

(The current method of making drawers always produces a tight-fitting drawer. But if you use some other—bad--methods for making drawers, the top may fit too loosely onto the bottom, so loosely that it may even knock. So here is a tip that helps fix loose-fitting knocking drawers. Paint the outside of the flange or inside of recess--or both--with Polycrylic or other varnish, and let it dry. The fit will be tighter. Keep painting and scraping until the fit is good.)

With the lid now correctly installed, inspect the crack all around drawer where top meets bottom. If the crack is more than a hairline crack, the reason is that a flange was sawed too high, or was not pressed downward enough into the dado recess toward the bottom of the drawer, and therefore sticks up too high. The solution is to sand the top of the flange, and try the top again, until you get a hairline crack. (A wide crack only at a corner, but not along the sides, was produced when you sawed the drawer apart, because of a faulty rip fence or faulty sawing. Use wood filler on top and bottom to reduce such a crack, as detailed above.) The edge of a flange is only ¼" thick, so it will sand very quickly, so to avoid oversanding it with the rotary random orbital sander, place the sander on top of the flange while off, use your finger to turn the sander on, sand very briefly, then move the sander fast to another spot or remove the sander quickly. Or (better) use a sander that has variable speed, and run it at medium speed to avoid oversanding.

Vacuum the outside of the drawer with a brush attachment on the end of the vacuum hose, and fix any flaw that you see with wood filler etc. Place the drawer in a dustless area in preparation for painting. Do not place it into the cabinet prior to painting, or the aluminum runners may make a bluish-gray smudge on the bottom.

Varnishing Drawer

One could paint the drawer prior to sawing it apart, but the process of sawing it apart and installing flanges may introduce blemishes in the paint. So it seems preferable to finish the woodworking completely before painting the drawer.

The rotating assembly table also works great for painting, if you place a support on it to raise the drawer above the aluminum walls, plus a wide sheet of plastic or wood etc. to protect the table and support from paint drips.

Painting supports can be made that fit under each drawer during painting. These supports can be made from ¼"-thick hardboard (surplus boards from making cabinets). Each support consists of two pieces 14" X 3", and two pieces 12" X 3". To fit these four pieces together, saw a groove halfway across the width of the piece 1-1 ¼" from each end (the groove ¼" wide and 1 ½" deep—carefully make the thickness of the groove equal the thickness of the hardboard), so that the four pieces interlock together fairly tightly and can be disassembled and stored compactly when not in use. (WARNING: the support may become varnished stuck to the bottom of the drawer, and may suddenly break free and crash down and break something such as the glass on the drawer beneath; so when you lift a dry drawer off a support, first grab the support and move it and the drawer to a table, then hold the support down with both hands and pry the drawer upward with your wrists, to make sure that the support has not become stuck to the drawer bottom.)

Polyurethane (gloss finish) "varnish" with paint-thinner base works well, can be applied a little more thickly than some other finishes (the label suggests only two coats, versus three for polycrylic), and is 2/3 the price of polycrylic. And the label does not mention that it must not be applied below a certain temperature, so it can evidently be used during low winter temperatures (outdoors). Drawbacks are that it takes longer to dry, turns a bit yellower than polycrylic with age, requires ventilation due to toxic chemicals, and clean-up requires mineral spirits/paint thinner. Never shake the paint can (stir it with a stick instead), or tiny bubbles will be introduced that will stay in the paint as you apply it and will dry into tiny little bumps that must be sanded off. A foam brush may apply it more evenly than a regular brush.

Water-borne Clear Varnish (gloss-finish) works well. Polycrylic is the most available and works well, but is a little watery and requires more coats. Other brands (more expensive?) may require fewer coats (Mantrose-Haeuser ultra-quick 15 II-gloss is excellent and requires only two coats). Water-based polyurethane is also available and looks the same (milky bluish). Water-borne varnish dries quickly (the best feature), remains clear, and has easy water clean-up. However, the Polycrylic label mentions toxic chemicals that require ventilation, and states that it should not be used below 50°, so the paint is usually unusable during the winter (when it cannot be used indoors due to toxicity, or outdoors due to low temperature). I have tried satin-finish and gloss-finish polycrylic, and like the gloss-finish results a little better; the gloss finish is shiny enough to look and feel nice yet is not slippery enough to slip out of one's hands.

First, use a 4"-wide paintbrush or vacuum to remove dust from the outside of the drawer.

The clear "varnish" should be applied with a brush, to the top, outside, and bottom of the sides. Place the drawer upside down by resting the glass on a support. Use a small ordinary paintbrush to slop a lot of varnish into the crack where the hardboard fits (to make sure the crack is sealed), onto the bottom of the wood sides, and onto the hardboard for up to an inch (because your fingers will contact this area). (If the hardboard is non-fuzzy, less varnish will be required, and the fuzz will not come off and spread to the rest of the drawer on your paintbrush.) Use the polycrylic brush to wipe off drips that run down the sides. Now, turn the drawer over (handle it on unvarnished spots on the sides with your thumbs, and make sure the lid does not come off while you rotate the drawer over) and place it on the same support so the drawer rests only on the unpainted hardboard. Varnish all four sides with the polycrylic paintbrush, rotating the drawer to varnish each side. After you finish each side, paint the adjacent top by moving the side of the bristles sideways along the top (which keeps paint from running onto the glass), then run the tips of the now-drier bristles along the top to smooth the paint. Put a little more paint on the brush and paint each side again (in the same sequence). When you finish each drawer, inspect it and brush off excess varnish such as drips beneath the corners (corners and the underside of the corners frequently accumulate excess paint that slops over the edge, so when you paint an edge, wipe off the paint that slops over).

If you are applying the second (or third) coat to the drawer, let the first coat dry the proper time (several hours for polycrylic at warm temperature), then simply place the drawer upright on the support, varnish the front, then use the side of

the brush to spread varnish on the top and bottom edges of that side, then smooth the varnish with the tip of the brush. Varnish the other three sides the same way. If the paint is watery (and will not make a thick coat) you might add varnish to all four sides again. Inspect all sides and underside for drips.

(One could apply varnish down to the glass, but this requires later use of a razor blade/chisel to remove the varnish from the glass [varnish removes fairly easily], and that area will almost never be touched anyway. One might possibly varnish the glass crack in hopes of sealing it, instead of using silicone, and one could even varnish the inside of the drawer including the glass crack [with great difficulty], for the same reason and to perhaps help reduce the harmful effect of high humidity on the drawer, but that does not seem necessary, see below).

Varnishing may reveal blemishes on the wood, including pale/yellow glue spots or dark dirty spots or bluish-gray aluminum smudges, which should have been sanded off earlier. To remove these blemishes during painting, just take a single-edged razor blade and scrape the wood—including the wet varnish—until the glue or dirt or smudge is no longer visible, scrape off the mess with the razor blade and wipe it off, then revarnish the spot. The drawer should be dry before placing it in the cabinet, or the aluminum runners may produce bluish-gray aluminum smudges on the underside of the drawer that you may want to sand/scrape off.

The lid should be kept on the bottom while painting, for two reasons: 1) to keep the task of painting simple, and avoid the bother of painting top and bottom separately; 2) to prevent paint blobs etc. from getting onto the wood where top fits onto bottom, which would cause the crack between top and bottom to widen and thus ruin the tight fit of the drawer. If you varnish the finished drawer with lid set on the bottom, the varnish will creep into the crack between top and bottom a tiny bit to seal it, which improves the tightness of fit (as noted above, a bad drawer made with inferior methods may have a loosely-fitting lid that knocks, and you can paint the inside of the recesses and flanges to make the lid fit a little tighter.). However, one must pry off the lid soon after painting, or the drying varnish will stick the lid tightly to the bottom. With polycrylic, four minutes or less seems to be about right at 50-60° F, and perhaps only two or three minutes would be best in 80° dry weather. One should clip a cheap digital kitchen timer to one's pocket to beep the proper time, at least until you get used to the procedure, when you can train yourself to pry the lid off of the last drawer right after you finish painting the next drawer. To pry off the lid, insert a razor blade into the crack at a corner to break the seal, twist it a bit to pry the lid apart there (remove it if you can't pry the lid easily, and shorten the time until you can pry the lid apart a little by twisting the razor blade with some force), then insert a very thin-edged wide putty knife (an old one, which has been used so much that the blade is worn into a sharp knifelike edge, not a new one with a thick edge) into the crack (farther away if the crack is already open) and twist it to lift the lid a little there, lift the drawer lid and insert the other hand into the lid and lift the rear off the bottom until the lid is free, then rotate and lower the lid obliquely onto the flanges until the drawer dries. Grab the support and carry the drawer somewhere to dry. (If you forget to pry off the lid and the paint dries, use the same process of razor blade and putty knife to pry off the stuck top. This procedure is much more difficult after the paint dries, because a lot of force is needed to insert the razor blade and to pry with the putty knife, and the lid finally breaks free with a loud crack, giving one the unnerving thought that the glass might break.)

Two generous coats may be sufficient to make the drawer look and feel nice, using the above method (which paints each side twice in rapid sequence), if the varnish is good (an "Ultra Quick" gloss water-borne clear varnish), but ordinary Polycrylic usually needs three coats because it is rather watery, and after only one coat the surface still feels rough due to the wood grain fibers being insufficiently covered. The can label for Polycrylic recommends three coats; the label for polyurethane recommends two coats. If the surface is rough, one can scrape it lightly with a razor blade a few times to remove the bumps. One should **NOT** try to give the drawer an ultra-smooth finish, like that on a fine piece of furniture that is achieved with multiple cycles of varnishing and 400-grit sanding or fine-steel-wool rubbing, because such a smooth drawer would be likely to slip from one's hands and fall and break the glass or break the valuable specimens inside the drawer. The thicker you apply a coat of varnish, the more it will run, so to make a furniture-quality finish one should apply one brush stroke of varnish to each spot (never backtrack over the same spot), let it dry, sand it smooth with fine sandpaper/steel wool, then repeat this process multiple times, until the finish is thick and perfectly flat and glassy smooth. I have admired that kind of nice thick smooth finish on some commercial drawers, but I would never put my specimens into drawers with a smooth slippery finish, and do not want to sand and apply multiple-coats that just make the drawers slippery. However, a nice coat or two of gloss varnish without sanding, makes the drawer look and feel nice, with a mostly smooth shiny coat that is not slippery.

One could varnish the inside as well as the outside of the drawer, in hopes that this would seal the wood and prevent damage from high humidity (and one could varnish the glass crack outside and inside the drawer to seal it too). However, humidity damage to wood generally takes the form of causing a large structure such as a door exposed to rain and hot sun to split apart where two wood pieces join together; it does not generally cause such damage to narrow pieces of wood such as these drawer sides. And plywood such as Baltic Birch would not tend to split anyway because of its many plies joined at right angles. And the 11 plies in 5/8" Baltic Birch plywood are glued together with impermeable resin that moisture cannot penetrate; so humidity damage to this plywood will be small. Also, some humidity may be protective to wood and keep it from shrinking and splitting, and indoor conditions are not as extreme as the outdoor wet-cold to hot-dry cycles that truly damage unprotected wood. So, overall, painting the inside of the drawer (especially on Baltic Birch) does not seem to be

necessary, and commercial drawers are not painted on the inside or on the surfaces where lid contacts bottom. Painting the flanges and recesses cannot be done with the current method of making drawers because this method already produces a tight fit, and painting the recesses and flanges tightens the fit so the lid would not fit on the bottom at all. And the current method gets a little glue near the flanges which—even though wiped off—would produce blemishes when painted with polycrylic. To make tight drawers while painting the inside and the flanges/recesses, would require repeated cycles of painting and scraping until the right tightness of fit is finally achieved, or would require a different method of construction (the bottom could be fully constructed then painted, then the lid boards could be sawed and painted then carefully miter-sawed to match the bottom); the effort is too much for mass-producing drawers, and seems unnecessary anyway.

Painting a drawer takes about 5-6 minutes for the first coat, and about 4 minutes for each additional coat.

Brush cleaning. When cleaning a paintbrush, a wide brush with metal wire bristles that are each bent in the middle (sold as cat brushes and dog brushes in pet stores; a brush made for cleaning metal files is similar but has bristles that are a little too short) works well to help remove the paint that hardens between the bases of the bristles and eventually makes the area bulge outward; wiggle the metal brush into the bristles there and then pull it toward the tips of the bristles to remove some of the hidden paint. (The comblike product sold for this purpose in hardware-type stores is useful only to rake paint blobs from the cat brush; it is useless to clean a paintbrush.)

When the brush dries after cleaning, the outer bristles may splay outward, and they remain splayed out for a long time when you reuse the brush, which is annoying and wastes paint; to fix this, simply place a rubber band around all the bristles (about halfway outward from the base of the bristles), and leave it on while you are painting, which keeps the bristles nicely tamed in place. This rubber band frequently moves distally and has to be repositioned, so you can hold it in place by using wire bag-twisters wrapped around the handle and hooked onto the rubber band.

Installing Brass Pull/Cardholder Fixture

The most useful simple brass fixture is a cardholder that also has a pull tab curling forward on the bottom, a bit more than 3 1/2" wide by a little less than 1 1/2" tall. It is attached by a screw on each side (#4 X 3/8" pan-head brass sheet-metal screw)(more-expensive fixtures have a third screw on the bottom). (The holes in about half the fixtures I received were too small for the screws to fit easily, so I enlarged the holes with a 1/8" drill bit, then removed [deburred] the jagged edge of the rear of the drilled hole by running a 3/8" drill bit on the hole for about 1/3 second. Check to see that your screws are present and are the right length, as some screws I received were too short or were missing.)

This fixture should be installed, using two supplied screws, on the middle of the lower part of the front of the drawer, equidistant from both sides. Rather than waste time measuring the right spot on each drawer, you should make a **plexiglass drill guide**. Obtain a piece of 3/8"-thick clear plexiglass or similar clear plastic, and use the table saw to trim it to exactly 2 1/2" wide and 19" long (the exact size of the front of the drawer)(a triple-chip saw blade works well to cut plastic, such as the one described above to cut the glass groove). Now, measure exactly where to put the brass fixture on one drawer, place the fixture there briefly, and mark the two screw holes with a pencil through the fixture onto the wood, so that the two drill points are marked in pencil on the wood. Remove the fixture. Place the plexiglass onto the front of the drawer so that it is flush on all edges with the drawer, and clamp it. Using a felt-tipped pen, mark the position of the two drill holes exactly onto the plexiglass. Place a brass fixture onto the plexiglass to check your marks. Remove the plexiglass, and drill a quality hole (vertical, ideally using a drill press) with a #44 drill through the plexiglass at both marked points.

Now, whenever you want to install the brass fixture, simply place the drawer flat onto a table, place the plexiglass drill guide on the front of the drawer, and clamp it lightly into place (Quik-Clamps that have a 17" grip and rubber grippers work well, and permit you to move the long bar of each clamp against the drawer side to automatically position the ends of the plexiglass flush with the sides). Now, use a drill that has a drill stop on it (the Makita 1/4" electric drill [model 6501] is ideal, because it has a steel rod with a rubber tip that slides out and can be clamped into place using a wing nut to ensure that the #44 drill bit goes only 11/16" into the plexiglass/wood [3/8" through the plexiglass, and 5/16" into the drawer], and it rotates fast at 4500 rpm to make a nice hole.) Or, one can use some kind of stop on the drill bit itself to make sure that the drill bit stops 5/16" into the wood. Now drill the #44 drill bit through the holes in the plexiglass and into drawer. Loosen the clamp 1/2", remove the plexiglass drill guide, and brush the sawdust from around the hole.

Hold the brass fixture front-upward, and place the two screws into place in the holes, hold the left screw in place with your hand and insert a Phillips-head screwdriver into the other screw's head, place the brass fixture onto the drawer front, and hand screw the two wood screws into place just enough so they grip the hole. Inspect the position of the fixture on the drawer (one fixture I received had a misplaced hole that I had to redrill to make the fixture fit properly). Then use a battery-operated drill/driver on its lowest clutch setting to screw the fixture securely onto the drawer (practice on scrap wood first to see if your drill/driver clutch will work, because a Makita 14V drill/driver on clutch setting #1 is gentle and works fine, with a #1 Phillips-head bit, but the lowest clutch setting on the Makita 9.6V drill/driver is too strong and strips out the hole). Do not overtighten and strip out the hole (if you strip the hole, fill it with glue and the shaft of a toothpick, break off the toothpick, use a razor blade to cut the stump flush with the wood, and reinstall the screw gently). The X-shaped recess in phillips-head screws and the X-shaped tip of screwdrivers/bits have a tendency to strip out, which can be

prevented by inserting the screwdriver/bit into the screw fully (correctly), and by pressing hard to keep the screwdriver/bit from coming loose and acting like a drill bit.

With the plexiglass drill guide, installation of the brass fixture takes exactly 2 minutes.

One can use thin paper or very thick cards as labels inside the brass fixture. A problem is that a piece of paper or even a fairly thick card can slip out the bottom of the fixture. (Some brass fixtures have a third screw on the bottom to prevent this, but that fixture is too large to install on the Cal Academy Drawer.) So use very thick cards. An inexpensive solution is to use white ordinary paper as labels, about 2.83" wide (a third of the width of typing paper) X 1.5" high, and insert each one into the opening until about 1/8" is above the top of the brass fixture, then fold the paper down over the fixture so that the fold keeps the paper from slipping out the bottom; the fold can be grabbed to remove the label to changing the writing.

Some brass fixtures have the bar across top bent inward so that the label cannot be inserted. To bend the bar outward, just insert a 1 1/2"-wide putty knife into the top of the fixture, and twist it to bend the bar.

Installing Foam Pinning Bottom into Drawer

Four steps are required to install the foam: select the proper type of foam, cut the foam to the right size, apply the proper adhesive to the hardboard bottom, and press the foam into place.

Selecting the Type of Foam. The ideal substance for holding pinned insects is easy to pin into; holds the pin tightly; does not show the pinhole when the pin is removed; keeps its integrity despite a dozen or more pinnings at the same spot; is not harmed by mothballs, fumigants, solvents in adhesives, etc.; and is inexpensive. The perfect pinning substance has not been found, as the best ones violate at least the last trait and are expensive. However, some pinning bottoms are much better than others. Cork and Celotex work, but are so tough to pin into that they cause pain in the fingers; cork crumbles, and Celotex shows the pin holes. Even styrofoam holds a pin well, but is destroyed by a few repinnings and by solvents (one teaspoon of gasoline or acetone etc. will dissolve an entire ice chest).

Elastic foam has proven to be the best pinning bottom. It is difficult to choose a suitable foam among the many available products, because densities and thicknesses and colors are limited, many products are limited in availability and a customer must purchase an entire manufacturing run to get any, it is difficult to find samples to look at, sources are few and are widely scattered across the country so one must deal long-distance with companies a thousand miles away, etc.

Many kinds of foam are currently manufactured. The cheapest is ordinary transparent very-large-cell polyethylene foam, which can be bought in giant rolls at a very inexpensive price (24¢/square foot for 2.2 lb./cubic foot white foam 1/4" thick in a roll 48" X 250'). This cheap foam does work well to hold the pin of a large insect; however a dozen repinnings at the same position on the foam largely destroys the foam at that spot (but it is easy to peel off bad foam from the bottom of a drawer, and reinstall new foam). 3/8"-thick clear very-large-cell polyethylene foam holds the pin a little better than 1/4" foam but is also destroyed by repeated pinnings. Foam with finer pores is better, such as Volara foam, 2.2 lbs./cubic foot of white foam with a smooth grainy surface, which holds the pin fairly well, and costs only about 30¢/sq. foot for 1/4" thick foam, and costs about 60¢/sq. foot for 3/8" foam, but the pin hole remains as a visible pit after the pin is removed. Volara of density 4.0 and 1/4" is a little more difficult to pin into, but is excellent for pin-holding and does not show pin holes much, and is about 55¢/sq. foot, but it is unavailable without ordering an entire \$9,700.00 manufacturer's production run. Polyethylene foam that is white, medium-celled, 4 lbs./cubic foot, and 5/16" thick, works well, and does not show pin holes, but is more expensive at ~\$2./sq. foot. Minicel polyethylene of density 2-3 lbs./cubic foot also works well, and is only 37-50¢/sq. foot for 1/4" thickness (5/16" would be better), and is a little easier to pin into than Volara. Polyurethane foam (Poron), also works well, especially the variety that has 55 psi of compression deflection and density "20" lbs./cubic foot; the pinhole mark disappears in this material, which is fairly expensive at \$2.90/sq. foot. Some types of neoprene-blend foam also work, especially the medium-cell 7.5-9.5 lbs./cubic foot foam, which does not show the pinholes.

One should get 5/16" foam rather than 1/4", and 3/8" foam will also work but will cramp the labels beneath a specimen that has 3-4 labels or has several labels and a pupal shell etc.

Plastazote (pronounced plastazoat) is widely considered to be one of the best kinds of foam for pinning insects. Plastazote is a registered trademark of Zotefoams plc. of Hackettstown, N.J. It is cross-linked polyethylene foam, made by mixing base resin and additive ingredients and extruding them into a sheet from which slabs are cut. Then the slabs are placed in a high-pressure autoclave and heated above the softening temperature within a high-pressure atmosphere of pure nitrogen, until the nitrogen completely dissolves into the material, which is then cooled, locking in the nitrogen. Then the material is placed in a low-pressure autoclave and reheated above the softening temperature under moderate air pressure; when the pressure is removed, the nitrogen expands, physically foaming the soft plastic in a uniform fashion, until the material expands into foam "buns" about 40" wide by 60" long. The buns are then cooled, and sliced to the desired thickness. Depending on the added ingredients and the amount of expansion, there are many kinds of zotefoams, including low-density plastazote of density LD18 to LD70, semi-rigid and rigid plastazote of density HL34 to HD115, evazote (added ethylene) of density VA25 to EV50, super-soft Supazote of density EM26 to EM45, electrically-conductive varieties, and propazote. These foams are made in all colors and white and black, and are made in fine-cell, medium-cell, and large-cell.

The plastazote used for insect pinning bottoms is LD33 (low-density cross-linked polyethylene of "nominal" density 33 [in some metric units], or 2.1 lbs./cubic foot "nominal" density [real samples are 1.9]), fine/medium cell, white, 3/8" thick.

Denser LD45 plastazote is also usable (nominal density 45, or 2.8 lbs./cubic foot [real samples are 2.5]), but is a little harder to pin into, and is more expensive because cost is roughly proportional to weight of material.

To obtain plastazote least expensively (about \$10.20 per 41 X 61 X 3/8" sheet of LD33 white plastazote, Dec. 2000, which is 59¢/sq. ft.), call the Zotefoams plc. free telephone number 800-362-8358 and ask for their current list of authorized fabricators (19 in U.S. and 3 in Canada, Dec. 2000). Then write to many of those fabricators stating your requirements (number of pieces of bun-sized 40 X 60" LD33 white plastazote, sliced 3/8" or whatever thick), and state that you can also use surplus remnants that are at least 16 X 18" in size. A minimum order of about \$600. or more may be required. Freight costs are high, because bun-sized pieces must be shipped on a pallet by truck (shipping by UPS could cost even more, because the foam must be cut down to 16 X 18" size at extra expense to fill smaller packages, and more packages are required).

Preparing the drawer and foam. To clean greasy fingerprints etc. from the foam, put a little isopropyl alcohol on a rag and rub the spot gently until the mess is gone.

Before installing the foam, make sure the inside of the drawer and the foam are free of dust. Dust sticks to foam with static electricity. I vacuum about 9 drawers at one time, inside and out, then stack them still opened (bottom rotated and on top of the lid) in a pile. Vacuuming each drawer takes about one minute if no clinging debris is found, or more than three minutes if you also scrape paint drips/silicone off the glass with a razor blade and scrape glue off the cracks around the wide bottom with a chisel.

Also, look around the bottom of the drawer to find oozed blobs of glue that might interfere with the foam, and scrape them off with a slightly-dull wide chisel.

Cutting the foam. The goal is to match the foam to individual drawer dimensions, as each drawer is a bit different from the others (because the glass was not cut square which makes the drawer not square, etc.), and the easiest way to do this is not to measure anything, but to place the foam over the drawer (or partly into it) and mark it there.

Three tools are needed, a snap-blade knife, a heavy straightedge, insect pins, plus a piece of scrap plywood to cut on (to protect the good table surface beneath). A snap-blade knife is a small inexpensive (69¢-\$4) utility knife, with replaceable blades that can be ratcheted out of the handle. Each blade of the regular duty snap-blade knife is 9 mm wide and 87 mm long and has 12 scored lines on the blade, and you use pliers to snap off 5 mm lengths of the blade when its tip gets dull, to make 13 fresh new points on the blade (but to cut the foam the blade has to be fairly long, so one cannot use the shortest lengths—the blade should hang out of the handle by about 4 ½ snap lengths). The blade is thin and sharp and is ideal for cutting foam, though a bit too flexible. The heavy duty snap-blade knife is less flexible so should work better; its blade is 18 mm wide and 11 cm long and has 7 scored lines on the blade to make 8 points (the blade should hang out of the handle by about 2 ½ snap lengths). The blade of a regular utility knife is too short. The ideal straightedge is heavy enough to hold the foam in place, and has the edge tapered down to where the knife will cut—the straightedge should be very narrow at the edge to keep the knife correctly on line even if the knife becomes a little non-vertical. I use an aluminum angle-iron that I sawed lengthwise from the cross-brace on a recycled giant highway sign, which has the edge tapered down to the cutting line (aluminum rulers that have a triangular cross-section are widely sold for construction and would work well). The insect pins are eight ordinary #3 pins, used to mark the positions where the edges of the foam will be cut. Tape several pieces of foam onto the top of the straightedge with clear wrapping tape to park the insect pins (stick the pins right through the tape).

Because the foam is rubbery, you should make the finished piece of foam a little larger than the drawer inside (by almost 1/16"), to make sure that the foam presses against the sides. But if you cut the foam too big, it will bow upward in the middle when you try to glue it onto the hardboard bottom. The edges should be cut vertically, because if the bottom of the foam is wider than the top a crack may appear between the edge of the foam and the drawer.

The insect pins are stuck into the foam to mark where to cut the line (one pin at each end of the line), then the straightedge is placed against the pins, the pins are removed and parked on the little pieces of foam on the straightedge, and the foam is cut with the knife. The cut you make in the foam will differ a little depending on which side of the pins you place the straightedge. But in practice, if you get into the habit of placing each pin just outside of the inside edge of the drawer, to make the foam a bit larger, the foam will cut fine. To avoid miscutting a piece of foam slightly, you should mark and cut at most two lines at a time, by placing the foam over the drawer and laying the heavy straightedge on top of the foam to hold it in place while inserting the pins. If you have only one line to cut, you will have to insert two pins, so for each pin, place the foam into the drawer so that the edge you are measuring (not the edge you are cutting) rests on the drawer flange, so the foam will not droop into the drawer and make your pin point inaccurate. (Marking the lines to be cut with insect pins works extremely well. I have tried marking the foam by cutting into each end of the desired line with a pointed knife, but the resulting slits are then hard to find, and that method tends to spoil those ends of the cut. One can even cut the foam by placing it over the top of the drawer and carefully running a sharp pointed knife forward through the foam, sharp edge facing upward/forward, while the side of the knife blade slides against the side of the drawer; this method works okay if your knife is very sharp and your technique is excellent, but it does not work as well as the pin-marking method unless your sides are very curved [warped].)

When you make a cut in the foam that is close to the existing edge of the foam, make sure the new cut is at least 1/8" (1/4" is better) from the existing edge, because the knife will mangle rather than cleanly cut a remainder that is narrower than this, unless the blade is very sharp (snap off the old dull tip of the snap blade to get a new sharp tip).

Make sure that your cut will be perpendicular and not parallel to the grain of the scrap plywood beneath, because parallel grain is more likely to grab the tip of the knife and lead it astray.

Do NOT cut a large sheet of foam down to smaller more-manageable pieces a little bigger than the drawer size, before recutting them to final size, as this process wastes time, creates unnecessary waste of foam, and risks ruining some pieces by cutting them too small during the downsizing process. To cut a new bun-sized 41 X 61" piece for instance, which has rounded edges that must be trimmed, arrange the foam so that the 41" edge is toward you, and place the left front corner of the foam over the left front corner of the drawer. This bun-sized piece of foam will make six Cal-Academy-sized foam pieces (two from the front, two from the middle, two from near the rear), and the remaining rear end of the piece will be about 41 X 13" and can be cut into five Schmitt-Box-sized foam pieces.

Cutting procedure. First, place the foam over the drawer, and try to find at least one side that is already cut and straight and fits properly against a drawer side. If no side fits properly, overlap the foam 1/4" beyond where you will cut it (on the left and front), place the straightedge or heavy object over the foam to hold it in place, and use insect pins to mark where to cut. Place each insect pin through the foam so the tip of the pin is just outside of the inside edge of the drawer. Lift the edge of the foam up a bit to see where to insert the pin. But if you can't lift it (where the foam greatly overlaps the far right corner of the drawer hidden beneath), place the pins by trial and error; first feel the drawer flange through the foam to see about where to pin, then take a pin and push it through the foam; if you contact air keep pushing it through the foam until you contact the drawer, keep pushing until you find the inner edge of the drawer, then leave the pin in place so it is barely outside of the inner edge of the drawer; do the same for another insect pin nearby on the adjacent side of the drawer. When you have marked where to cut on two adjacent sides (the rear and right sides) with four pins (the other two adjacent sides [on left and front] overlap the drawer by 1/4" at the original non-cut edge of the foam), move the foam onto the scrap plywood. Cut the right-hand edge of the foam first: place the far end of the straightedge against the insect pin marking the rear cut, and place the working edge of the straightedge (on the right side) against the two right-side pins, remove the pins and cut the right edge. Then rotate the foam counterclockwise 90° and cut the rear line. When both edges are cut, place the foam barely into the drawer, so that the cut rear edge is tight against the upper part of the rear of the drawer, and place two pins to mark the next cut along the front of the drawer (as described above, rest the right side of the foam on the flange on the right side of the drawer to position the right pin, and rest the left side of the foam on the flange on the left side of the drawer to position the left pin), and cut the foam there. Place the foam barely into the drawer again, place two pins to mark the final cut on the left side, and cut the foam there. When you are done cutting the foam, place it in the drawer and push it down all over to see if it fits nicely (without any crack around the sides), and leave it there until you are ready to glue it.

If the foam to be cut already has a usable cut edge (usually on the front or left), place that edge against the proper side of the drawer, and mark two other adjacent lines to be cut on the foam, cut them, then mark and cut the final line.

If the cut foam is a bit too short, leaving an unsightly crack between foam and wood side, you can place a small trim slice in the crack to fill it and make the foam look good. If there is a crack between foam and wood at one spot because the foam edge is cut wider on the bottom than on the top, or the foam is too wide at one spot, you can eliminate the crack by using a knife to undercut the bottom 2/3 of the edge of the foam a little so that the top of the foam will now press against the side of the drawer.

When the foam is cut and placed into the drawer successfully, turn the drawer over, and use a felt-tipped permanent marker to write the type of foam you used such as "LD33 plastazote", the type of varnish you used such as "polycrylic" (to prevent a future painter from adding an incompatible finish), and if you wish write "made by" and sign your name.

Complete installation of the foam (including hauling the drawer and writing on the bottom, but not glueing) takes about 5-6 minutes (only three minutes if two edges are already cut satisfactorily).

Glueing the foam. Use only pure clear silicone in a tube to glue foam. Silicone works great for this purpose. Silicone is fairly expensive (\$4 per tube for GE Silicone II Clear for Kitchen and Bath, or equivalent), but only about half as much needs to be used compared to awful products such as gummy adhesives, so the cost per drawer is about the same (about 8¢/drawer). Silicone is easily spread with a putty knife, is excellent for sticking the foam to the hardboard, does not stink as do adhesives, is not toxic as are adhesives, is not dissolved or harmed by pest-control fumigants such as ethyl acetate and lacquer thinner (these solvents will dissolve some other adhesives), and does not require any clamps or pressure on the foam while the silicone cures. In addition, its pinning properties are similar to foam, so it contributes to the pin-holding purpose of the foam.

Put the tube of silicone into a caulking gun, cut off the tip with a knife, pierce the inner seal many times with a narrow wire, pry the foam from inside the drawer with a knife, and squeeze a small amount of silicone (a line about 4-8" long depending on the thickness) on the bottom of the drawer. Use a putty knife about 6" wide to spread the silicone very thinly all over the bottom. Press hard and angle the putty knife blade nearly vertically (70°) to spread it very thinly. No need to hurry, as the silicone will not dry too fast if you keep working. Place the putty knife against each long side and spread toward the middle, and rotate the drawer and repeat this process with each short side until the silicone is spread very thinly

everywhere. Scrape off excess silicone from the whole bottom with the putty knife, and leave the silicone (which will be a lot) on the putty knife for the next drawer (if you work at reasonable speed this silicone will still be fluid enough for the next drawer, but if you interrupt your work and this silicone becomes more rigid, or if after several drawers some silicone becomes stiffer, just scrape it off the putty knife with a chisel and wipe it on a newspaper and discard it, because the foam will not stick well if the silicone is too dry). (Never touch silicone with your hands, because that will spread the mess [silicone is not toxic]. To clean up a mess of silicone, let it dry and then remove it.) Then place the foam into the drawer, and press the foam into place slightly with your hands, starting at the middle of each side to center the foam in the drawer, then press from center to sides and center to corners to efficiently remove air from beneath the foam (the air escapes at the corners), and rub all over to press every spot of the foam onto the bottom and remove all air from beneath the foam. If there is a narrow crack between foam and drawer side, press the foam down and over to that side to eliminate the crack. Then use a Schmitt box to moderately press the foam flat onto the bottom, especially in the corners (don't press too hard on the middle of the hardboard bottom, as the hardboard is not heavy-duty). You are finished, because clamping is not necessary.

If the foam was bent along one edge (because it was stored in a bent position there perhaps), the bend may lift the foam off the drawer bottom and prevent it from gluing properly, so you may have to place a weight over that spot to press it down while the silicone dries.

Gluing the foam into each drawer takes about 3 ½ minutes. One tube of silicone will glue about 40 drawers. The drawers can be stored indoors while the silicone dries (a day or so), because silicone does not give off noxious fumes.

Do NOT use "Panel and Foam Adhesive", which is sold in a tube for a caulking gun. Here's what will happen if you do use it: You squirt out a bead of this tan gummy stuff, spread it around with a putty knife, and press the foam into place, all while trying to avoid breathing the horrible poisonous fumes. Then, five hours later, you examine the drawers and find that the adhesive has produced gas in copious amounts that has blown the foam right off the bottom about 1/3" to form a volcano-like dome in the bottom of the drawer!! Then you desperately push the foam down and hold it down with heavy objects such as encyclopedias. The next day you are gratified that the foam has stayed down, however the box continues to give off horrible stinky poisonous fumes for months. It is a mystery to me how a product this awful can be sold and labeled as "foam adhesive", when it volcanically blows the foam right off the substrate. Other gummy adhesives are said to be susceptible to damage by chlorinated hydrocarbons (paradichlorobenzene, etc.), so should not be used either. Use only pure silicone, which works great, does not cost any more, and does not pollute your air.

If you installed bad foam in a drawer, and you wish to replace it with good foam, or if your silicone became dry and did not glue part of the foam in a drawer, remove the foam. Insert a wide chisel at the edge of the foam in a corner, pry upward, then grab the corner of the foam and slowly pull it off. The Panel and Foam Adhesive adheres to the foam very little better than pure silicone (polyethylene foam can be rather easily pulled off of both), so there is no reason to reject silicone to make the foam stick more tightly.

Fixing a Drawer with Broken Glass

If you break the glass on a drawer, remove the glass from the groove all around the lid, and scrape silicone/glue out of the groove. Use a rubber mallet to pound on the inside of one side of the lid at a corner, to break the glue joint at the corner. Break the glue joint on an adjacent corner to remove one whole side. Place new silicone into the groove on all four sides, slide the glass into the groove, glue the ends of the removed side, and place the removed side onto the glass. Place the lid onto the bottom of the drawer in the proper position, and clamp the drawer tightly in that position, so that the lid miter joints seem to match the bottom. Nail the corners again that need to be joined, remove the clamps, remove the lid from the bottom, then reclamp the lid in the same way. Remove excess glue. Hopefully the lid when dry will fit properly onto the bottom. If it fits imperfectly, you will have to scrape some flanges on the bottom if the fit is too tight, or varnish the inside of the lid where the lid fits against flanges if the fit is too loose, until the lid fits tightly.

The same clamping procedure can be used to fix a drawer that has been dropped onto a hard surface and one or more of the corner joints has cracked open.

Drawer Fumigation

Now that you have made nice tight-fitting drawers, you can use them to house insect specimens without placing poisonous fumigants (naphthalene, paradichlorobenzene, dichlorvos, etc.) inside to kill pests (dermestid beetles, etc.).

However, you must first ensure that the specimens that you place inside the new tight drawers are pest-free. There are several ways of doing this.

First, purchase suitable fumigant fluid, such as a gallon of ethyl acetate (\$30.). Lacquer thinner also contains a little ethyl acetate, but is presumably less toxic to pests. Ethyl acetate and lacquer thinner are strong solvents, so you must be careful about selecting materials that come into contact with them. Place a piece of your material into the fluid in a jar for a day, then inspect it for damage. Ethyl acetate and lacquer thinner dissolve clear hard plastic and the soft rubbery ring seal around the inside of most jar lids, but will not dissolve polyethylene or bakelite-type vial lids. They will not harm polyethylene foam (such as plastazote) or pure silicone (another reason to use silicone in the glass groove of the drawer,

and an important reason to use silicone to glue the foam to the drawer bottom). Ethyl acetate might dissolve some other glues used to stick the foam to the bottom.

Ethyl acetate is fairly safe but is still a poison and like other solvents can cause neurological problems etc. I found that the gas-mask sold in hardware stores that has two carbon canister filters (\$30) works well; very little of the smell of ethyl-acetate can be detected when using this mask.

Obtain a polyethylene spout cap which screws onto the gallon can (\$3.59). This spout saves a lot of money because one cannot pour fluid out of the gallon can without wasting half of it and poisoning the air. Obtain a polyethylene bottle that has a pointed tube extending from bottom of bottle up through cap and angled downward, to apply the fluid. The tube should be wide enough near its narrow applicator tip tube so that a rubber eyedropper bulb can slide tightly over the tip to keep the fluid from evaporating. Ethyl acetate is very volatile so these can and bottle caps and the eyedropper bulb must fit tightly. Use the spout to pour fluid from the gallon can into the bottle, place the original cap back onto the gallon can, then use the bottle to apply fluid to each cabinet/drawer.

The simplest process of poisoning pests is to fumigate each drawer individually. This process is simpler as no cabinet cover is needed, and the process uses a little less chemical than fumigating the entire cabinet. Obtain some tiny bowl-like containers to hold the fluid. 1"-wide polyethylene caps off water bottles work fine, because they are like tiny bowls with wide flat bottoms that cannot tip over, and cost nothing if you pick them out of trash cans or off the ground wherever people gather outdoors on a hot day. Place a cap in the middle of each drawer, and use the applicator bottle to squirt about a ¼"-deep pool of ethyl acetate into it. Close the lid, and place the drawer in a cabinet in a garage or some other area where you will not breathe the fumes for a day. The fluid evaporates inside the drawer in a few hours and fumigates it. The next day, remove the lids and caps, let the drawers air out in a pest-free environment (or cover the cabinet with very-fine-mesh cloth such as a large fine-mesh veil that is sewed up each side), then place the lids back onto bottoms and you are finished.

An alternate method is to fumigate the entire cabinet. Make a cover for the six-drawer cabinet that is airtight because of soft foam rubber where the cover fits against the cabinet. Clamp the cover to the cabinet with hooks or screws. Screw an absorbent pad to the middle of inside of the cover to absorb poisonous fluid. Then remove the lids of the drawers and place the bottoms inside the cabinet. Pour poisonous fluid (ethyl acetate etc.) onto the absorbent pad and clamp the cover onto the cabinet. After a few hours or a day, remove the cover, let the drawers air out in a pest-free area (outdoors perhaps, any area without pests rain hail wind etc.)(one could cover the cabinet with very-fine-mesh material to exclude pests) for a few hours, then place lids back onto bottoms and you are finished. One could use a cyanide killing jar with this method.

Other Methods of Killing Pests. Potassium **cyanide** works well. Buying it is difficult, you must pay as much as \$87. for 500g, by ordering it from a chemical supply company, by sending them a letter on official company letterhead, stating the reason for your purchase, stating the use to which the cyanide will be put, and stating that that use is a normal use of the product for your company. These requirements are to protect the company selling the cyanide from legal liability if someone used the cyanide to kill people etc. To use the cyanide, mix it about 50:50 with sawdust, place ½" of that mixture into the bottom of a glass jar, cover the mixture with ½" of wet plaster, and let the plaster set and dry outdoors for a day. Then place the lid on the jar, wrap the bottom of the jar with strong tape for safety, and it is ready to use. If this jar is short enough it can be used inside a drawer, but it is difficult to find jars short enough, so you can install the cyanide in a small screw-cap lid that is short enough to be placed in a drawer, then the small cyanide lid can be stored in a larger jar that has a regular lid. A larger jar can be used inside a cabinet by removing one drawer, then covering the cabinet to fumigate the other five drawers. Cyanide works very well, if you can get it. Of course you must be careful using it, and apply it outdoors or in an outdoor shed etc., and avoid breathing the fumes.

One can also kill pests inside a drawer using **heat**, by merely placing it outside in the sun, so the sun goes into the drawer and heats it (heat does not escape out of the glass because infrared cannot get through the glass well). Every living thing inside the drawer will be killed if the temperature gets hot enough; reportedly nothing on earth can survive 130°F for 3 hours, except some bacteria etc. that are adapted to living in hot springs and ocean-bottom hot-water vents. The only problem is that heat might cause a little warping etc. of the drawer, or could cause grease in an abdomen to dissolve and make its way outward onto the surface of the abdomen or wings. One should experiment with heating methods by placing a shaded thermometer inside one drawer and checking for warping etc.

Newly-built museums should plan and construct their buildings with fumigation in mind. Collections should be placed in a separate area from the rest of the building, that can be sealed off and fumigated to kill pests, without affecting the rest of the building. The worst case scenario is an old building that cannot be partially fumigated, where dermestid beetles are used to clean off vertebrate skeletons, and the beetles then take flight and swarm toward the entomological collection and the bird skins and the herbarium.

Appendix I. Table Saw Tips

Some tips can greatly improve performance of the table saw. First, unplug the saw, raise the saw blade as high as it will go, grab the saw blade, and try to wobble it. If there is no wobble, the bearings are still good and the saw will work.

Saw cuts are best (fewer chips in the wood, no scorching) if the saw blade is parallel to the wood it is cutting, and parallel cuts require that the rip fence be parallel to the saw blade. See if the saw blade is parallel to the table saw grooves,

by using this procedure: raise the saw blade all the way, mark one saw tooth with a felt-tipped marker, move that tooth forward until it reaches the level of the table saw surface, and measure the distance to one of the grooves on the table saw with a ruler measuring to 1/100", move the tooth backward until it reaches the level of the table saw surface far to the rear, and measure the distance to the same groove. If the distances are the same the saw is aligned properly. If the distances are different by more than a small amount, you should realign the saw, by unbolting the table top from the frame underneath and twisting the table top a bit then rebolting it (you could consult your saw manual here). Or, you can just place an **angle-iron rip fence** on the table top and measure its distance to the groove and adjust it to make it parallel to the saw blade, then clamp it tightly with large metal C-clamps (this actually makes the best rip fence, because only with these massive clamps can you be absolutely certain that your rip fence will not gradually creep out of adjustment and ruin your wood). But if your rip fence is fixed in its alignment (self-aligning when clamping), as most modern rip fences are, you can measure the same two distances to the rip fence and see how bad the misalignment is. But basically, even a bad table saw is completely usable if the bearings are good, because you can use an angle-iron as a rip fence and massively clamp it to the table saw. I clamp an angle-iron with large C-clamps, while backing it up with the lousy rip fence, and backing that up with wood clamped with more clamps. The goal is to be able to saw 1700 saw cuts or more without the rip fence moving at all. Most rip fences are questionable or bad, so an angle-iron would be better. Check the sawed wood now and then to see if the rip fence has not slipped (when you finalize your rip fence setting, saw some practice boards and measure them, and keep those on the table saw to compare with the pieces you are currently sawing—place the practice board and current board side-by-side against rip fence, and see if the saw cuts are identical in distance from rip fence).

A steel angle-iron is better than aluminum, because wood rubbing against aluminum picks up a bluish-gray smudge that has to be sanded off.

Wood chips a little less if there is little space between the saw blade and the table saw insert (a "**zero-clearance insert**"). Go to a countertop company and get a scrap of Corian (a hard plastic countertop composite) or similar laminate plastic material, and make your own insert. Use a jigsaw to cut the block to size, and the table saw to thin the underside if the outside of the insert must be thinner than the middle, etc. Drill and countersink the necessary machine-screw holes, and fasten it to the table saw without cutting the saw blade groove, turn the table saw on, and then raise the saw blade gradually up through the material until the saw blade is the height you want (you may have to start with a 7 1/4" saw blade), and the insert is finished.

The saw blade wobbles less and the cut is more precise if you use **saw blade stabilizers** whenever the saw blade sticks up only about an inch or less. These are ~7" diameter metal discs, with an arbor width the same as your table saw, placed on one or both sides of the saw blade, just to increase the mass and keep the blade from wobbling. They work very well. You can make them from thick old 7 1/4" saw blades by grinding off the teeth. Ideally you should use one on either side of the blade, but if installing one on the base of the shaft would mess up your zero-clearance table saw insert, use just one distal to the saw blade.

Place some plumber's putty on the threads of the machine screws that fasten the insert to the tabletop, to make sure that the screws will not come loose while sawing and rise up and mar the wood or let sawdust under the insert to mess up the saw cut.

Resin builds up around the carbide cutting edges of the saw blade, and hinders the dissipation of heat that is the main enemy of carbide. Resin buildup can be removed with spray oven cleaner (spray it on, leave it on for a few minutes, wash it off thoroughly and dry it with a towel). Spraying a little Empire Mfg. Wood-Cutting Lubricant on the saw blade (while it is coming to a stop) seems to work fairly well to prevent resin buildup, by coating the saw blade with some nonstick substance. Use a rag to rub the excess that was sprayed on the sawblade but went onto the table top, all over the table top where the wood contacts; this makes the wood slide easily and results in less muscle fatigue. Wax can also be used to help the wood slide and keep the table top from rusting.

Use a nylon brush to remove the sawdust/chips from the table top near the rip fence, from the the rip fence where you will be placing the next piece to be sawed, and from the wood surfaces that fit against the rip fence and table top, or else the chips will make the cut too shallow or will make a cut that is not far enough from the rip fence.

Vacuum/blow sawdust out of the saw motor every now and then.

For safety, gloves that have a network of sticky clear rubber ridges all over them are very useful to keep one's hands from slipping off the board during sawing, and these outstanding gloves are warm enough to be used outside in freezing winters, and are great for painting (one can even wipe off paint with the glove without ruining the glove much). Safety glasses are needed to keep wood splinters out of the eyes. A breathing mask is needed when sanding.

A squaring sled was described in the cabinet paper (Papilio [New Series] #16) that is great for squaring large pieces such as hardboard. It consists of a large aluminum sheet, with an aluminum angle-iron bolted to the top edge, and a steel runner bolted beneath that fits into the groove of the table saw.

Various push sticks are required to saw certain wood pieces safely and well. A side push stick for sawing sides, a narrow high flange push stick for sawing flanges, and a wide rounding push stick for corner-rounding flanges on a router table, were all described above.

A drawer-splitting-shim and tall rip fence are described above.

When sawing narrow strips of wood (narrowing the strips a little, for instance), the strip has a tendency to wander away from the rip fence, even with a push stick. You should use a feather board (a cheap plastic one works fine), which has two clamping feet that fit into the miter-gauge groove on top of your table saw surface, and can be clamped so that angled strips press against the wood as it exits the saw blade to keep the wood pressed against the rip fence (and prevent kickback). By using this feather board, and a narrow high push stick, you can saw on narrow wood strips quickly and safely.

Appendix II. Sanding Tips

The rotary Random Orbital Sander is the only kind of small portable sander that works well (traditional rectangular-base sanders—even those stated to be random orbital—shake a lot and cause the nerves in your hand and wrist to become numb, but accomplish very little sanding). The base of this rotary sander spins around very fast and simultaneously wobbles, and as a result works extremely well. The base has velcro hooks, which fit into the felt on the bottom of the sandpaper disc, so the disc is simply pressed onto the base and sticks onto the velcro hooks. There are many brands, and probably any that rotates at 10,000-12,000 orbits per minute would work well. For sanding the tops of narrow flanges a lower speed is better, for instance the excellent Makita B05021K rotates from 4,000 to 12,000 opm (other variable-speed sanders only go as low as 5000 opm, which would also work).

These sanders are sometimes aggravating when the sanding disc comes off prematurely, due to failure of the fabric backing. I have not fully determined all the causes of backing failure. However, the major factor is that good sanding discs have quality mat backs that stay stuck on the sander well, while some cheap bulk sanding discs (Mirka from Finland etc., sold at woodworker shows) have less-dense mat backs that strip off after only 15 minutes. One can sand a small spot very much faster by tilting the rotating disc to make the edge of the sandpaper sand the spot more vigorously, which is very useful for sanding the edges of the sides, although this procedure may shorten the life of the abrasive disc (and if you forget to check the sandpaper frequently, the edge of the sandpaper could wear away and damage the plastic velcro on the edge of the rotating rubber pad of the sander, which is expensive). The variable-speed Makita sander manual states that one should keep the pad flush with the workpiece and exert slight pressure on the tool, and states that excessive pressure may damage/shorten the life of the abrasive disc. The single-speed Makita sander manual also states that one should apply only slight pressure to the tool, but also states that one should start the tool while it rests on the workpiece surface, and states that withdrawing the tool from the workpiece before the tool has come to a complete stop may cause the abrasive disc to come off (but in my experience, when the disc comes to a stop on the wood, it shudders and may make big scratches on the wood). However, the variable-speed manual states that the tool should be turned on and allowed to attain full speed before placing it gently on the workpiece surface. The variable-speed sander has a thinner lighter rotating disc, which stops much more quickly after it is turned off.

The single-speed sander continues to rotate for half a minute after it is turned off (the variable speed Makita much less time), time wasted holding it until it stops, so you should make a holder for the sander (or let the sander come to a stop against the wood as the single-speed manual states—but the final gasp and wobble of low speed scratches the wood in some cases). The holder consists of a two-pronged fork-shaped wood yoke that holds the top of the sander, a vertical board in back attached to the back of the yoke, and a support base for the vertical board.

Cloth-backed sandpaper (Emory Paper) of about grit 125, held by hand, works best to round the edges of wood a little without tearing off splinters, because it is flexible and splinters cannot penetrate it and then tear off. Foam-filled blocks of sandpaper work well to sand wood filler off the top of flanges. Hand-held sheets of ordinary sandpaper work well to sand wood filler off edges and flat surfaces of sides.

Appendix III. Wood-Filling Tips

Elmer's Carpenter's Interior Wood Filler (For Heavy Duty Use or For Light Woods) works fine for filling the nail holes in Baltic Birch, although the Elmer's wood filler For Darker Woods would look better for walnut etc. The wood filler For Heavy Duty Use seems to hold together better than other kinds of Elmer's (including the Light Woods and Dark Woods varieties, and the Contractor variety which is much more crumbly, etc.). Avoid the wood filler brands that are thinned by organic solvents, because they are poisonous, and seem to perform no better than water-based Elmer's (some of them labeled as "pine" dry strangely pink). To better match the color of Baltic Birch, one can mix a little (~20%) Light Woods filler into a lot of Heavy Duty Use filler.

Wood filler dries rapidly, so place the lid loosely on the container immediately after you scoop out some wood filler with the putty knife. If Elmer's Wood Filler dries out too much, just add a few drops of water and mix it well with a putty knife to reclaim it (scrape the dried filler off the sides and reclaim it too).

Only small amounts of wood filler are needed for these drawers, so you should grind a putty knife narrower until the tip is only about 3/8" wide. A 1"-wide putty knife is better for filling splinter holes on the edge of wood and making beveled fills next to the glass.

When applying wood filler, apply more than is necessary to fill a hole, to make sure that when you sand the hole that it will be completely filled. Wood filler dries very rapidly, and can be sanded within a minute or so if necessary, except on the edge of a board where it will flake off unless you let it dry fully and then carefully sand the edge. One can even sand

wood filler immediately if you let the rotating random-orbital sanding disc fly over it awhile to move air over the wood filler to help dry it, although this may gum up the sandpaper with wood filler a little.

(Other types of wood fillers are excellent, but have deficiencies. Bondo [automotive] Body Filler is very tough, sandable, inexpensive [\$12./gallon], and will stick to almost anything [even paint and metal], although it has to be mixed with a catalyst, which makes it too inconvenient for the multitude of little holes on these drawers. Other brands of wood filler also require a catalyst and are very expensive. Pure silicone also fills holes well because it does not contract when drying, although it takes hours or days to dry and paint will not stick to it, which makes it unusable for surfaces that will be varnished.)

Appendix IV. Glue Tips

Use a small (one-pint) plastic Elmer's Glue bottle to apply glue, and refill it from a gallon container. To help apply the bead of glue more precisely to the recess on the side boards where flanges will be installed, you can let the glue dry except at one end of the slot, which you can then keep open with a tiny implement, or simply use electrical tape to block off most of the slot except one end. To spread glue evenly with your finger, you will learn to squeeze out a little more glue where your finger starts, and use your fingernail to spread glue upward onto the wood backstop of a recess. Keep large pieces of paper (not newspaper, which transfers black ink to your finger) on a table to wipe excess glue off your finger, and also keep a pile of rags nearby so you can always find a dry rag to wipe off glue.

Titebond II aliphatic resin (yellow) glue works well for these drawers.

Acknowledgements

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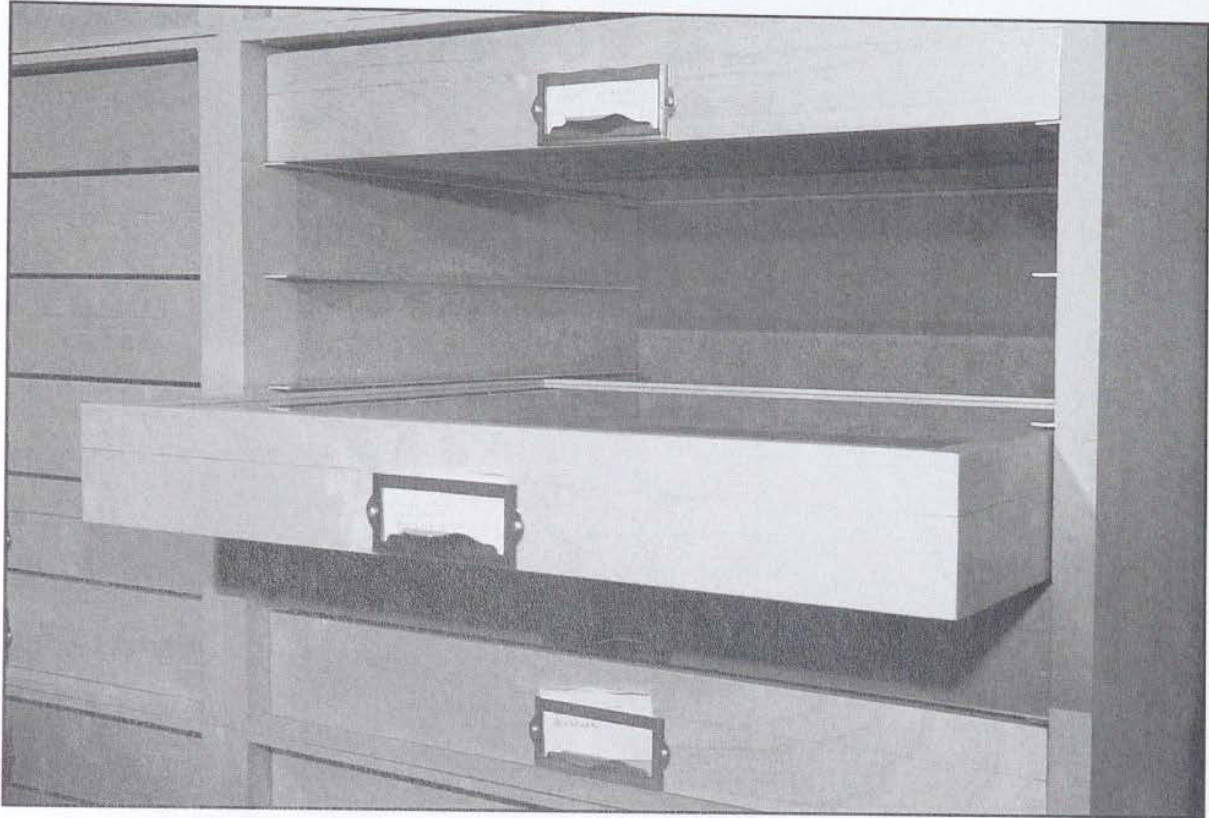
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