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PORTABLE (SIX-DRAWER) CABINETS FOR CALIFORNIA ACADEMY DRAWERS

By Dr. James A. Scott
60 Estes Street, Lakewood, Colorado, 80226-1254, USA

The portable cabinet described below is small enough—containing six drawers—and lightweight enough that it can be carried by one person without a dolly to a new location, even with all drawers included (weight is 21.6 lbs. empty, 61.4 lbs. full with all six drawers). The cabinets can be stacked four or five deep in an 8 foot room. The sides are thick (3/4" particle board), the same thickness that is standard on entomological cabinets, so they permit the cabinet to withstand as heavy a load of cabinets etc. stacked on top as any cabinets now commercially made. The back, top, and bottom of the cabinet are thin (1/4" hardboard) to keep the cabinet lightweight, yet are plenty strong enough to ensure the integrity of the cabinet, because only the sides of entomological cabinets support the drawer runners and thus the sides are the primary load-bearing structures and the top/bottom and back serve in an engineering sense only to maintain the orientation of the sides. Measurements and photos of the cabinet are at the end of this article.

The portable cabinet extends ¾" beyond the drawers in front, to allow room for brass cardholder/pull fixtures to extend forward on the front of the drawer. This extension would also allow for a front cover to be attached to the cabinet for use as a fumigation device. Such a fumigation cover would have thin foam all around to act as a seal, the cover would be fastened to the cabinet by four hooks around the sides that fit over four "nails" on the cover, and the inside of the cover could have a sponge for disseminating a lethal fluid such as ethyl acetate, or cyanide gas, etc. To use the fumigation cover, the lids of the drawers would be removed, the bottoms of the drawers reinserted into the slots of the cabinet, ethyl acetate would be poured onto the sponge, and the cover pressed into place and fastened.

This portable cabinet is simple to make, and uses inexpensive materials that cost only about $8 per cabinet ($14 for melamine, more for maple veneer).

Because this portable cabinet is just as stong as giant nonportable cabinets, and has the advantage of portability, there is really no reason to buy or make large nonportable cabinets.

Materials and Expenses

Each cabinet requires one top, one bottom, two sides, and one back. The top and bottom are identical. The sides are identical, until the aluminum runners are installed, when they become left and right sides. The sides and back fit completely between the top and bottom. The back fits between top and bottom, but is nailed to the rear of the sides.

The two sides are made from **¾" particleboard** (or melamine or MDF) and measure ¾" thickness X 17 ¾" length X 16" height. One could use melamine-coated particleboard, or ordinary MDF, if desired. Or, one could use ¾" maple-veneer MDF ($58. per 4 X 8' sheet) and cover the edges with maple/birch-veneer edge tape ($9. per 50 foot roll) which is applied with a household iron.

To reduce the weight of the cabinet further, narrower sides only 5/8" in width were tried, but I found that the process of sawing the grooves (which receive the aluminum runners supporting the drawers) causes 5/8" particle boards to warp a little, becoming concave on the side containing the sawed grooves. ¾" sides do not warp after sawing the grooves, so the thicker sides are necessary, despite their adding 1.75 pounds of weight to the cabinet.

The back is **¼" hardboard**, and measures ¼" thickness X 20 21/32" width X 16" height.

The top and bottom are also made of **¼" hardboard**, and measure ¼" thickness X 20 21/32" width X 18" length.

(If you want a sealed hinged cover on the front, you will have to make the top and bottom out of 5/8" particleboard, and then glue foam all around front, and hinge the front onto one side.)

¼" hardboard may warp, and severely-warped boards could block the insertion of the top or bottom drawers. To prevent possible warping of top or bottom from obstructing the insertion of the top or bottom drawers, 1/16" is added to the height of the sides (which otherwise would be 15 7/8"), making the height of the sides 16". Using 16" sides is more costly

because only 10 sides 16" high can be sawed from a 4 X 8' sheet of particleboard, leaving 5 remainder pieces that are a little too short; however these 5 pieces can be salvaged by splicing a 1"-wide scrap piece (from the end of the sheet) to them, making 15 total. Or, one could saw 15 whole shorter (15 7/8") sides from the 4 X 8' sheet, then glue a 1/8" strip of wood to the top of each to make it taller 16". 15 whole sides per sheet can be sawed from ¾" MDF because it is larger (49 X 97"), but MDF is even more expensive.

Even though an extra 1/16" space is added to top and bottom drawers to allow for moderate warping, you should inspect the boards for severe warping. If both surfaces of the hardboard are the same, always place warped top and bottom boards so that the convex side faces outward (not inward). The ¼" hardboard that I usually use is smooth on one side and fuzzy like fabric on the other side, but this type of hardboard tends to warp a little and become slightly concave on the smooth side, yet the fuzzy side is more difficult to paint. One could substitute ¼" hardboard that is smooth on both sides, which should warp less, but it is more costly and less available. One could use white-vinyl-coated MDF if desired, because it is smooth on both sides (one side is brown), although it is 33% more expensive, and it also warps some (the vinyl side tends to be concave). Another solution is to make top and bottom out of thicker lumber (3/8" or ½" perhaps) that does not warp as much, although this thicker material would make the cabinet heavier. Appendix I details how to replace a top/bottom that blocks the insertion of a drawer or is otherwise ruined.

If unpainted particleboard/hardboard are used throughout the cabinet, the cabinet can be painted a color that matches the particle board, to allow the inside of the cabinet to remain unpainted and yet remain inconspicuous by matching the paint on the outside of the cabinet fairly well. Particleboard and hardboard with a white melamine finish could be used instead, at greater expense, but sawing the melamine would expose unpainted edges, and those exposed edges that remained on the finished cabinet would then have to be painted white to match the melamine. Melamine boards that have one edge finished (white) would produce nice-looking cabinets, as the finished edge would be placed forward, and the sawed edges would be glued to the brown smooth side of the white-vinyl-coated hardboard. That cabinet would be 70% more expensive, mostly because sides made of melamine-edged boards are four times more expensive than ordinary particleboard. However, the total expense for materials even for this cabinet is very small compared to the price of commercial cabinets. Painting a melamine cabinet would be easier, however, and if similar tough paint such as semi-gloss whitish epoxy were used, the resulting cabinet would be quite mar-resistant. Maple-veneer MDF sides, with iron-on maple-veneer tape on the front edge, maple plywood on top, and cheaper plywood on bottom, would also make a nice-looking cabinet, at even greater expense.

Aluminum sheet metal .063" thick (16-gauge, approximately 1/16") is used for the runners, as detailed below. Unvarnished (and sometimes even varnished) wood picks up a bluish-gray smudge when rubbed against aluminum, so anodized aluminum would be better. Or **galvanized sheet steel** could be used, because it is smudgeless and rustless, and costs half as much as aluminum, although it is heavier.

Ordinary Particleboard and Fuzzy-Hardboard Cabinet

Particleboard ¾", $13.28/sheet, 15 sides/sheet, 2 sides/cabinet……$1.77
Hardboard ¼", $10.49/sheet, 10 tops-bottoms/sheet, 2/cabinet……$2.10
Hardboard ¼", $10.49/sheet, 10 backs/sheet, 1 back/cabinet..……$1.05
Aluminum runners, $0.22 each, 10/cabinet……...……....$2.16
Caulk, $3.67/tube, ~32-41¢/cabinet…….……...……~$0.32
Wood filler, glue, ?15¢/cabinet..……...……..…..…~$0.15
Nails, 8¢/cabinet……...…….$0.08
Paint (latex), 75¢/cabinet…….……..$0.75
Total per cabinet (July 2000)…….……...…….**$8.38**

Melamine (White Surface and Edge) and White-Vinyl-Coated MDF Cabinet

Melamine (white-edged, ¾" x 24" x 96"), $20.95/board,
6 pieces/board, 2 sides/cabinet…….……..……$6.98
Vinyl-ct-MDF (1/4" x 4' x 8'), $13.95/sheet, 10 tops-bottoms/sheet,
2 tops-bottoms/cabinet……$2.79
Vinyl-ct-MDF (1/4" x 4' x 8'), $13.95/sheet, 10 backs/sheet, 1 back/cabinet…....$1.40
Aluminum runners, $0.22/apiece, 10/cabinet…….…….$2.16
Caulk, $3.67/tube, ~32-41¢/cabinet……...……~$0.32
Wood filler, glue, ?15¢/cabinet...……...……~$0.15
Nails, 8¢/cabinet……..…….$0.08
Paint (latex), 75¢/cabinet.…….……~$0.25
Total per cabinet (July 2000)..…….……..…..….**$14.13**

Dimensions

The height of each side and back is calculated from the six included drawers (each 2 ½" in height), adding an empty clearance space of 3/32" above each of the six drawers, and adding the 1/16" width of each of five aluminum runners (the bottom drawer rests on the bottom, while the five drawers above it each rest on the aluminum), totaling 15 7/8". 1/16" is then added to the bottom and to the top, to allow for warping of top and bottom boards, totaling 16".

The length of each side is calculated from the 17" length of each drawer, plus a ¾" space in front of the drawer to allow room for the brass cardholder/pull drawer fixture, totaling 17 ¾".

The length of the top/bottom is the length of the side (17 ¾"), plus the distance that they extend over/under the back to cover it, which is the approximate ¼" thickness of the back or >7/32", totaling >17 31/32" or 17.98", which I round off to 18".

The width of top and bottom and back is the 19" width of the drawer, plus 5/32" to serve as clearance (to prevent the drawer from sticking and allow for slight warping of sides or slight imperfections in assembly or slight variations in the widths of drawers, etc.), plus the width of both sides (two times ¾" = 1 ½") because the top and bottom are nailed onto the sides, totaling 20 21/32".

Aluminum or galvanized runners .063" thick X 1" wide X 16" long are used. They fit into grooves in the side 11/32" deep, leaving 21/32", or a little more than 5/8", to protrude into cabinet, where the drawer walls are 5/8" thick, so most of the drawer sides can rest on the runners.

Rough-Sawing 4 X 8' Sheets, and Finish-Sawing the Sides, Backs, Tops, and Bottoms

To make the **sides**, 4 X 8' sheets of ¾" particleboard are used (or 49 X 97" sheets of MDF or veneered MDF). Each sheet makes 15 sides. First, set the table saw rip fence for a cut of approximately 37" in the middle of the saw blade, and rough-saw each sheet 37" from one long end (the other end being 96"), to make two pieces 37" X 48" and 57.6" X 48". Two people may be necessary to handle the heavy sheet.

The same procedure should be used to rough-saw 4 X 8' sheets of ¼" hardboard at 37" to make the **tops** and **bottoms** and **backs**. Each sheet makes 10 tops or bottoms or backs.

Then set the table saw for a cut approximately 18.5" in the middle of the saw blade, and saw each of the sawed pieces already made (all sides, tops, bottoms, and backs) into pieces measuring 18.5 X 48". Stack these pieces into three piles: the particleboard piles will make the sides, while the hardboard piles will make tops and bottoms (the second pile) and backs (the third pile, which should have half as many pieces as the second pile). Use sticky notes or tape etc. to label the piles.

Saw the sides to 16 1/8" wide (each side piece previously made will become two pieces each measuring 18.5 X 16 1/8" and a too-short piece 18.5 X 15.5").

To salvage five more sides from each sheet of particleboard, glue and clamp a scrap piece (~3/4-1" wide, sawed from the surplus at the end of the 4 X 8' particleboard sheet) to an 18.5" edge of all the too-short pieces, and let them dry (to contain the glue, sandwich the glued boards between newspapers, then sand off the newspaper later).

Saw the backs and tops/bottoms to 22" wide (each piece previously sawed will make two pieces 18.5 X 22", plus a scrap piece 18.5 X 4").

Saw the sides and backs to exactly 16" height (the sides will become 16 X 18.5", the backs will become 16 X 22"). The sides and backs must be sawed with the same rip fence setting here, or the backs will not fit precisely onto the rest of the cabinet during later cabinet assembly.

Sawed front edges of particleboard sides are fuzzy and quite porous, and the fuzziness rises up into water-based paints. So you should wood-fill and sand the entire front edge of the sides to plug the pores and keep the fibers out of the paint. (The fuzziness of the saw cuts might be reduced a bit by using a special saw blade [which can now be wider than 1/8"in kerf] that has sharp sides of the teeth that are parallel to the plate and plane the surface of the board to make a smoother finish. The Vermont American #27716 Premier Plus 10" smooth-cut trim 80-tooth industrial dyanite carbide .131"-kerf saw blade works well. The Systimatic #1910, 10SF60-085 10" 60-tooth super-finish saw blade [kerf .131] also has planing sides of the teeth and should also work.)

Square the side pieces, by sawing a bit of material off either of the two 16"-long edges, preferably by using a quality squaring sled on the table saw. Mark the squared perpendicular corner with a penciled "L". (Most table saw miter gauges are very bad for squaring large pieces. I made an outstanding **squaring sled** from a 24 X 25" piece of 3 mm aluminum, a 25" aluminum angle iron, and a steel slide from an old table saw miter gauge. The angle iron is bolted to one side [the top] of the aluminum sheet to act as a backstop to the wood, and the slide is bolted to the opposite surface [the underside] of the sheet. A drywall square is used to make the slide perpendicular to the angle iron, but to give the drywall square something to rest against, a longer second angle iron must be clamped to the first, flat metal pieces must be clamped to the end of the second angle iron, a third angle iron on the opposite side [underside] of the sheet must be clamped to those pieces, and finally the drywall square will rest along the third angle iron while squaring the slide.)

Saw the sides to 17 ¾" length. Of course, you must saw the side opposite the side that was trimmed during the squaring operation, and place the squared corner next to rip fence during this operation. The sides are now finished, except for the grooves to be added later.

Square the backs, by sawing a bit of material off either of the two 16”-long edges, and mark the squared perpendicular corner with a penciled “L”.

Saw the backs to 20 21/32” width (or greater if your sides are thicker than the usual ¾”). Of course, you must saw the side opposite the side that was trimmed during the squaring operation, and place the squared corner next to rip fence during this operation. The backs are now finished. Keep the rip fence clamped to the table saw in its current position.

Saw the tops/bottoms to 20 21/32” width (or greater if your sides are thicker than the usual ¾”), so that each top/bottom piece previously made is now sawed into two pieces 18.5 X 20 21/32” in size.

Square the top/bottom pieces, by sawing a little material off either of the two 20 21/32”-long edges, and mark the squared perpendicular corner with a penciled “L”.

Saw the top/bottom pieces to 18” length. Of course, you must saw the side opposite the side that was trimmed during the squaring operation, and place the squared corner next to rip fence during this operation. The tops/bottoms are now finished.

Sawing Grooves into Sides

A. Use a felt-tipped pen to write “T” (meaning top) on the inside top edge of each side board (you could place the prettiest side inside, and paint the uglier outside).
B. Purchase a very-thin kerf saw blade, about .065” in kerf (approximately 1/16”), to match the .063” aluminum runners. Such a saw blade is difficult to find in ordinary stores, so try a commercial professional woodworking supply store (the kind of store that sells $6000. table saws, $5000. shapers, $2000. panel saws, and $200. saw blades). A perfect saw blade is the Porter Cable No. 12820 Riptide 7 ¼” 40 tooth carbide-tipped Premium Thin Kerf saw blade (about $30.00), which purrs through the wood to saw a groove ~.065” or .066” wide (my measurement in MDF fiberboard), and has a 5/8” arbor usable on 10” and 8” table saws. Half a dozen Freud 7 ¼” red-teflon-coated blades of kerf .067” and arbor 5/8” should also work. (Some Makita 4 3/8” 50-tooth steel trim saw blades work, but these trim saw blades should be avoided, because other blades of the same model are too narrow in kerf, this trim saw blade has a 20-mm arbor that requires one to use a milling machine to make a bushing of 5/8” inside diameter and 20 mm outside diameter to adapt it to the table saw, and the small size and steel [non-carbide] teeth make these trim saw blades burn out quickly.)
C. Install this saw blade on table saw and set depth to 11/32”.
D. Make an aluminum measuring rule to simplify correctly setting the table saw rip fence for sawing the grooves. This rule should be sawed/grinded 16” long (the height of each side piece). Write “bottom” and “top” on the ends of rule with felt-tipped pen (even though the ruler is symmetrical and should be the same when top and bottom are reversed). Use a sharp steel point to score grooves on rule at these distances from bottom of rule: 2 21/32”, 2 23/32” (these two grooves mark the edges of first saw groove), 5 10/32”, 5 12/32” (second groove), 7 31/32”, 8 1/32” (third groove), 10 20/32”, 10 22/32” (fourth groove), 13 9/32”, 13 11/32” (fifth groove).
E. Set the rip fence of saw exactly using the measuring rule (place bottom of rule against rip fence, and sight along each edge of saw blade to align blade perfectly between the two scored grooves on rule), clamp rip fence tightly to prevent any movement (lousy rip fences will gradually move out of position due to pressure against them during sawing, in which case you will need to place an angle iron [steel is best, because aluminum will rub off onto the wood creating a bluish-gray smudge that must be sanded off] in front of rip fence and clamp it to saw table with heavy metal clamps), and saw each of the five saw grooves. Pick the cosmetically best surface of the side for sawing, because you will later paint the ugly side. Be careful here, as one badly-placed saw groove will ruin all the side boards. The aluminum measuring rule is needed to help avoid an expensive mistake. Saw the first (lowest) groove on all the boards. Then, since the ruler is symmetrical (it is the same when top and bottom are reversed--turn the ruler around, placing top of ruler against rip fence, to make sure your ruler is correct and the rip fence is properly placed for the fifth groove), rotate the side boards 180^{o} and saw the fifth groove using the same rip fence setting. Set the rip fence for the second groove, and saw that groove, then rotate the side boards 180^{o} and saw the fourth groove. Set the rip fence and saw the third groove.

Wood Filling Front of Sides

Paint will not fill the saw grooves on the front edge of the side well, and paint (especially latex paint) will not fill the large pores on sawed edges of particle board, so for cosmetic reasons, the exposed grooves and the large pores on front edge of side boards should be filled.

Place many (even 25 or more) sides together, on edge, the front edges upward, and clamp them together so their ends are parallel. Clustering them like this makes wood filling and sanding much easier, and prevents the sander from rounding the 90^{o} edges too much. Use wood filler (the cheapest Elmer’s Carpenter’s Interior Wood Filler works fine) and a putty knife (blade width 1” works well) to fill each groove on front of the side (the aluminum runner will be installed in the groove behind the front, starting ¾” behind the front) and to fill the pores on the entire front edge of each side. I am told that Bondo (automotive) Body Filler is the best product to fill the pores on the edges of particleboard; it hardens after mixing a

hardener into it, applies easily, sands easily after drying, and costs only ~$13.00/gallon. Let the wood filler dry, then sand the clamped boards smooth. Sand off any wood filler that has gotten between boards.

Making Aluminum or Galvanized Runners

A. Obtain sheets of aluminum .063" thick. (Anodized aluminum would be best because it does not leave bluish-gray smudges on the drawer, but is scarce and must be specially-ordered in large quantity, and is rarely found in recycling yards.) Aluminum sheets are manufactured in 4 X 12' size, but a surplus aluminum recycling company will have smaller portions (48" wide by variable length) of these sheets at a greatly reduced price (~$2.00/pound). You could use 16-gauge galvanized steel sheets instead, which is much heavier, but costs half as much, and does not leave bluish-gray smudge marks on the drawer. Wash any dust or grit off the metal, as sand grains in dirt will damage the shear, and sheet metal shops will refuse to shear gritty metal.
B. Take the aluminum to a sheet metal shop to be sheared into strips (runners) 16" X 1" X .063". The California Academy Drawers are 17" long—not 16"—but cutting strips 16" long saves money because the 48" width of sheet metal can be sheared into three parts; and the 16" runners also allow you to use any size recycled scraps with almost no waste as long as they are 48" wide (after shearing into 1" runners, the waste would be less than 1"). Also, the 16" runners leave a space in rear of cabinet that makes removal of any excess glue around back a little easier during cabinet construction. To find an inexpensive price for shearing, you should call many such sheet metal shops; these shops charge about $55./hour (July 2000) for shearing, and by using the adjustable stops on the rear of the shear they should be able to shear about 700 pieces per hour. The shearing knife compresses the edges of the pieces a bit during shearing, which helps prevent gouging of the drawers. (However, if you have a band saw, you can clamp a rip fence to the band saw and use the saw to make lots of 1" strips. The saw will chew up a little aluminum, and takes a lot of time, but the resulting strips will not be twisted like sheared strips. If you need only a few 1" runners—say 20 or 40, you can even saw them from the sheet using a saber-saw [jigsaw] with a blade having about 12 teeth/inch [a blade with more teeth will quickly become clogged with molten metal unless you lubricate it with oil etc.]. Do not attempt to saw a lot of strips yourself using a table saw or hand saw etc., because the saw eats up a lot of material, galling is a big problem while cutting aluminum because aluminum tends to melt and fuse into the gullet between the teeth of the saw blade, lubricants to prevent galling are messy or hazardous [kerosene is often used despite being flammable, oil is messy, water produces an electrical shock hazard in the saw motor], the sawed edges are ragged and not compressed thus require extra sanding, a special metal-cutting saw blade with negative hook should be used, etc. The price of shearing is well worth it if you are making many runners.)
C. Using a bench belt sander, smooth any burrs and sharp places on the ends and edges of each aluminum runner.
D. Twist each runner a little to remove the slight twist imparted to the piece by the shear.
E. If the surface of some runners is rough or sharp or not smooth, sand them with fine sandpaper using the rotary random orbital sander, by holding three strips side by side on a table.

Installing Aluminum or Galvanized Runners

Runners sealed in place with Polyseamseal caulk will never come loose. The Polyseamseal caulk stays a little sticky, and fastens the aluminum runners very securely into the groove. Prying out a fully installed runner requires great force, by grabbing one end with large 16" pliers then using a 3' crowbar to pry the jaws of the pliers upward, and repeating this process all along the runner, which bends and mars the runner but finally extracts it. This method of installation is far stronger than other methods, such as nailing angle-irons or sliding aluminum molding into slots, etc., and costs enormously less.

A. Install a tube of Polyseamseal (clear) into caulking gun, cut only the extreme tip off of the tube applicator nozzle to make only a tiny applicator hole, stick a thin wire in the hole 3" and repeatedly puncture the seal that extends across the wide end of inside of tube just basal to the applicator nozzle. (Paint will stick to Polyseamseal somewhat, whereas paint will not stick to silicone, so be careful about substituting different kinds of caulk that may not work as well.) Each tube will make about 9+ cabinets.
B. Mark a pencil dash onto the inside of each side beside each groove, ¾" from the front (you previously wrote T for top in pencil near top of front of the inside of each side piece, which helps keep the sides oriented properly during cabinet construction), using three wood helper strips (place both sides onto table, insides upward, and fronts beside each other, place a third taller board [about 2" high X ¾" wide X 18" long] between them, move the sides together to clench this third board, place a ¾" width wood strip [about ¾" wide X ½" high X 18" long] on each side of third board, and run pencil along edge of each strip to mark the line).
C. Remove helper strips.
D. Squeeze a tiny bead of caulk into all grooves of side (just enough to fill top of each groove).
E. Use finger to press caulking into grooves, moving finger from back to front of each groove.
F. Run a wide chisel over each groove, from rear to front, to remove excess caulk. Wipe caulk off of chisel.

G. Place side piece onto floor, select an aluminum runner and give it a final inspection to make sure it is smooth and untwisted, select the smoothest side of the runner to place facing top of cabinet, and push aluminum runner slightly into groove, starting at the pencil line ¾" from front edge of side, until runner stays in place. Place **pressing board** (hardwood about 1 ½" X 1 ½" X 18" that has a saw groove about ½" deep along one side) onto the aluminum runner (the aluminum runner should fit into the groove of pressing board), then use both hands and both knees and your body weight to press runner into groove, pressing from front of runner (near front edge of side) to back of runner. The aluminum runner should press smoothly into place. A slight wiggle of rear of pressing board, or a few whacks with a rubber mallet on the pressing board, are very rarely needed.
H. Use a chisel to remove excess caulk (usually none oozes out, or perhaps a little oozes out at the end of each runner). Installation of the runners takes about 10 minutes for each pair of sides.
I. Let caulk dry for a few hours or a day or so.

Assembling Cabinet from Sides, Top, Bottom, and Rear

A. Make an **alignment board** to temporarily hold the sides vertically (upside down, front forward) while the bottom is installed. This board saves time by positioning the sides during assembly, and reduces excess glue cleanup by keeping the sides and bottom where they should be. The alignment board should be about 31" long, and about 6" wide or wider, with two ¾" grooves (one groove between 5" to 5 ¾", the second groove between 24 29/32" to 25 21/32"); the grooves can be made by nailing a board on each side of a ¾"-wide space on the alignment board. A narrow board should be nailed onto the back of this grooved board to serve as a backstop to the sides. Place the alignment board on the work table, grooves upward, and backstop to the rear.
B. Place the two sides into the two grooves of alignment board upside down (tops downward, fronts forward, flanges facing inward).
C. To **attach the bottom**, check for warping. The concave side should face inward if both surfaces are the same. If the bottom is covered with white vinyl, you will probably want the white side to face inward, but wood glue will not stick to vinyl, so mark where the sides and back will be on the bottom, score those lines with a knife, and peel off the vinyl there so that the bottom can be glued to the sides and back with regular glue.
D. Spread glue (the aliphatic resin glue Titebond II is best because it is waterproof; Titebond Original Wood Glue, Elmer's Carpenter's Wood Glue, etc. will also work) onto bottom edge of sides (which are upward now). Position the bottom onto sides, the concave side facing inward, which usually means the smooth side downward (but if your hardboard is smooth on both sides, then face the concave side toward center of cabinet, unless you want the white smooth side to face inward and the brown smooth side outward), so that the front edges of bottom and side pieces are aligned and the bottom extends backward from sides ¼". The smooth side of the bottom should face into the cabinet so that the lowest drawer can glide smoothly on its smooth surface, and the fuzzy side of the bottom can grip the surface beneath the cabinet. Nail the bottom into place; 1" brads from a nail gun work great everywhere on the cabinet. To maintain alignment while you nail, first adjust and nail the right front corner, then adjust and nail right rear corner, nail three nails in right middle, adjust and nail left front corner, adjust and nail left rear corner, nail three nails in left middle.
E. Use a sharp wide chisel to scrape off the mound surrounding each nail hole. When a nail shoots through hardboard, a low volcano-like mound erupts around the hole, evidently due to release of stored pressure in this pressed-wood product, or due to lateral pressure from the nail. The chisel scrapes off this mound.
F. Wipe off excess glue.
G. Grasp alignment board ends and pull (pitch) cabinet toward you until it rests on bottom. Grasp lower part of cabinet and rotate (yaw) cabinet so that front faces toward you. (A ship has three movements that change its orientation: it can pitch forward or back, yaw [turn] to right or left, or roll [rock sideways]; these words are useful to describe how to move the cabinet.) Leave the alignment board in place.
H. Chisel off excess glue from installation of bottom. (The best way to remove glue quickly from a joint is to orient chisel with flattest side against board, move chisel forward on board while side of chisel runs along perpendicular board to scrape glue up onto chisel, wipe glue off chisel, then do the same while flat side rests on other board and side of chisel contacts first board. Use two chisels so you can scrape dried glue off one chisel with the other.)
I. Place alignment board out of the way onto table behind cabinet in the position for receiving the next cabinet.
J. To **attach the top**, first check the top for warping. If you have added 1/16" to top and bottom of sides to make them 16" height, then slight warping will not matter. But if your sides are only 15 7/8", or warping is severe, the concave side should face inward. If you use fuzzy-sided hardboard, generally this means the smooth side should face inward (downward, toward center of cabinet), the fuzzy side outward (upward). The smooth side of top could be oriented outward for several reasons: to conserve paint, as the smooth side requires [absorbs] much less paint than the fuzzy side; and the fuzzy side is the same color as the particleboard, so if the fuzzy side were inward it would match the color of the sides better and could remain unpainted. However, the smooth side of ¼" hardboard tends to warp a little and become concave, so if the smooth side is oriented upward away from the drawers the fuzzy side tends to be a little

convex and droops downward and almost touches the topmost drawer in some cabinets, so it is better to orient the smooth side inward, so that pressure from cabinets above will straighten the top (just as the bottom is straightened by resting on a cabinet below it). This orientation is consistent with the bottom and back also; all three are oriented with smooth side inward. If your hardboard is smooth and brown on both sides, then face the concave side toward center of cabinet. And if your hardboard is smooth on both sides but white vinyl on one side, the vinyl side is generally concave so will have to face inward. (See Appendix I to reclaim a cabinet that has an excessively warped top or bottom.)

K. Spread glue onto top edge of sides. Position top onto sides, so the front edges of top and side pieces are aligned and top extends backward from sides ¼". Nail on the top, as you did the bottom
L. Rotate (yaw) cabinet so that rear faces you. Pitch cabinet back so that rear of cabinet is facing upward.
M. Chisel off excess glue from installation of top.
N. To **attach the back**, spread glue onto rear edge of sides. A bit more glue is needed here, because the glue will dry a little more before glue can be applied to all four of the places where it is needed.
O. Quickly pitch cabinet toward you so that rear is facing toward you, and pull cabinet toward you so that rear overhangs edge of table a little (about one inch) so that your thumbs can later grip the underside of cabinet.
P. Quickly spread glue onto the ¼" top margin of the bottom that will touch the bottom edge of rear when rear is installed. To hold the nozzle steady, place a finger beside nozzle and run that finger along edge of bottom.
Q. Orient rear piece properly for installation (fuzzy fabric side facing outward [toward you], top edge upward) and spread glue along top edge of rear piece (running finger on side of piece to hold nozzle steady). The fuzzy side of back faces outward and resembles particleboard in color, so can remain unpainted (if your hardboard is smooth on both sides, then orient the concave side toward interior of cabinet, unless you want the white smooth side to face outward and the brown smooth side inward).
R. Carefully place top edge of rear piece beneath rear of top piece and place top margins of rear piece onto sides, and exert a little upward pressure as you hold the rear piece from beneath, then press bottom of rear into place above back edge of bottom piece. (The back should fit into place exactly and tightly, because the sides and backs were previously sawed to identical height using the same table saw rip fence setting.)
S. Place a heavy weight onto back edge of top to act as a clamp for gluing the back.
T. Adjust the lateral position of bottom of back precisely, place a nail there, then adjust the lateral position of top and place a nail there.
U. Nail back piece completely onto sides, exerting pressure with the nail gun to help press the back into place.
V. Check the joints where back fits into top and bottom by sighting across the back. If back is bowed inward or outward a bit at the middle of top or bottom, it should be pressed outward or inward a bit until it is recessed the same amount all across cabinet. The weight should now hold it in place.
W. Chisel off the mound surrounding each nail hole on back and on top of cabinet.
X. Fill the nail holes on top of cabinet by using a narrow (11/32" wide is ideal; grind a wider putty knife to narrow it) putty knife and wood filler. The tiny nail holes on back of cabinet can remain unfilled and unpainted.
Y. Rotate (yaw) cabinet to face you.
Z. Chisel/wipe off excess glue inside and outside cabinet.
AA. Let cabinet rest, with weight still on top of rear, until glue is dry. Assembling the cabinet takes about 15 minutes with a nail gun.

Painting Cabinet

The easiest color to use is a tint that matches the particleboard and fuzzy side of the hardboard (which is exposed on top and back of cabinet), so that the paint will match the inside of sides, which thus do not need to be painted.

Epoxy paint is fairly expensive, but is very hard and durable and is said to be excellent. Enamel is also good.

Latex paint is not the best for use on particleboard, because it is water-based, and all water-based paints raise wood fibers and make the surface look fuzzy (although some people might like the texture of a non-smooth paint job), whereas oil-based paints do not raise the fibers and make a smoother finish. But if you do use latex paint, a custom-color-matching machine reported that particleboard could be matched, in Glidden Evermore Wall Interior Latex Flat Pastel (HD-9018), by using these colorants: (first trial) C (yellow oxid), 5 oz, 8/48 oz, 0/96 oz; E (thalo blue), 0 oz, 25/48 oz, 0/96 oz; V (magenta) 1 oz, 13/48 oz, 0/96 oz.; (second trial) C (yellow oxid) 3 oz, 36/48 oz, 0/96 oz, E (thalo blue) 1 oz, 3/48 oz, 1/96 oz, F (red oxide) 0 oz, 30/48 oz, 0/96 oz; both trials produced results that would make very similar tan-colored paint.

It would be possible to paint the entire inside of sides, but paint (especially messy sloppy latex paint) would interfere with sliding of the drawers, so this paint job would require laborious masking of the aluminum flanges. Masking tape, or folded cardboard that is taped at the ends, could be placed over the runners, and a spray gun could be used to spray the cabinet inside and outside, and then the tape or cardboard could be removed. Or, each side could be painted before sawing the grooves, with the hope that the table saw would not mar the paint while sawing the grooves, but after sawing, the grooves on front of side would have to be filled then repainted. There are hundreds of ways to paint this cabinet that the reader could investigate. Melamine sides would already be painted white.

I paint the top of the finished cabinet (the fuzzy surface requires two coats), the sides, the rear edge of top, the rear edge of bottom, the front edges of all sides/top/bottom, and, to make the cabinet look better when the drawers are installed, the front interior of the cabinet (inward into cabinet about 2") all around the inside.

If white-edged melamine were used to make the sides, and white-vinyl-covered hardboard were used for top/bottom/back, then the only areas that would need to be painted (with semi-gloss non-latex paint that matches the creamy-white melamine) would be the grooves extending forward from the flanges, the nail holes on top, all four ¼" edges around the top and bottom, the lateral ¼" edges of back, and the inside of top for at least the front several inches.

Water-Repellent Foundation Supports

Water leaks may happen where the cabinets are stored. To prevent damage to the cabinet from up to 1 5/8" of water, you should make composite blocks to place under each side. Each block should be about 17 ¾" X 2" X 1 ¾" in size, and should consist of four layers. The top and bottom layers should be 1/8"-thick plastic, and the middle two layers can be ¾" particleboard. Nail these layers together. The bottom plastic layer prevents a thin layer of water from damaging the supports. The top plastic layer prevents a deeper pool of water (up to 1 5/8" deep) from creeping up through the support wood into the cabinet.

Place the supports under the sides of the cabinets. One support can be placed under the right side of one cabinet and the left side of the adjacent cabinet.

Appendix I. Replacing Flawed Tops/Bottoms

If the top (or bottom) of a cabinet warps inward enough to block a drawer from entering smoothly (which should not happen as extra space has been allowed on top and bottom to accommodate warping), or has suffered accidental damage, you can reclaim the cabinet. Saw off the flawed top, right through the nails using a cheap expendible saw blade (such as an inexpensive used thick 7 1/4" carbide blade), and then install another top onto the cabinet. Saw through the middle of the hardboard top piece, leaving an extra 1/16" (or more) thickness of hardboard top still attached to the side to make the side higher so that the new top will be 1/16" higher. To make this saw cut, place the other side of the cabinet against the rip fence ~16 ¼" away, because the saw blade widens the ¼" hardboard as it saws through it, so if you place the saw blade next to the rip fence the hardboard will bulge outward and make the saw cut go awry. Saw the cut a little more than 5/8" deep. The top will remain on the cabinet after this sawing. So, use a laminate-trimmer router bit on a router to remove the top. Place the cabinet on the saw again and resaw it the same way to trim the sawed edges a little better (saw the two sides first, then readjust the rip fence a bit to resaw the back if it looks like the saw will take too much off the back). Use a knife to cut out the round corner of top at left rear and right rear where the laminate trimmer did not remove that bit of the top. Attach a new top with glue and nails (check the new top for warping), remove excess glue, wood fill holes and cracks, and paint the top.

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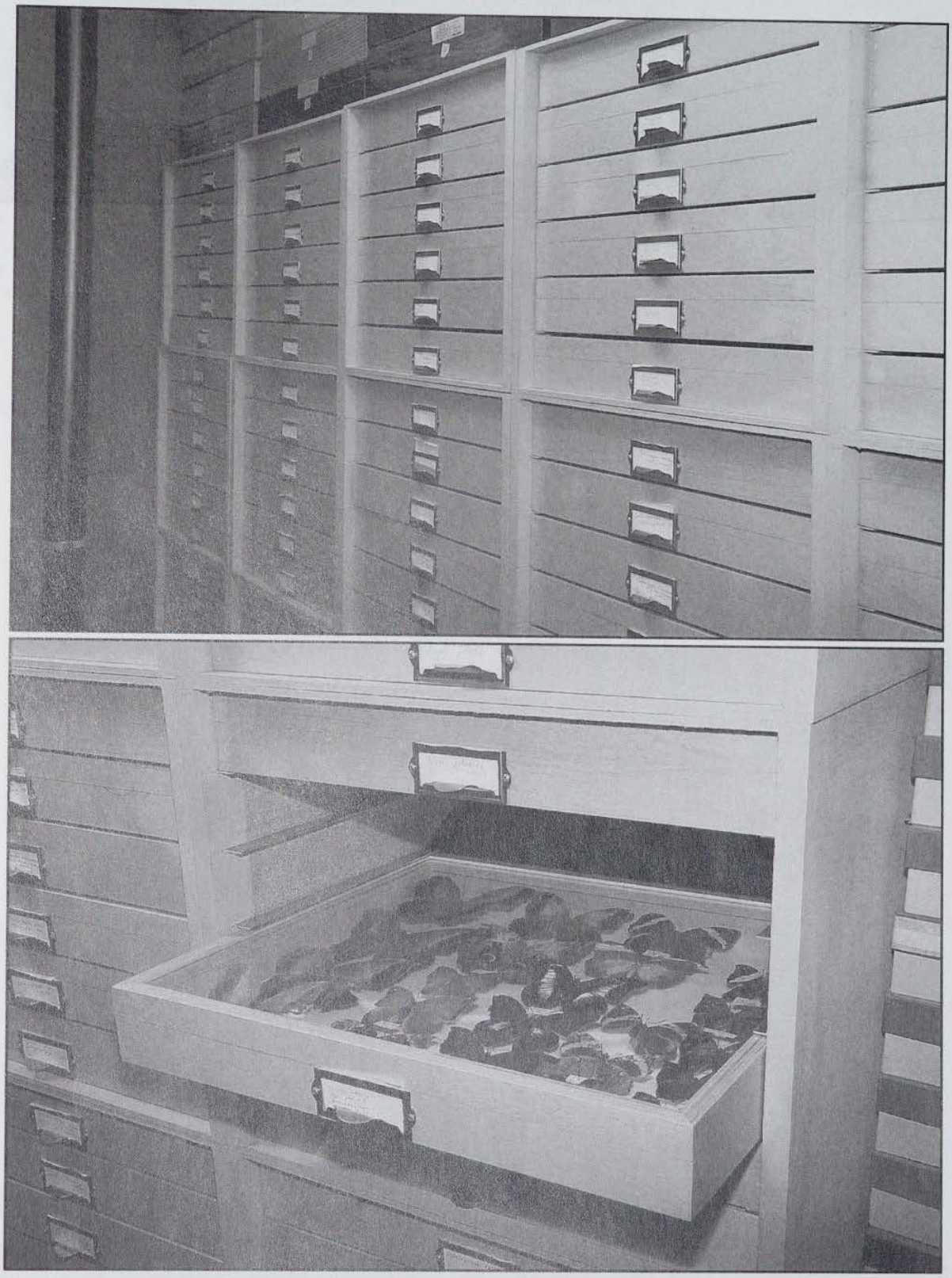

Cabinet system and representative specimen drawer showing slide rails

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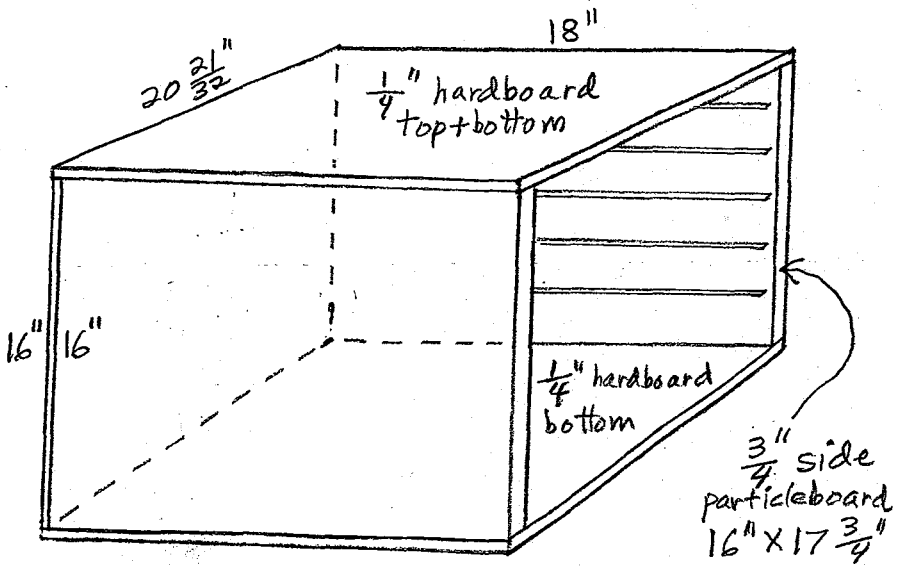
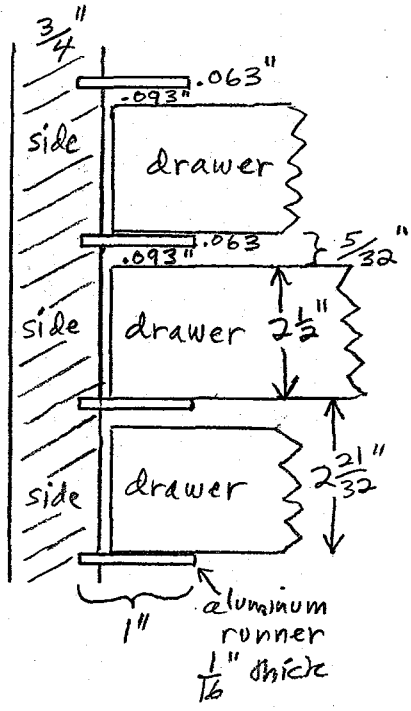
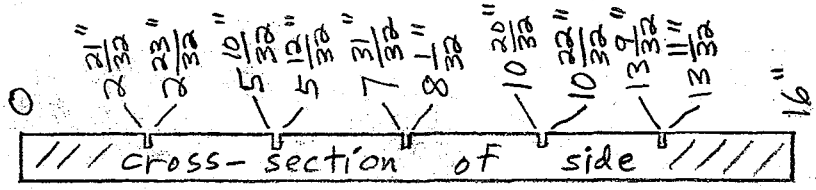
Cabinet for California Academy Drawer



Back 1/4" hardboard X 20 21/32 X 16"





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