

Laminate Toy Cars & Trucks

Tips and Techniques

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***** CAUTION *****

Always work safely. Wear appropriate clothing; eye, ear and respiratory protection. Read, understand and follow all operating, maintenance and safety documentation provided with shop tools and materials employed in this manual. Prior completion of Valley Woodworkers Safety Training Class is highly recommended for all club members and is mandatory for club members who wish to use Valley Woodworkers shop tools.

Laminate Toy Cars & Trucks – *Tips and Techniques*

I. Introduction

For more than 20 years The Valley Woodworkers of West Virginia have joined forces with the Salvation Army to produce and distribute hundreds of high-quality wooden toys to needy children at Christmas. Toys produced by the Valley Woodworkers currently include: wooden doll cradles, block wagons with sets of alphabetic and numeric blocks and an assortment of toy vehicles. In 2013, The Valley Woodworkers produced, and The Salvation Army distributed, nearly 900 individual toys.

Producing large quantities of beautiful and fun wooden toys is a year-long process involving several coordinated team projects, gaining momentum in the second half of the calendar year. Project participants dedicate dozens or even hundreds of hours every year to insure the success of this worthy cause and its positive effect on the club's public image.

Participation in the production of wooden toys is a rewarding experience on many levels. Not only a worthwhile civic effort, working on toy projects provides opportunities to work with and enjoy the company of fellow woodworkers; to learn, practice, and perhaps discover new interests and talents. Making quality wooden toys, including cars and trucks, requires the mastery of a surprising variety of basic woodworking skills.

This brief manual covers the author's adopted and developed methods of making the club's traditional laminate toy cars. The contents reflect his experience and experimentation in producing over 100 vehicles of varying designs during the author's first year of toy project participation. The purpose for creating this manual is to encourage and assist both new and veteran club members, regardless of skill level, to join the fun of working on Valley Woodworkers toy projects.

Many thanks to Andy Sheetz, Peter Howell, Dan Pleska, Jerill Vance, Allan McNeil and many other Valley Woodworker toy makers who developed the fundamental designs and methods upon which the expanded tips and techniques found herein are built. Any errors in applying, communicating or attempting to improve upon their wisdom are attributable only to the author.

Let's build some cars!

II. Basic Description

The toy cars and trucks we will build all share a basic style and method of construction. Vehicle designs are fanciful instead of realistic making them easy to build and modify. Finished models can vary wildly in appearance while sharing common materials and construction techniques. Sizes vary from two to three inches wide, five to ten inches long and up to six inches tall.

All vehicles, including cars, trucks and trailers are constructed using profile templates, three-layer hardwood glued-up laminates, standard 2 in. dia. prefabricated wheels, 3/8 in. dia. hardwood dowel rod axles and are finished with clear, non-toxic-when-dry salad bowl oil.

Finished toy vehicles are delightful in appearance, durable and safe for children to play with, and have an enduring quality and feel only handcrafted wooden objects possess.



Clockwise from left: Sedan, Van, Pickup & Trailer, Dragster, Coupe, Speedster – vehicle designs limited only by the imagination!

III. Materials

Materials incorporated in the construction of this style vehicle include:

1. Outer hardwood boards (2), lighter color (e.g. ash, oak, maple), approximately 5 in. wide, 30 in. long, $\frac{3}{4}$ in. thick, planed 2 sides and jointed one edge.
2. Inner hardwood board (1), dark color, (typically walnut)
3. Prefabricated and preassembled 2 in. dia. hardwood wheel/hubcap assembly with 3/8 in. dia. through hole for axle and hub cap. See Appendix B if hubcap preassembly required.
4. Prefabricated 36 in. long, 3/8 in. dia. hardwood dowel rod stock - cut to desired lengths (club-provided dowel rod stock)
5. Wood glue, e.g., Titebond II yellow glue
6. Salad bowl oil (club-provided)

IV. Recommended Tools and Shop Supplies

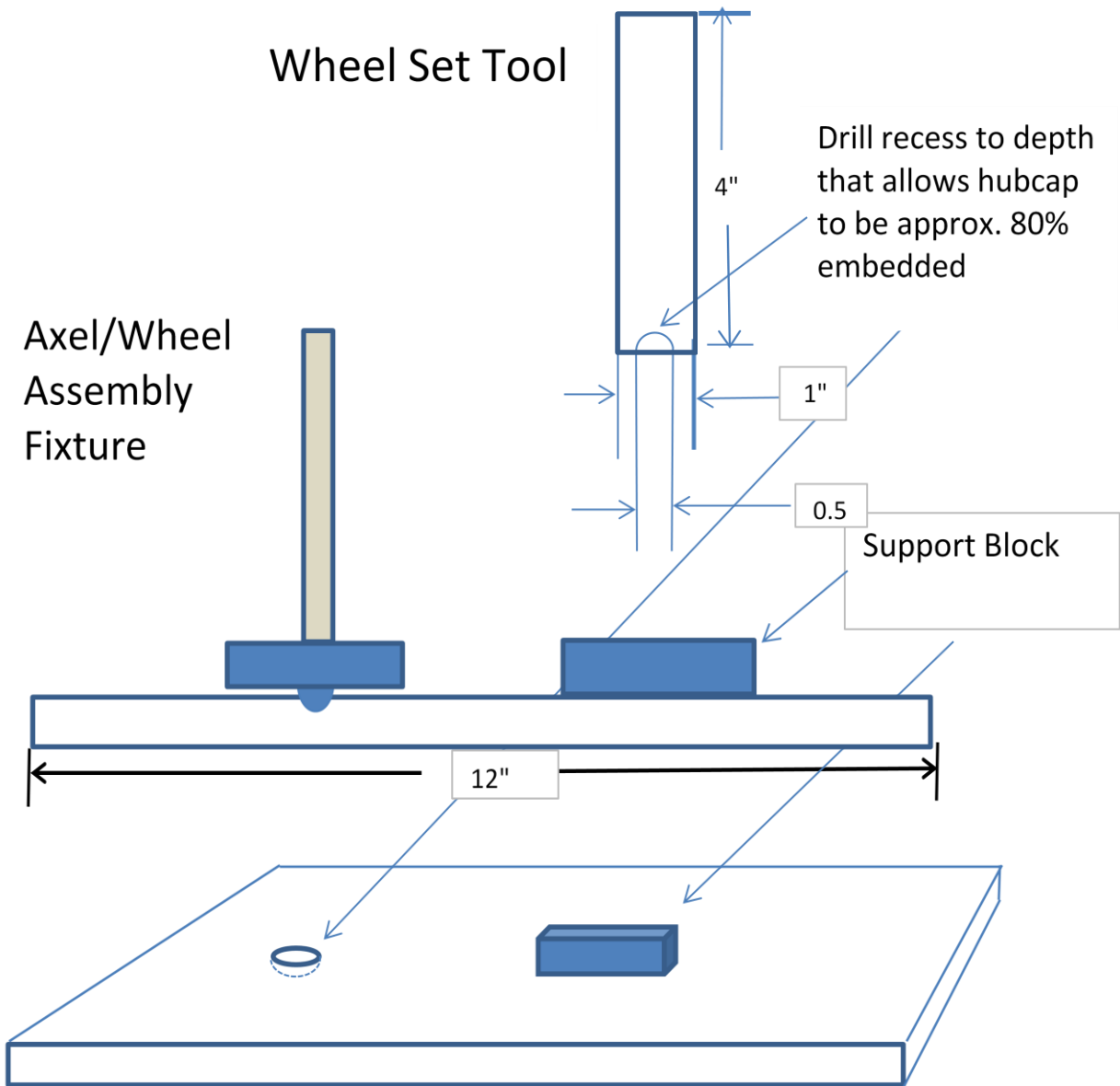
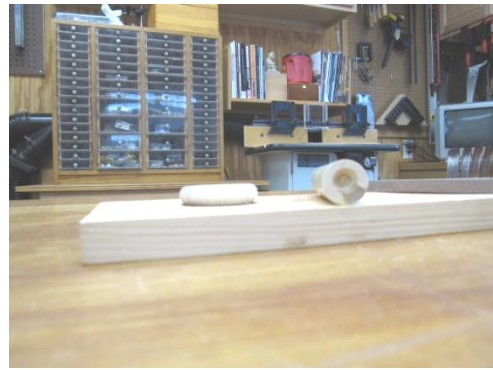
Tools employed in the construction of this style vehicle may vary based on personal preference and availability. The list below is based on tools used in the author's home workshop. The Valley Woodworkers shop has a complete inventory of tools and supplies if some or all of the work is done at that location. Note that members must have passed the shop safety test and attained "Sawdust Maker" certification status before using shop tools.

1. Wood clamps as required, including a minimum of 2 ea., 2 ft. pipe clamps – laminate glue-up
2. Table saw – cleaning up and making parallel edges on glued-up laminates
3. Miter saw – trimming ends of glued-up laminates
4. Drill Press with table and fence – boring holes for axles, windows, fender recesses
5. Forstner bits (slower but cleaner holes) – diameters up to 1 in., plus optional 2 1/8 in. dia.
6. Spade bit set, e.g., Irwin "Speedbor" (faster but holes not as clean) – 7/16 in. dia. recommended for axle through holes, other standard sizes optional for boring window holes.
7. Band saw, 3/16 in., 10T or ¼ in., 6 T blade – cutting out vehicle bodies
8. Table-mounted router, 1/8 in. radius round-over bit with bearing
9. Random orbital sander with assortment of disks
10. Belt/disk sander, benchtop, 36 in., 120 grit
11. Oscillating spindle sander with assortment of 120 grit spindles.
12. Sandpaper/sponge assortment, 120 – 220 grit (320 grit optional), rubber sanding block
13. Fixture for wheel/axle assembly, shop made (see A. below)
14. Wheel set tool, shop made (see B. below)
15. Wooden Mallet
16. Plastic tray or shallow tub (approximately 24 in. X 24 in. X 5 in. deep) for applying oil finish
17. Inexpensive 2 in. and 1 in. paint brushes, shop rags, disposable gloves, mineral spirits.
18. Vehicle profile templates representing styles of vehicles to be constructed (see C. below)

A. Axle/Wheel Assembly Fixture (see drawing & photo below)

The axle/wheel assembly fixture facilitates perpendicular insertion of axles into wheel hubs while preventing damage to or accidental removal of wheel hubcaps. Because hubcaps and axles share a common through-hole, it is possible to dislodge and/or damage the glued-in hubcap when driving and seating the axle if the hubcap is not backed up during this operation. The fixture also provides hubcap location and support when assembling opposite side wheels.

The fixture may be made from a piece of 12 in. x 6 in. x ¾ in. scrap pine board or plywood. The recess for the hubcaps may be made using just the tip of a ½ in. dia. standard drill bit, drilling vertically into base only to a depth at which the rounded surface of the hubcap, when inserted, still may be seen from the side. The recess distributes the driving energy over a greater portion of the surface of the hubcap, reducing marring, and will support the hubcap when the axle is driven and seated. The support block is approximately the thickness of the wheel and is used to help keep the vehicle body level when driving opposite side wheels onto axles.

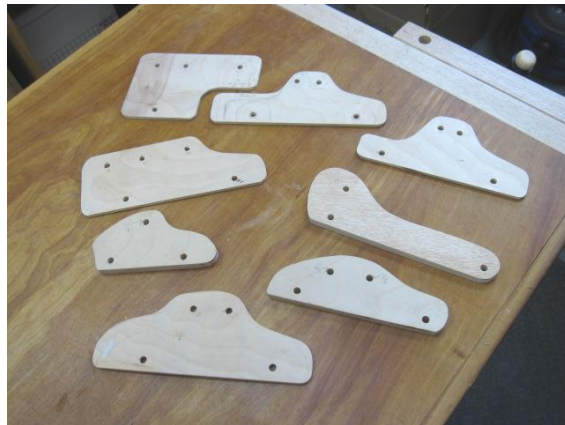


B. Wheel Set Tool (see drawing & photo above)

The wheel set tool is used to drive opposite side (unsupported by the wheel/axle assembly fixture) wheels onto the axle and in assembly of hubcaps to wheels (see Appendix B). The tool focuses the driving force to seat the wheel perpendicular to the axle while helping to protect the hubcap from marring during this operation. The wheel set tool is made from a piece of approx. 4 in. long X 1 in. dia. hardwood dowel stock. A shallow recess for hubcaps with same dimensions described for the wheel/axle assembly fixture should be drilled in one end of the dowel.

C. Vehicle Profile Templates (see photo examples below)

An assortment of vehicle profile templates and drawings to make them are available from the Valley Woodworkers. The author has deviated somewhat from traditional club templates for some vehicles in order to create new and, in some cases, easier to produce models. Woodworkers are encouraged to design or modify profile templates to provide more varieties.



Plywood Vehicle Templates, note axle & window center locations

V. Vehicle Body Fabrication

Several major operations must be completed to form the vehicle body, from preparation of the glued-up laminate to final sanding. Operations should be performed in sequence, maintaining tool setups for batches of laminates as much as possible.

A. Wood Selection:

Valley Woodworkers will supply the wood needed to fabricate the vehicle bodies. Wood will be supplied in the form of boards approximately 30 inches long and 4 to 6 inches in width. Thickness may vary but will be approximately 5/8 to 3/4 in. Boards will be planed on both faces and will typically have one jointed (straight & perpendicular to both faces) edge.

- 1.** Select 3 boards you will use for a given laminate. If possible, try to select boards for each laminate that are approximately the same length and width. Outer boards should be equal thickness as well. Take note of defects, if any, and grain patterns on the outer boards.

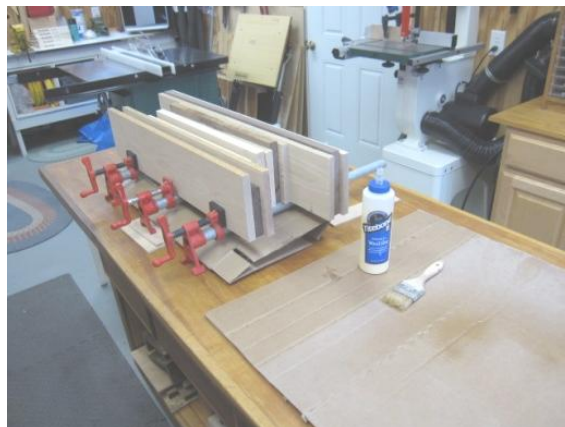
2. Align selected boards so that jointed edges will be together.
3. Match color and grain patterns of outer boards as closely as possible to enhance the appearance of the finished vehicle body. Typical laminates will consist of light-colored ash for the outer boards and a dark walnut for the inner board.
4. Repeat steps 1 though 3 for all laminates in the batch (recommended max. 3-4 per batch)



3-Piece Laminates Arranged Prior to Glue Application

B. Laminate Preparation:

1. After selecting the boards to be used and the number of 3-board laminates to be made in a batch, set up pipe clamps on a work table and dry-stack the laminates, jointed sides down on the outer pipes. Stack back to back to back in the clamps to optimize clamp pressure.
2. If laminates are of varying lengths, place longer laminates at front and rear of stack and “sandwich” the shorter ones between as shown in photo below.
3. Position pipe clamps about 3 in. from each end of longest boards and one or two in the middle if there are shorter laminates in the stack – your method may vary.
4. Note that it is not necessary at this stage to trim ends of the boards to make them even.
5. Distribute the 3-board laminates within easy reach and in glue-up alignment. Prepare a space and materials to be used to apply the glue to each laminate.



Clamp Setup, Glue Area Preparation

C. Laminate Glue-Up:

Work on one 3-piece laminate at a time and work quickly to complete the entire batch before glue sets up. You will have 5 minutes or less to get the entire batch glued and clamped.

1. Using an inexpensive 2 in. paint brush or glue applicator brush, apply a liberal amount of glue to the inside surfaces of each of the outer boards. Glue may also be applied to the inner board if preferred. Glue should be applied evenly to the entire surface. Use enough so that the yellow color of the glue will just mask the underlying wood grain.
2. Place the inner board on the glued surface of one outer board, aligning the jointed edges. Place the second outer board glue-side-down onto the inner board and again align the jointed edges. Work the outer boards back and forth a little to internally spread the glue to the walnut inner piece. Keep jointed edges aligned as much as possible.
3. Place the glue-up vertically into the clamp setup and repeat for the remaining laminates in the batch. When all the laminates are in the clamp setup, check again for good alignment of the jointed edges, i.e., orient laminates vertically with jointed edges on the pipes.
4. Slowly close the outer pipe clamps until they start to snug up – close both outer clamps simultaneously to insure equal pressure on the ends. Do not tighten yet.
5. Check that all jointed edges in the stack are still in contact with the pipes and add additional clamps as required. Slowly tighten clamps symmetrically from the middle out while making sure the jointed edges stay in contact with the outer pipes. Do not over-tighten the clamps but try to exert equal pressure across the faces of the outer boards until all visible parallel surfaces close up. Some glue “squeeze-out” will occur during tightening.
6. After final tightening there is no need to clean up any glue “squeeze-out”. Leave the laminate stacks to cure in the clamps overnight.



Glue Applied to Outer Boards



Typical Glued-Up Stack with Clamps

D. Trim Work Piece Edges and Ends, Sand:

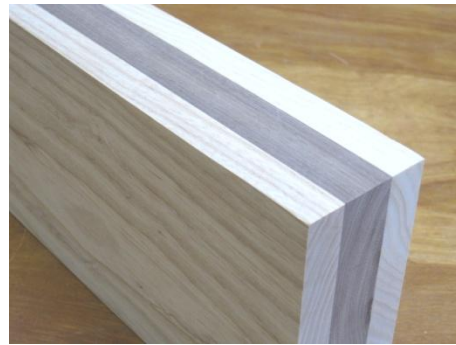
1. Remove laminate work pieces from the clamp setup. Use a sharp chisel or scraper to remove excessive glue from the jointed edges. Check that jointed edges will ride evenly against the table saw fence. Don't worry if all 3 boards with jointed edge are not perfectly aligned. As long as at least one of the 3 jointed boards contacts the table saw fence along

its entire length, or the laminate will not rock on the fence, a straight trim cut will result. Use shims if laminate rocks on the fence. In rare cases the edge may need to be re-jointed.

2. Set the jointed edge of one laminate work piece against the table saw fence. Set the blade height and fence position to trim the opposite edge flush and square. Note that the 3 boards selected for a laminate will probably not all be the same width. Cut this edge to the width of the narrowest board, less enough to remove any glue, offset or major defects.
3. Flip the laminate work piece so that the straight edge just cut is against the fence. Set the fence position to just trim and square the other (jointed) edge. The result of this cut should be a laminate with 2 clean, parallel edges and 2 parallel faces.
4. Cross-cut the ends to square them up and remove any visible glue from the end surfaces. You should now have a work piece with 6 clean and perpendicular sides.
5. Repeat steps 1 through 4 for all laminates in the batch.
6. Sand the 6 surfaces of all trimmed laminates with orbital sander and 120 grit disks (drum sander if available). Remove all remaining planer and saw blade marks or burns.



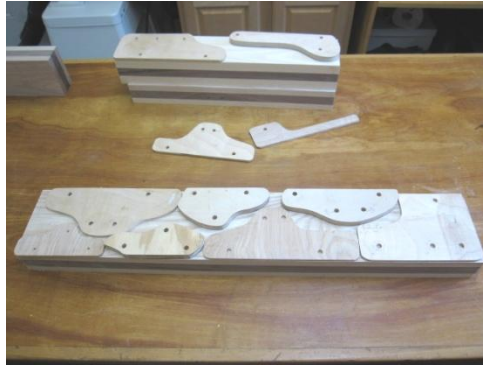
Trim Non-jointed Edge First



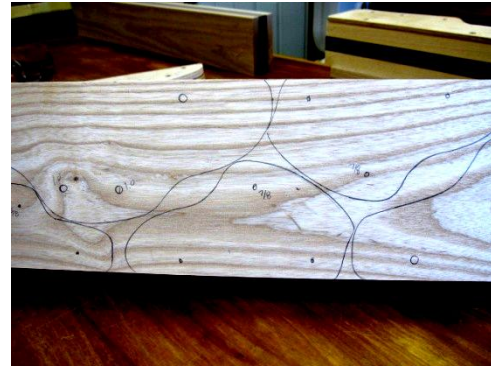
Work Piece after Trimming & Sanding

E. Layout Templates, Trace Vehicles (see photos below):

1. Select template(s) to be used to cut out a grouping of vehicles from each laminate.
2. Position templates so that the flat bottom edges of templates align with either the top or bottom edges of one face of a laminate work piece. Arrange the template positions so that they “interlock” without touching as much as possible in order to optimize use of the glued-up laminate (see photo). A 30 in. X 5 in. laminate should yield 5 or more vehicles.
3. After laying out the grouping, trace the outline of each vehicle body, window and axle centers onto the face of the laminate work pieces using a #2 shop pencil.
4. Lightly write the final size of window and axle openings next to its position. You should also note if recessed wheel openings will be bored at axle locations, see section F.2. below.
5. Note that the bore hole size for 3/8 in. dia. axles should be 7/16 in. dia. for best fit, although 1/2 in. dia. axle holes are also acceptable if standard wheel mounting, i.e., no “fender recess” in the body is to be created. See F.2. below for more on “fender recesses”.
6. Center punch all bore locations to facilitate positioning of boring tools, next operation.
7. Complete steps 1-6 for all laminate work pieces in the batch



Typical Template Layout



Templates Traced on One Face

F. Bore Holes for Axles and Window Openings: (See first notes on bore "Tear-Out" below)

1. Move laminate work pieces to drill press table with rear fence. You may choose to complete Window Openings first if preferred (see steps 3 & 4 below). If only non-recessed wheel/axle openings are planned, or if recessed and non-recessed types will be mixed on the laminate, through-bore all **non-recessed** axle hole locations using a 7/16 in. dia. bit and backup board. If recessed wheel/axle openings are to be employed, see step 2.



Drill Press Setup for Drilling Non-Recessed 7/16 in. dia. Axle Holes

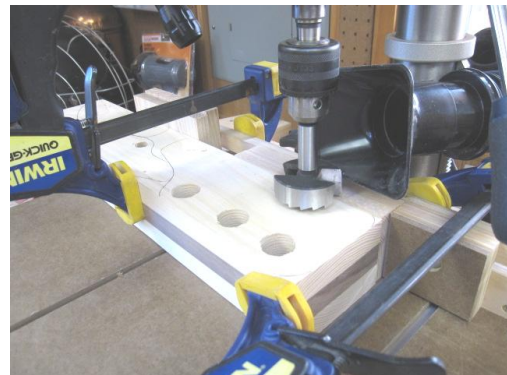
2. If you choose to recess the wheels into the car or truck body to create a "fender recess" then **do not bore axle holes at recessed locations** as described in step 1 above. Instead, use the following setup and procedure to create the recessed wheels and axle bores.
 - a. Mount a 2 1/8 in. dia. Forstner bit in the drill press. Note RPM recommendation for this size bit (around 400-500 RPM).
 - b. Mount a solid hardwood or plywood sacrificial backing board against the fence behind the work piece, two boards may be required to achieve desired thickness. Cut backing boards that are the same height as the thickness of the work piece and of sufficient thickness that the Forstner bit will not "cut" into free space when centered on the axle location. The backing board prevents the large bit from chattering and vibrating when cutting the partially round recess feature in the work piece. Be sure to move to a "fresh" place on the backing board with every cut.
 - c. Set the depth of cut for the Forstner bit to be 1/4 in. to 3/8 in.
 - d. Align fence and stops so that the Forstner bit is centered on the axle hole location.

- e. Clamp the work piece flat to table and to the fence in two locations, preferably to straddle the cutting tool. Cut wheel recess on the template side to the desired depth.
- f. Unclamp the work piece and relocate it and the backer board to the next axle location on the same (template) side of the vehicle body and repeat the recess cut. Complete all recess cuts in the same manner on the template side.
- g. Change the cutting tool to a 7/16 in. dia. spade bit and readjust drill press depth so that the spade bit will bore through the vehicle body and only the tip of the bit will exit the car body at the bottom of the bore. Shoot for a pinpoint exit hole.
- h. Re-clamp work piece and bore axle holes down through the recesses, centering the spade bit on the center of the recesses just made by the Forstner bit.
- i. Turn the work piece over so that the side with the small spade bit exit holes is up on the drill press table.
- j. Remove the spade bit from the drill press chuck and reinsert the 2 1/8 dia. Forstner bit.
- k. Repeat the setup and procedure above for cutting recesses using the small exit holes made by the spade bit as center locations for the Forstner bit.
- l. You may or may not need to re-bore the axle holes on the second side depending on how deeply you cut the recess with the Forstner bit. The recess cut should expose most, if not all, of the 7/16 in. dia. axle bore.

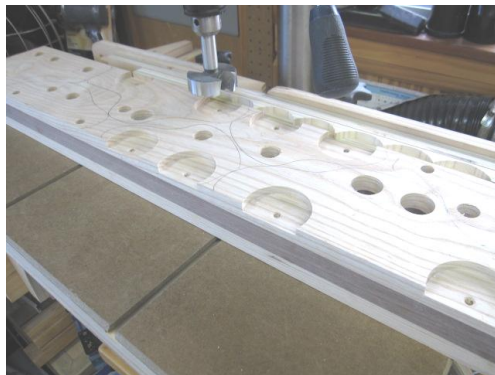
Recessed Fender & Axle Sequence, note window openings shown completed first



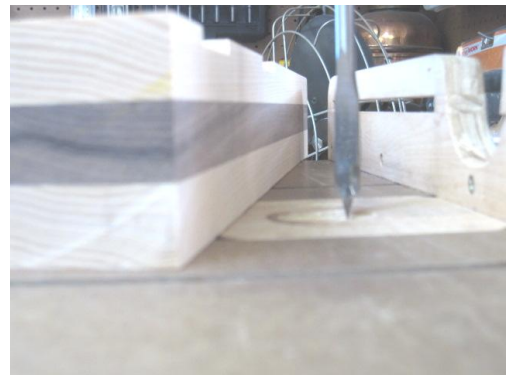
2 1/8 in. dia. Bit & Backer Board



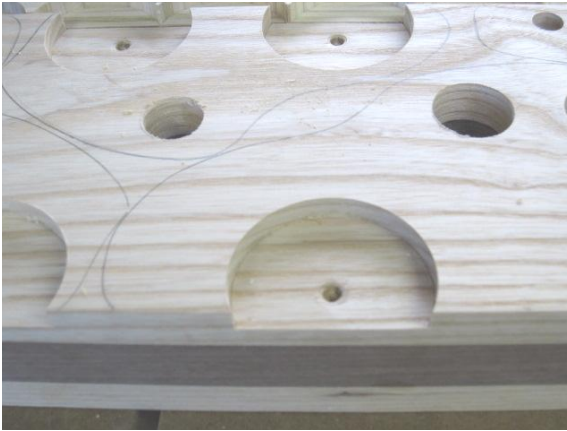
Clamp Setup for Fender Recess Cut



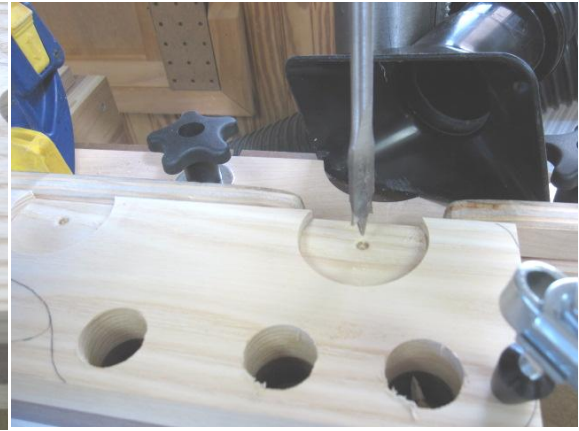
Fender Recesses in Progress



Spade Bit Depth Setting for Axle Holes



Recess Before Axle Bore



Locating Work Piece for Boring Axle Holes



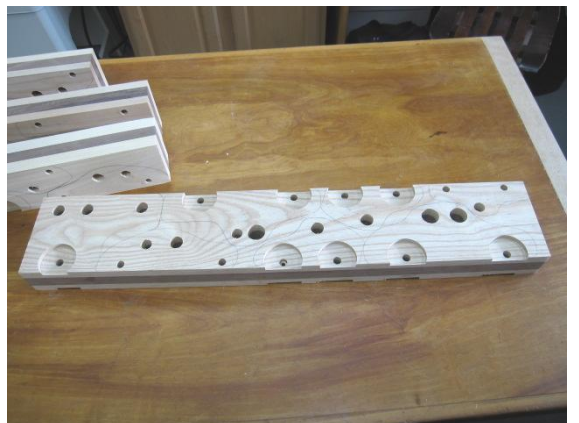
Axle & Window Holes on Template Side



Backside Exit Holes (small holes at top)



Backside Recesses Cut (axle holes opened)



Completed Work Piece

3. Window openings may be bored before axle bores and recesses if preferred. Bore all window openings using Forstner or Spade bits of required diameter. Take your time as this operation can be tedious, especially if Forstner bits are used. Before boring window openings, **see first notes on bore "Tear Out" below.**
4. Complete window boring operations on all laminated work pieces in the batch.

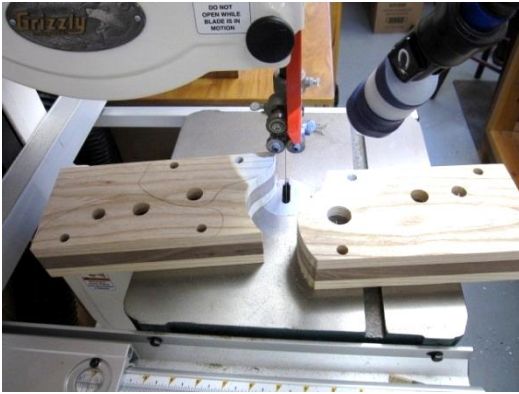
Notes on Bore “Tear-Out”

Ash (or any hardwood) is susceptible to tear-out on the exit side of the bore. This type of surface damage is caused by destruction of the integrity of surrounding wood at the circumference of a boring tool when it punches through from the inside to the outside. Depending on severity, you can be left with a small but sand-able blemish or having a big chunk missing. The problem is most prevalent for window opening exits. Note that axle holes are mostly hidden by the wheels so tear out on axle holes is not as critical. The following tips are helpful in minimizing or even eliminating bore tear-out:

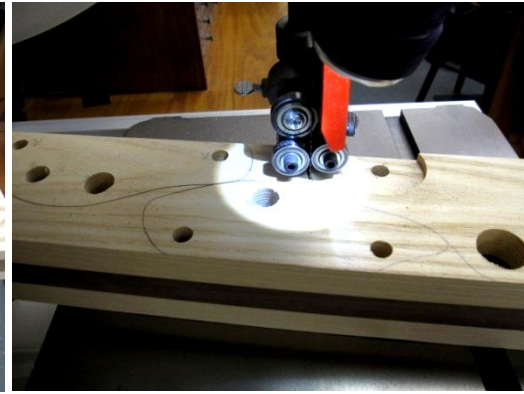
- a. Use sharp tools; clean them out frequently during this operation.
- b. Use a backup board on the exit side. Select a flat piece with a hardwood face with no previous holes at the exit location, i.e., do not re-bore into a “used” location.
- c. Place a piece of painter’s tape over the entire exit site.
- d. Clamp the work piece flat on the table and against the fence and use lateral stops to eliminate movement and vibration, especially when lifting the bit to clean out chips and at the time of punch-through.
- e. Make sure boring tool is tightened securely in drill press chuck.
- f. Set the drill press for the recommended RPM for a given size tool and wood type.
- g. Lower tool slowly with minimal downward pressure and keep chips cleaned out so the tool does not plug, bind or get too hot. Dull Forster bits can actually start a fire in a chip-clogged deep hole!
- h. Lift the bit regularly to remove chips (a vacuum port is very effective when boring). Go especially slowly when the bit is about to exit on the opposite (down) side.
- i. **Best tip:** do not punch the bit all the way through the exit side. Set the drill press depth so that only the center tip of the tool punches through. You may then flip the work piece, center the tool on the small exit hole and complete the bore. *This is by far the most effective method to prevent or greatly minimize tear-out even though it adds a step to the operation.*

G. Cut Out Vehicles Bodies (see photos below):

1. Mount either a 3/16 in. 10T. or ¼ in. 6T band saw blade in the band saw. Smoother cuts will be made using 10T blade. Check blade tension and that table is level.
2. Separate work pieces into sections which are short enough to be easily managed on the band saw table surface during cutout.
3. Use the fence to cut parallel surfaces required for some vehicles and trailers.
4. Cut out all vehicle bodies which have been traced onto the work piece surfaces. Work slowly and smoothly to minimize blade marks.
5. Cut just outside the traced lines and keep curves as smooth and continuous as possible.



Separating Laminate Work Pieces



Cutting Out Vehicle Bodies



Use Fence to Cut Parallel Surfaces



Rough-Cut Vehicle Bodies



Batch Cutouts Completed (note scrap)



Ready for Sanding

H. Sand and Shape Cut Surfaces:

1. Move the cutout vehicle bodies to the sander(s) and sand all cut surfaces using 120 grit belts and cylinders. Objective is to remove all burns, blade marks and irregularities.
2. Use roller end of tabletop 36 in. belt sander and/or spindle sander to sand and shape contours on the body shapes. Touch up flat surfaces as needed. Note that template contours are designed for ease of sanding using these machines whenever possible.
3. Sand rough surfaces until they are smooth and regular. Check profiles from each side, as well as fronts and backs of vehicle bodies.
4. Do not sand edges as they will be rounded over in the next operation.



Use belt sander to shape & sand large contours, also flat edges and surfaces



Use spindle sander to shape & sand smaller contours



Before sanding, after sanding

I. Round Over Edges and Window Openings (axle openings optional):

1. Mount a 1/8 in. radius round over bit with guide bearing into the table-mounted router. Mounting a piece of hardboard on the router table will reduce friction and marring when vehicle bodies are fed and rotated on the table top.
2. Round over the edge of a scrap piece to check the height of the bit to make sure it does not cut a groove.
3. Round over all edges of each vehicle. Note that the round over bit may leave some burn marks along curved edges but these are easily removed afterward with a little hand sanding. Use of clean, sharp tools, the correct RPM and feed speed may reduce burn marks.
4. Round over the window and (optional) axle openings. Carefully lower the window openings over the rotating bit until the vehicle body rests flat on the table surface. Use a circular motion and pressure on the guide bearing to achieve a smooth round over of the window opening.
5. Fender recesses are too shallow for router, break edges with sandpaper.
6. Inspect all edges and window openings to make sure of smooth, continuous round overs.



1/8 in. Round Over Bit with Bearing



Note Hardboard to Reduce Marring



Rounding Over Window Openings



Rounding Edges Creates a Finished Look

J. Final Body Inspection, Sanding, Cleaning:

1. Carefully inspect vehicle bodies for any defects, including any remaining tear out at window openings and burn marks on rounded edges.
2. Sand tear out and burn marks by hand using rubber sanding block and 120-150 grit paper.
3. Use hand sanding or flap sander to sand entire body surface using 180, then 220 to 320 grit paper and/or sanding sponge. Be sure to sand in the direction of the grain during final sanding. Do not over-sand as this will reduce the rounded edges.
4. If Trucks and Trailers are to be fitted with Hitches and Receivers see Appendix A. and complete those operations before vacuuming and cleaning.
5. Vacuum, then clean vehicle bodies using mineral spirits and a clean shop rag. Cleaning with mineral spirits removes organic contamination and any remaining dust. Mineral spirits also temporarily enhances color, brings out the grain, exposes hidden defects and gives an idea of how the finished body will appear after it is coated with oil
6. Set vehicle bodies aside to dry. Note enhanced grain and color will fade when mineral spirits residue dries.



Hand Sand with Rubber Sanding Block



Remove Router Burn Marks



Clean With Mineral Spirits



Cleaning Enhances Color & Grain

VI. Wheel/Axle Assembly & Installation

A. Prepare Axles:

Axles for this style vehicle are made from prefabricated 3/8 in. dia. hardwood dowel rod stock which is provided by the club. Dowel rods are provided in 36 in. lengths and must be cut to the lengths required for each different vehicle type and/or body width, see formula in 2 below.

1. Measure body width using a linear caliper or other measuring device with resolution of 1/32 in. (0.031 in.) or less. Sort vehicle bodies into groups that have very similar or identical widths as measured at the bottoms of the vehicles at the axle openings. Note that boards of varying thicknesses were used to fabricate the glued-up laminates. Sort vehicle bodies into groups where the width varies by a maximum of 1/16 inch total (+/- 1/32 in.). Record the nominal width of each group.
2. Calculate the length of the axles to be cut for each group. The following formula should result in nominal wheel clearance of 1/8 in. on each side. Note that axles penetrate wheel opening to depth of 3/8 in. on each wheel. The total of 2 wheel penetrations ($3/8 + 3/8$) + 2 wheel clearances ($1/8 + 1/8$) = 1 inch. Subtract 1/8 in. if tighter wheel clearance is desired.

Therefore: Axle Length = Body Width + 1 in. for nominal 1/8 in. clearance each side

Example: If body width is 2.25 inches, then axle length should be 3.25 in.

3. Set up band saw using a thin board clamped to the fence that stops just at the blade. This board will allow the cut dowel rod to release from the blade and not be pinched after cutting. Check length after first axle is cut. Use a miter gauge set at 90 deg. and backup pusher block to cut all axles required for a given length setup.
4. Cut all axle length groups, keep groups separated and identified.
5. De-burr and lightly round over (taper) the end edges of the axles using belt/disk sander.



Measure Vehicle Body Widths



Groups with Similar Body Widths



Band Saw Setup for Axle Cuts



Axle Ends Slightly Rounded

B. Partially Assemble Wheels and Axles (work on one vehicle at a time):

1. Using a fixture similar to that shown in section IV., place a previously assembled wheel/hubcap assembly cap-side-down in the cap recess on the fixture. The recess is just deep enough to contain most of the hemispherical surface of the cap. The wheel itself should not touch the fixture surface. The purpose of placing the rounded portion of the cap into the recess is to keep it located and distribute the driving force across a greater portion of the cap surface, reducing damage and marring.
2. Place a small amount of wood glue on the end of the axle rod. Glue requirement is minimal since the fit will be very tight (3/8 in. dia. dowel into 3/8 in. dia. hole).
3. Place the end of the axle rod vertically into the wheel opening. Hold the rod vertical with one hand and tap it in with a wooden mallet. You will feel and hear resistance when the axle seats on the back side of the hubcap. Insertion depth is 3/8 in. Check that insertion is vertical (axle perpendicular to wheel hub). Hand-adjust if necessary before glue sets.
4. Repeat steps 1-3 on the second axle for a given vehicle.



Assemble Axle into Wheel Hub



Check for Perpendicularity

C. Final Assembly (complete one vehicle at a time):

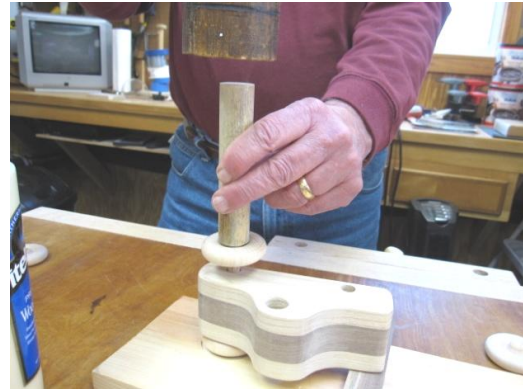
1. With one axle/wheel assembly still in position on the fixture, place an axle opening of the vehicle body over the vertical axle rod and lower the vehicle body until it rests on the wheel. Slide the leveling block (same height as the wheel which rests in the recess) under the opposite end of the vehicle body to keep it level and provide support. Place a very small amount of wood glue on the protruding end of the axle rod.
2. Hold the vehicle body steady with one hand, place a wheel onto the protruding axle rod. Push it down until it is stable and perpendicular to the axle.
3. Using a wheel set tool (see illustration section IV.), place tool recess over the hemispherical surface of the wheel hubcap and tap the wheel down onto the axle until it seats or until desired clearance (see note below) is achieved. Use of wheel set tool during this operation helps prevent damage to the wheel cap and focuses the driving force of the mallet to help maintain perpendicularity.

Note: Wheel clearance observed when seating second (top) wheel in step 3 above is approximately 2 times that observed on each side when the vehicle body is removed from the assembly fixture and axle is centered. This is due to the vehicle body resting on the bottom wheel with zero clearance during the second wheel assembly step.

4. Spin the completed wheel/axle assembly to check that wheels do not have excessive (noticeably unacceptable) runout due to non-perpendicularity of axles and wheels. Adjust as necessary – absolute perfection not required!
5. Repeat operation for the second axle on a given vehicle. Note position of vehicle body on wheel/axle assembly fixture during final assembly of second axle in photo below.
6. Complete assembly and installation (operations B & C) for all vehicles in the batch.



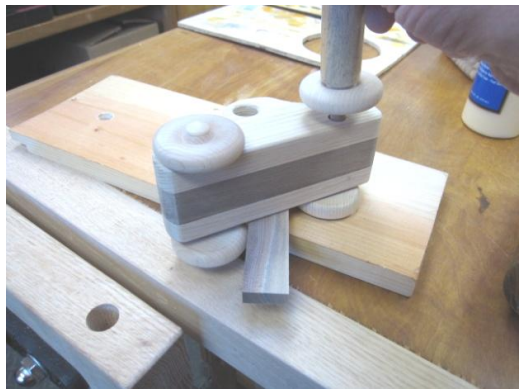
Place Top Wheel on Axle by Hand



Tap Wheel Onto Axle Until Seated



Wheel Assembly on Trailer Body



Final Assembly of Second Axle Wheels



Check Clearance and Runout



Check for Free Movement

VII. Oil Finish

A. Apply Salad Bowl Oil:

Apply General Finish Salad Bowl Oil or similar non-toxic-when-dry clear finish to the vehicle using the procedures described on the can and recommendations below. Apply finish in a well ventilated area, wear hand (e.g. nitrile gloves) and eye protection. Wear old clothing and/or an apron. Apply finish in a large plastic container (see section IV.), or over a tarp or other protective covering to keep it from getting on bench or floor. See photos below.

1. Prepare to apply finish by wearing recommended clothing and safety equipment and setting up the ventilated finishing area. Obtain a 1 in. bristle paint brush, stirrer and shop rags.
2. Open Salad Bowl Oil container and stir. Place both the open container and the vehicles to be oiled inside a plastic tray (see recommendation in section IV.) or in protected area.
3. Apply Salad Bowl Oil liberally to the entire vehicle and wheels using the 1 in. paint brush. Flood all surfaces thoroughly, especially areas with end grain. Pay special attention to the backsides of wheels and insides of window openings. Wheels are especially absorbent and may require extra applications.
4. Place vehicles on a rack or cardboard and allow the Salad Bowl Oil to penetrate the surfaces for several minutes.
5. Wipe off excess oil with clean shop rag and set vehicles aside to dry for 24 hours.
6. A second coat of oil greatly enhances color and surface finish. Follow manufacturer's directions if second coat is to be applied.



Salad Bowl Oil Provided by Club



Flood all Surfaces, Check Wheels and Windows



Make Sure Entire Vehicle is Wet with Oil Allow Oil to Penetrate for a Few Minutes



Wipe Off Excess Oil After Penetration



Allow Vehicles to Dry for 24 Hours

Congratulations! You are a toy car expert!

Appendix A

Hitches and Receivers

Trucks and trailers made using techniques described in this manual may require hitches and receivers. Hitches are pegs that are centered and inserted into the bottom sides of the trailers. Receivers are holes that are centered and bored into the bed areas of trucks. The pegs can be made from the same 3/8 in. dia. dowel stock used to make axles. The most important factors to consider when laying out the positions, lengths and depths for hitches and receivers are: the truck and trailer must stay connected when towing, the trailer must ride level, the trailer must not interfere with the truck when cornering.



Mark Locations for Hitch and Receiver



Bore Hitch Hole Using 3/8 in. dia. Bit



Bore 1/2 in. or 7/16 in. dia. Receiver Hole



Measure for Length of Receiver Peg



Cut Peg, Glue and Tap into Place on Trailer



Completed Receiver and Hitch

Appendix B

Assembling and Reworking Wheel Hubcaps

Wheels used to make the vehicles described in this manual are ordered by the Valley Woodworkers and come prefabricated with a 3/8 in. dia. though-hole hub. Hubcaps are 3/8 in. dia. hardwood plugs which are inserted into the outer side of the wheel hub to create a hubcap effect. A small amount of glue is put into the wheel hub before the hubcap is driven and fully seated into the hub using the wheel set tool described in section IV. Note that hubcaps may be damaged if driven at an angle or if excessive driving force is used. Wheels and hubcaps are always pre-assembled before wheels are assembled to axles. See photos below.

Occasionally hubcaps need to be removed from a wheel if damaged during insertion or subsequent operations. The best method for removing hubcaps, especially if glue is dry, is to use a chisel applied to the hubcap outer surface (not at the seat) and mallet to separate the hubcap from the wheel. Normally a single blow directed away from the wheel will dislodge the hubcap in one piece. This will destroy the hubcap but should not damage the wheel if performed carefully. Any residual glue inside the wheel hole may be cleaned up by manually reaming with a 3/8 in. dia. drill bit.



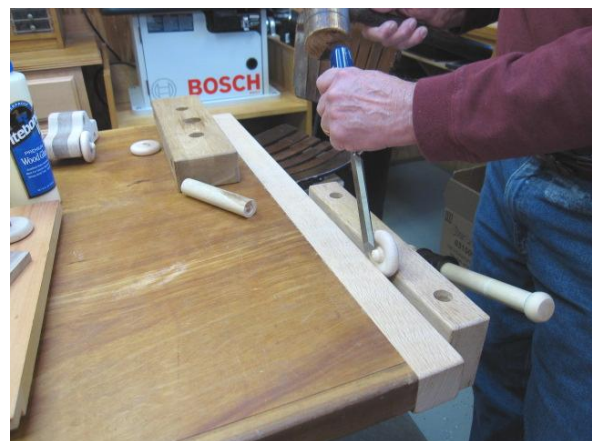
Apply Small Dots of Glue to Inner Wheel Hub



Center & Level Hubcap On Wheel



Use Sharp Blow to Seat Hubcap



Remove Hubcaps with Chisel & Mallet