Woodline USA
Wooden Gear Clock

By Wayne Sutter
Rev 09/12/10
Revision # 12

New Mission clock not yet finished!

Winner of the Grand Champion prize for Woodworking. Wilson County Fair Lebanon, TN

I have had repeated requests to modify the revisions to indicate which pages were changed. This is very difficult for me to do. When a page is modified to change ripples through many other pages and the constant changing of page numbers would be exceptionally difficult to control. I may try to implement some version of individual page revision control in the future instructions but for now the entire manual stands as is.

Revision History.
Revision 12:

- addition of the Mission style option
- enhanced front and back plate drawings
- pendulum Bob carving
- expanded discussion on clock weights
- new pictures of alternate hand designs
- more customer pictures

Release 11 changes Include;

- Dedication To Sam Maloof
- Minor grammatical corrections.
- Revised dimensions for figure 22 page 21
- Addition of winding key drawing
- Use of shim washers on weight arbor
- Correction of the dimensions of Part 28 Escape Lever Bracket.
- Expanded Freewheel test information
- Customer clock pictures.
- Better wording of some instructions.
- More information in the "common issues" section to the end of the manual. READ THIS SECTION FIRST it will save you a lot of frustration!

Revision History. Release 10.2 release 3-2009

Revision History. Release 9. 3-2008

Revision 3-07 Document version 8.0

Initial release 9-06 Version 7.1a

This project is dedicated to the work and memory of my friend SAM MALOOF

The clock shown in this manual resides in the home of my Friend Sam Maloof. Many of you will have heard of Sam and others should Google his name. Sam died recently leaving a legacy of world class craftsmanship built over a lifetime of passionate wood working. Sam was a gentle spirit and one of the finest men I have ever known. I was proud to call him my friend. He was also one of the true greats at our craft and an inspiration to all who knew him. His legacy lives on in the many wood workers he inspired.

To the builder:

New to this version of the instructions is the mission style of clock. The addition of a mission style clock is a direct result of requests by customers. All of the gears and internal parts of the clock are the same. Only a few items including the front and back plates, nut covers, intermediate pate and the hands have been changed to a mission look. The stand is also changed to a more traditional appearance. You will find a notation in the instructions when something is to be made different for a mission style clock.

Clock building is a rewarding project. I highly recommend every builder make changes where appropriate to personalize the appearance and style of the movement and case. Work with care and have high standards. You will end up with a heirloom that will last for generations.

I also have several ideas for future projects with additional clocks and mechanical movements. If this project is successful we may add chimes or animation and new mechanisms to future projects.

Wayne Sutter
Woodline USA
E-mail for tech support and comments to Techsupport@woodline.co

Please allow a few days for response as we travel a great deal.

This manual includes the following Sections:

1. **Brief history of the project**
2. **Installing and using the pin router**
3. **Selection of materials**
4. **Making the parts**
5. **Assembly of the movement**
6. **Free wheeling and tuning movement**
7. **Install the escapement and pendulum**
8. **Installing the drive cable or cord.**
9. **Adjustments**
10. **Case options**
11. **Troubleshooting chart**

TERMINOLOGY:

Wheels, and gears are the same thing and the terms are interchangeable.

Pinions are small gears, usually with less than 20 teeth.

Arbors and shafts are the same thing and the terms interchangeable.

Horology is the study of clocks.

NOTE:

This instruction set is written under the assumption that the reader is familiar with proper safety procedures and the proper operation of all tools and procedures used. If you are not an experienced wood worker or if you are not sure of the correct procedure consult your tool manuals or get help from an experienced wood worker before proceeding. Serious injury may result from improper operation of tools.

Do not depend on the drawings in this instruction manual. Use the line drawings for all measurements. When making a part check the line drawings every time. The drawings in the instructions are for reference only. They are never updated if changes to the master drawings are made.

Operational notes:
Part numbers of each part are indicated by numbers Example:# 2 refers to part number 2 and matches the part numbers in the parts list and the drawings. Part numbers are the same for both mission and original style parts

DO NOT LUBRICATE THE CLOCK other than in the spots mentioned in the instructions.

The only spot where lubrication is appropriate is the ends of the weight arbor where they pass through the intermediate and front plate. A small amount of graphite on the end of the escape lever arbor is also acceptable. Lubrication of the bearings and gears will cause the clock to fail and is very difficult to clean once done.

DUST:

There is no need to enclose the movement as normal dust will have little effect on the clock movement. Simply clean out the dust with a vacuum or blow it off with a compressor periodically.

Some personal preferences of mine:

- Brass screws only in clocks
- Slotted head screws are traditional for clocks instead of phillips or square drive
- Polish the ends of all cut brass pins
- Glue must never show anywhere
- Parts that do not show are sanded and finished just as if they did.
- If you are not proud of it do it over
- Use the good wood you deserve it.

This is not a "simple" project and will challenge almost anyone. However it can be accomplished by almost any woodworker of modest tools and modest skills. Methodical work is the key to producing accurate parts. When complete you will have an heirloom that will last for generations.

The materials for the bearings, brass pins, clock string and specialty hardware is available as a kit from Woodline USA at 1-800-472-6950. For the purist who insists on an all wood clock, you can substitute wooden bearings cut from a very hard wood but I strongly suggest the use of the plastic bearings as shown in these plans because of the significantly longer life they will give the finished clock.

Undoubtedly there will be upgrades and corrections to this manual. If you find things I need to correct please send an e-mail to Techsupport@woodline.com and we will make the changes so everyone will be informed. We have worked very hard to produce this manual and we appreciate your support in making it better. Check Woodline.com and look under the instructions tab for the latest drawings and updated manual.

Clock Overview

Figure 1 Movement complete except for the second hand and nut covers

An all wooden clock is an exciting project sure to impress anyone viewing or watching the gentle ticking of this magnificent piece. We have worked hundreds of hours to make this project easier to complete and result in a working timepiece. With careful attention to detail almost any wood worker can produce this work of art. The clock will keep time accurately if properly constructed and adjusted but please be aware that if you want perfect time keeping, buy a digital watch. This is primarily a work of functional art and is to be enjoyed as such.

Figure 2 Original clockworks built from plans in Fine Woodworking Magazine. Movement is not finished.

The clock is made almost entirely of wood but uses plastic insert bearings with brass pins at the end of the arbor shafts. Though purists may choose to forgo these parts in favor of other wood components or perhaps tauga nut plugs to serve as bearings. The use of plastic bearings and brass pins reduces friction, which is the sworn enemy of clock movements. Reducing friction also allows the use of less weight which makes the clock last longer.

Development History

This clock uses a Grahm deadbeat escapement. A “deadbeat” escapement gear has no reverse motion commonly called “recoil”. This is a more efficient design than many other types of escapements. The pendulum is designed to be approximately 39″ long and the gear ratios are designed for this length. If you wish to learn more about these escape movements visit http://www.geocities.com/CapeCanaveral/Hall/3934/introduction.html for an in depth discussion of escape movements. I recommend that every builder learn all they can about escape movement operation. A greater understanding of escapements will make the adjustment of the clock easier to understand.

Wayne Westphale wrote a great article featuring a wooden gear clock. It and published in issue # 56 and 57 of Fine Woodworking magazine. The articles were reprinted in a book by the Taunton Press called Small Woodworking Projects. Taunton Pr; ISBN: 156158018X. This book was an inspiration to many. My hat is off to Mr. Westphale for his pioneering work in creating a design that

has inspired so many people to build wooden gear clocks. His article was the first exposure I had to wooden gear clock building and this clock would not have been possible without his vision and hard work. This work is a derivative of his clock with some changes based on experience.

While building the original design, some flaws were found. The original movement has the pendulum mounted to the case while the movement sits on a shelf within the case. This design makes the relationship of the movement of the case critical and caused much frustration when the clock would stop ticking for no apparent reason. Investigation revealed simple wood movement caused by small temperature or humidity changes resulted in enough misalignment to stop the rhythmic swinging of the pendulum.

Figure 4 FWM clock with case mounted pendulum

The movement has been redesigned to suspend the pendulum from the back of the rear plate making it an integral part of the movement. Other items were changed that experience indicated need to be addressed. The spoke pattern of the gears is altered and overall aesthetics of the clock were improved. A second hand was added and changes made to the method of mounting the hands and securing other items. These changes were made to increase the life span of the clock and to make it easier to assemble. Small screws were added at some points to improve the mechanical assembly and reliability of the movement.

Figure 3 Improved pendulum mount is just one of the reliability improvements of this design

Bearings are installed in the front and back plate to support the clock arbors and increase durability while reducing friction.

Like the original, we chose not to add a face with numbers. This design consideration was so the movement would be more visible. A face with numbers could be added if desired by attaching to the 4 through bolts that hold the front and rear plates together.

IMPORTANT NOTE:

Read and understand this document completely before you make any parts. Many mistakes have been made by clock builders and most can be traced to getting in a hurry to see progress. Work carefully and with an eye to detail.

Figure 5 Plywood kit from Woodline USA

Wood Selection and Preparation

Gears are made from laminated stock or plywood. Lamination is required to give the gears strength and prevent excessive warping. Lamination will also allow the gear be cut without excessive tear out due to cutting cross grain as can happen on a solid wood gear.

High quality hardwood plywood with few voids and free of internal stress is only recently commercially available.

Baltic birch plywood is readily available, inexpensive and machines well but tends to finish poorly and does not have the high end look preferred in finished clocks. Birch plywood is excellent as a backer board for the gear cutting process described later. Also you can use Baltic birch as a base for lamination with more exotic face woods and produce your own plywood for large gears.

Woodline has found a specialty manufacturer of plywoods that has custom made special cherry and walnut faced plywood for use in clock making. The plywood has a very stable center core and a thin face veneer. Though excellent for cutting when the spokes of the gears are rounded over more of the center core shows and should be stained to match the face veneer. You may order a basic wood kit which contains 6 pieces of plywood for the large gears from Woodline. If you purchase this wood kit you may skip over the next section on plywood manufacturing. The clock shown in most of the pictures of this manual used hand made plywood as the source was unknown until after the project was almost complete. The glue to make your own plywood will cost more than the wood kit from Woodline.

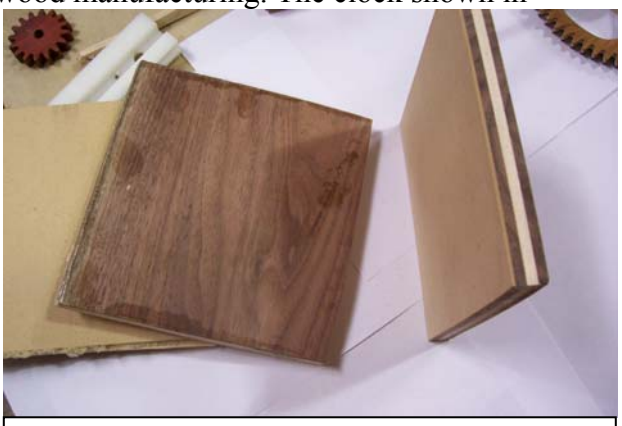


Figure 6 Hand made plywood

You may make your own plywood of any material you desire. Making plywood is tedious but does give you the ability to use more exotic woods and control the final look of your project. Make more pieces than you think you will need because you will make mistakes and sometimes even with your best efforts a part will not turn out properly. Wood is an unpredictable medium and occasional mistakes are expected.

When preparing blanks for the wood gears, select clear, straight grained stock with no warp, twist or wane. Use only premium grade materials.

Never make a gear with lumber that has not been properly dried. Warping may result if you are not careful to follow good practices. Use a moisture meter to check water content. Ideal percentage is between 6 and 8% moisture. If no meter is available be sure you are using well dried lumber that has had time to stabilize in your shop area prior to use.

Wood for laminating should be cut to 1/8″ thick and should be smooth sanded to uniform thickness. The final thickness of a gear blank should be about 3/8″.

Laminating the gear blanks using a vacuum press is ideal. If no press is available the gears can be laminated with clamps. In lieu of a vacuum press a kitchen "seal a meal" can be used and will work reasonably well because the largest blank required is small enough to fit within a large food storage bag.

Glue, use the right kind or you will have problems.

DO NOT USE STANDARD WOOD GLUE FOR GEAR BLANKS. Glues that are water based are not acceptable for gear lamination. They will cause warped parts. Clock builders have made this mistake several times and have always regretted it. They may take months to warp but every gear blank I have ever seen made with traditional yellow or white glue has warped and made the resulting gear run very crooked. Use URETHANE glue or epoxy for gear blanks. Be aware that some exotic woods contain oils that may interfere with setting of epoxy resin. More than one rosewood blank has been ruined by failure of the epoxy to harden. If using an oily wood, wipe the surface with lacquer thinner to wipe away excess oil prior to applying the glue.

Apply glue liberally to entire surface of the gear blank. Alternate the grain of layers by 90 degrees. Rotation of the grain adds strength and assures minimum warping of the gears after cutting. Wrap the glued gear blank in paper and place between two pieces of ¾″ MDF (medium density fiberboard) the MDF will help keep the gear blank flat during the gluing process. Follow the instructions of the glue manufacturer. If using clamps, use several clamps and start applying pressure to the inside of the gear blank with clamps and add clamps around the perimeter until the entire blank is very securely clamped with sufficient pressure to assure full contact of the wood across the entire surface of the blank. Leave the blanks clamped a minimum of 24 hours to assure complete curing of the glue. A small nail in the corner of the blank will help assure the layers do not slip during clamping. Remove the nail or cut away that corner before routing the wood.

If using a vacuum press, place the MDF sandwich in the vacuum bag and activate the vacuum pump. Make sure the parts do not slide around as the bag tightens around them. Leave the vacuum in place at least overnight. Several gear blanks can be placed in the vacuum system at one time but do not delay. Working time for epoxy or urethane glue is limited and it is better to do two batches rather than have the glue set up ruining all work in progress.

Remember to make extra gear blanks. Mistakes will be made and when using hand made plywood occasionally a gear will warp in spite of your best efforts.

Front and back plates are made of either plywood or hardwood. Turned parts, pinions, ratchet, arbors, winding keys, hands and other small parts are made of solid hardwoods. Choose a well seasoned wood with tight grain. Many builders choose cherry, walnut or maple for small parts. Exotic woods add color and visual appeal to the design and work well for accent parts. The clock shown in the pictures in this instruction manual contains 12 different types of wood.

FINISH

Finish all parts except those surfaces to be glued prior to final assembly. It is difficult to properly apply finish to a completed assembly.

Gears can be a little tricky to finish. The core material of the plywood is lighter in color than the face veneer. If you want to produce a more uniform look I recommend the use of a pre-stain conditioner followed by an oil based stain on each gear. Follow the directions on the can.

The gears and all other parts should be finished with two coats or more of a good quality finish. We recommend Deft semi-gloss spray lacquer. Deft is sold at most home centers or Wal-Mart and is available in spray cans and quarts. Deft is an exceptionally easy finish to apply. Merely spray or rub on and wait 10 or 15 minutes, lightly sand and apply the next coat. It dries very fast and builds to an excellent finish that is both attractive and durable. The last coat should be rubbed out with #0000 steel wool to produce a smooth finish. If available use bronze wool or a synthetic abrasive pad. If steel wool is used, be sure to clean away any steel wool particles to prevent them rusting. Complete the finish with a light coat furniture wax and rub with a soft cloth. The teeth of the gears should only receive a light coat of finish and careful rubbing with steel wool to produce a smooth finish. Do not wax the gear teeth.

Arbors can be finished while on the lathe with any finish desired. Thin coats are recommended to prevent interference with the gears mounting to the arbors. Avoid wax on the arbors to prevent glue from holding the gears and pinions in place.

Front and back plates should be finished and rubbed out to a smooth high quality finish.

Parts

The clock has 6 large gears and 5 small gears called pinions. There are many other parts such as arbors, hands and winding ratchets and pawls. The parts are held together between two pieces of wood called plates. The plates form the frame of the movement and support all the other parts.

The following pages include a detailed parts listing. All parts are numbered and part numbers are consistent throughout the instructions and drawings. Part numbers are not in a specific order and are not intended to have any special significance. You may chose to make all the arbors first or cut the gears first.

Mission style as a builder you get to decide what the finished clock will look like. New to this version of the instructions is a Mission style option. We have created this option because many customers said that it would fit better in the decor of their home than the design originally offered.

All the internal parts are exactly the same in the movement and assembly, adjustment, and finishing remain unchanged.

Part number **1** (front plate) and part number **2 (**back plate) have been changed. A full size paper plan for the revised plates is now included with each clock kit. It is strongly suggested that you do not copy these plans, not because of copyright issues, but because copiers tend to change size is subtly and you will have building issues if the size is not correct. Woodline sells copies of the plate drawings in full size for a small fee. These drawings are printed on a calibrated printer and it is strongly suggested that you use originals for each clock you build.

- The plate drawings show the original design and the mission design. Pay careful attention to which line should be cut. The heavier lines indicate the mission style. All the holes are used on all designs.

- The spacing between all the gears is identical in all versions of the clock. Feel free to make any alterations to the design of the clock and stand. I hope you will send me pictures of your clocks to us via email to Techsupport@woodline.com

Plan overview and detailed parts list

The following table is a list of clock parts and sizes of finished parts. A blank column is provided to use as a check list as the parts are completed. The order of the list is not important

	#	Qty	Description	Approximate Size	Thick/dia	Comment
	1	1	Front Plate	14 x 9 1/8	1/2	See drawing for detailed sizes
	2	1	Rear Plate	18 x 9 1/8	1/2	See drawing for detailed sizes
	3	1	Intermediate Plate	Solid wood	3/8	Supports weight arbor
	4	1	Right lower Standoff 2 pieces		3/4	17/64″ hole through part
	5	2	Right and left lower standoff spacers		3/4	17/64″ hole through part
	6	1	Left lower standoff		3/4	17/64″ hole through part
	7	2	Upper Spacers	4 1/16″	3/4	17/64″ hole through part
	8	1	Escapement gear	7″ OD	3/8	Sand carefully and balance. See instructions
	9	2	64 tooth gear	6″ 13/16 OD	3/8	One dark, one light looks good
	10	1	48 tooth gear Dial Train	5 1/32 OD	3/8	Very visible highly figured works well
	11	1	48 tooth gear Drive Gear	5 1/32 OD	3/8	Mount pawls in spoke area
	12	1	40 tooth gear	4 5/16 OD	3/8	Color should compliment the smaller 10 tooth pinion
	13	1	8 tooth pinion for escape	1 ″ OD	1/2	Solid wood
	14	1	8 tooth pinion for second arbor	. 1 ″ OD	1/2	Solid wood
	15	1	10 tooth pinion for dial train	1.128 OD	ID 5/16	Color should compliment the 48 tooth gear. solid wood
	16	1	16 tooth pinion for center arbor	1.645 OD	ID 1/2	solid wood Drill an anchor hole
	17	1	16 tooth pinion for dial train	1.820 OD	ID 5/16	Color should compliment the 40 tooth gear solid wood
	18	2	Escapement arbor and Second arbor	4 1/16 x 1/2	1/2	Second arbor is identical to Escape arbor but uses a longer brass pin for second hand
	19	1	Dial train arbor	1 ¼″ x 1/2″	1/2	Size carefully to 40 tooth for rotating fit.
	20	1	Escape lever arbor	2″ x 1/2	1/2	Very critical dimensions must rotate freely. Trim to length after install.
	21	1	Weight arbor	Multiple dim	.475 Dia	Can build up or turn from solid stock
	22	1	Main arbor		1/2	Size carefully to gear, fit length at assembly
	23	1	Cannon tube	1 1/8 x 5/8 Dia		Make after center arbor. Free rotating fit to center arbor
	24	1	Ratchet	See Pattern	3/8	Solid wood
	25	1	Minute hand	See Pattern	3/16	Screw holds hands in place on arbor
	26	1	Hour hand	See Pattern	3/16	Screw holds hands in place on arbor
	27	1	Second hand	See Pattern	1/16	Color to be highly visible.
	28	1	Escape lever bracket	See drawing	3/4	Secondary operation to slot opening
	29	1	Escape lever		3/8	Finish very smoothly on pallet edge
	30	1	Escape lever bracket screw	# 8 x 1		Locate after beat adjustment

	31	4	Hex bolts & Nuts	5 ½″x1/4 -20		Secures plates together
	32	6	Brass pivot pins	3/4″ long	3/32	Extend 3/8″ past end of arbors
	33	1	Brass winding pin	1/8 x 1		Press fit but not glued in (for future disassembly)
	34	1	Crutch		3/16	Tight slip fit onto escape lever arbor for beat adjust
	35	1	Crutch pin	1/8 brass		Loose slip fit into pendulum rod slot
	36	6	Pivot bearings		1/2 OD	Drill to accept 3/32″ pivot pins 1 drill 21/64 hole (for main arbor)
	37	8	Nut covers			Cover with wood cap to match spacer
	38	3	Brass screw for hand and crutch retainers	#1 brass wood screw	3/8″ long	Small wood screw
	39	2	Pawl Strips	3/32 x 5/16 x 2		Fit length to ratchet at assembly
	40	2	Pawl retainer dowels	3/8 OD x 1″		Saw slot to hold pawl trim at install
	41	1	Pendulum adjust wedge			
	42	1	Pendulum Bob	5 ″ dia ¾ thick		Turn to a hollow shell. Must be fairly light in weight.
	43	1	Pendulum hanger mount	½″ dia x 1 ½″		Has v groove to support pendulum
	44	1	Pendulum support and pivot			Goes at top of pendulum rod
	45	1	Pendulum rod	40	1/8″	Match to bob for color and grain trim to length at install
	46	17ft	Weight Cable	17 ft required Cord or cable		Supplied clock string works best. Cord or string is acceptable. 17 ft with weight pulleys. 11 ft without pulleys
	47	2	Weight Case with top	10″ x 2 Dia		Wood tube with top hook for cable attachment. Or use as rock
	48	2	Weight Lead shot available at sporting goods store	Approx 15 lbs total weight		Use minimum weight that will run the clock reliably
	49	1	Winding engagement cylinder	¾″ x 2 ½″		Use a very dense wood.
	50	1	Winding handle knob	½″ x 1 ½″		Turned decorative knob
	51	1	Winding handle plate		3/8″	Holds knob and cylinder
	52	2	Pulleys for Movement		3/8″	Same as 53 except for center hole size. Refer to templates. Make from a hardwood. 3/8″ center hole
	53	2	Pulleys for Weights			Same as 52 except for center hole size. Refer to templates. Make from a hardwood. 1/8″ center hole
	54	4	Links for weight pulleys			Dog bone shape with 1/8″ hole at each end
	C1	1	Case Top	¾″ x 2 ½″		
	C2	4	Case Leg	¾″ x 2 ½″		
	C3	2	Case Upper rail	¾″ x 2 ½″		
	C4	2	Lower rail	¾″ x 2 ½″		
	C5	2	Side rail	¾″ x 2 ″		
	C6	2	Case Filler Block	¾″ x 2 ½″		

Pin router

The secret to making high quality gears is sturdy accurate setup and use of the pin router. Any over arm pin router with a 1/8″ guide pin will work fine. An inexpensive pin router attachment is available from Woodline USA and will fit onto almost any router table. A good pin router must be sturdy and have a moveable pin. Woodline pin routers can be used to duplicate almost any part from an original part or template.

A great accessory for any pin router is a foot switch to control router on/off. A footswitch makes the operation easier and safer. Heavy Duty Foot Switches (WL-FPS101) are also available from Woodline USA.

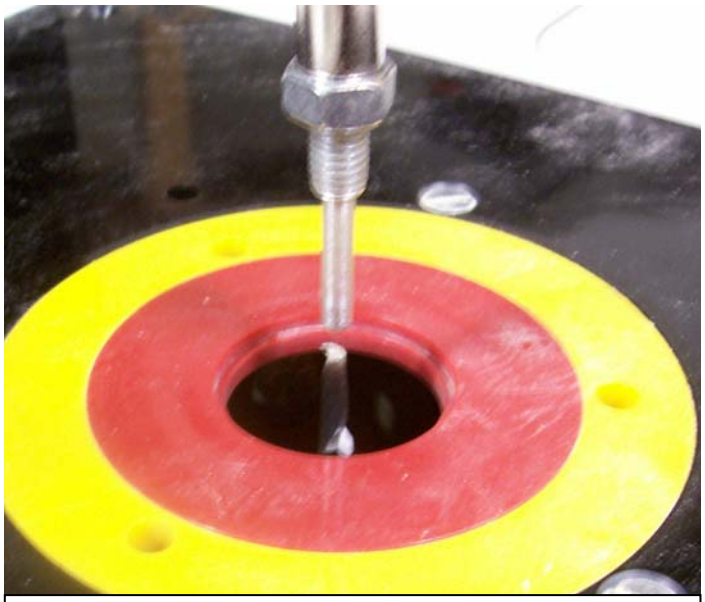


Figure 7 Guide pin aligned with bit

Setup on a router table

UNPLUG THE ROUTER

Install the pin router attachment by securely mounting it to the table top. For most applications drilling the top to receive the mounting holes is best but it can also be clamped with sturdy clamps. Be careful to align the guide pin to the center of the collet. Pin router must be attached securely so no movement occurs when tracing the pattern and pressing against the pin with mild pressure in any direction.

The goal of this alignment process is to assure the router guide pin is aligned over the center of the router collet, (make sure the unit is unplugged. NEVER turn on the router during this setup)

IMPORTANT: Tighten all screws in the head of the pin router assembly to prevent slippage, some screws may be loose in new pin routers and should be checked before use. There may also be some movement in the pin positioning assembly when the lock knob is loose. The clamp normally returns to the same place each time the clamp knob is tightened. NEVER MAKE A CUT WITHOUT THE LOCK KNOB TIGHTENED, THE PART MAY BE DAMAGED.

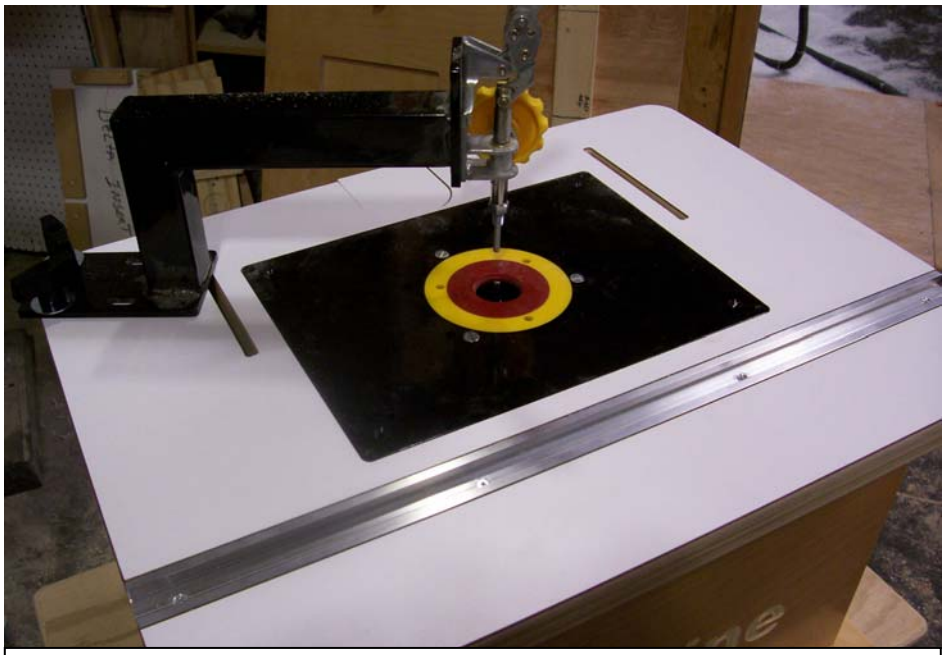


Figure 8 Pin router can be bolted or clamped to any table

Alignment method for Pin Routers

Drill a hole the same diameter as the bit and guide pin in a block of wood. (1/8") Raise the bit above the table top to the desired cutting height. Place the block of wood over the bit and see that the guide pin aligns with the hole on the block of wood. This method works very well and wood blocks can be saved for reuse when the setup is changed. You can make an alignment block for each size of pin you will use simply by drilling multiple sized holes in one block and keeping it with your pins. Check alignment each time pin or bit is changed.

Guide pin selection

Select a guide pin that is equal to or smaller than the smallest radius you desire to cut. This means that for all gear templates you must use a 1/8″ guide pin and bit. A larger pin will not be able to follow the fine detail of the gear templates. The clock templates were specifically designed for a 1/8″ guide pin.

Bits for gear cutting

Bit selection is important for quality part production. Spiral bits are best for most types of pin routing applications. In the small size of 1/8″ you can use either up or down spiral. In larger sizes only up spirals should be used. An up spiral bit will pull the chips out of the cut and make cutting easier with less tear-out or loading. Spirals produce the smoothest possible cut but due to small size can wear more quickly in plywood. If you experience burn marks or excessive pressure is required the bit may be dull. Bit life will depend on the type of wood and how aggressively you cut it.

Figure 9 1/8″ bit required to cut fine detail of teeth

Woodline WL-1001S is a premium quality spiral bit which produces excellent results.

Solid carbide bits are fragile especially in smaller sizes and are not guaranteed against breakage. You will occasionally break a small bit. Work carefully and do not try to rush the process. Let the bit do the cutting without excessive force. Be conservative especially in hardwoods. When using the gear plywood supplied by Woodline, it is good practice to cut each gear in one pass at full depth. Experience has shown that cutting full depth of just over 3/8" is best. While this is contrary to normal router practice, it eliminates the problem of small misalignment in the pin router resulting in poor quality teeth on the gears. In very hard woods, small pinions may need to be cut in multiple passes

Templates use, care of templates

The process of making the templates can sometimes cause the gear templates to warp. This is caused by internal stress in the plastic just as wood often warps when cut. Unlike wood these templates are easily fixed by bending them back into a near flat condition. A small amount of template warp is acceptable and will not affect the finished product. Place the warped template in a vice and bend it until it is near flat and then release. It should stay this way long enough to complete gear cutting operations. DO NOT HEAT THE TEMPLATES in an attempt to make them easier to bend.

Templates can be affixed to the gear blank in multiple ways. I recommend using the center locater, tape and screw method describe here. I recently discovered a great shortcut in gear making that makes the process much easier. I use the microwave!

Use industrial strength double sided carpet tape available at Lowe's or Home Depot, the kind with threads in it, and fasten a 3/8″ thick gear blank to a piece of ½″ scrap plywood that will act as a backer or "sacrificial" board. Cover the board completely with tape and press the blank in place. Hammer with a rubber mallet to assure the bond is as strong as possible. We recently discovered that if you heat the assemblies in the microwave for 45 seconds then place a heavy weigh on it while it cools, the tape holds much better. Do this before mounting sandwich to the templates.

Figure 10 Use heavy duty double stick tape

Drill a 1/2″ hole in the blank and through the sacrificial board using a forstner or brad point drill bit. Insert a center pivot dowel in the gear blank and the template to force proper alignment of the gear center hole to the template before proceeding to install the hold down screws. DO NOT DRILL THE HOLE AFTER MOUNTING TO THE TEMPLATE. DO IT FIRST!

Screw the sacrificial board to the template using the pre drilled screw holes and # 6 x ¾″wood screws.

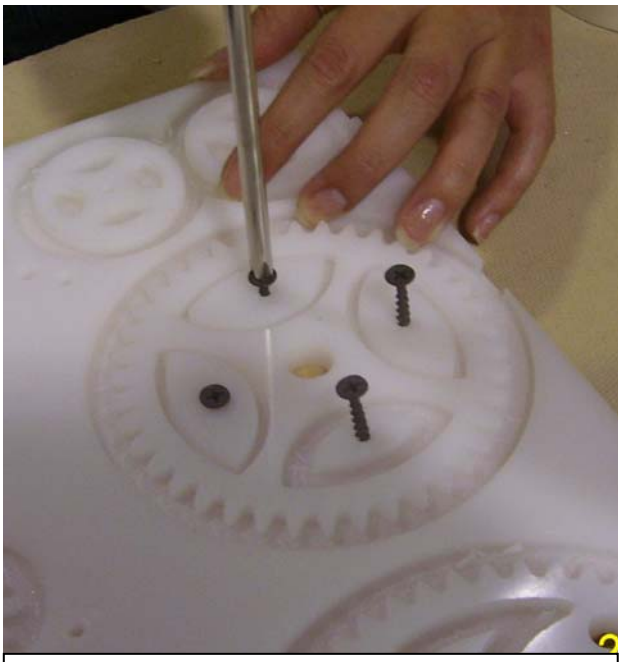


Figure 11 Screw to sacrificial board

Figure 13 Gear blank with center dowel and sacrificial board ready for cutting.

For some of the small parts such as hands, pinions and escape lever the best method is to attach a solid wood block that is thicker than the final part to the template, route, remove and resaw with a band saw to free the parts from the block. The parts can then be sanded to final thickness.

Gear cutting READ BEFORE CUTTING ANY GEARS!

Cutting gears is a simple process but it will take a bit of practice. Insert a 1/8″ guide pin and a 1/8″ bit. After installing the bit and pin, raise the bit to the desired height. Assure the guide pin is properly aligned and then raise the guide pin to the maximum height above the table surface level. Place the template with the blank installed in a position where the pin engages the template in the area to be cut. Start the router (maximum speed) and hold the template securely while lowering the pin router guide pin until the router bit and material are fully engaged. Lock the pin in place with the lock knob and then move the template around until all the material is removed. Stop and check your progress occasionally. Do not rush the process. Let the bit do the cutting with only mild pressure on the template. Hold the template firmly. Never release the template with the router still running. Failure to hold the template steady can result in damage to the part and possible bit breakage. STOP THE ROUTER AND WAIT FOR IT TO COME TO A COMPLETE STOP **BEFORE** ATTEMPTING TO REMOVE THE PIN AND TEMPLATE FROM THE ROUTER TABLE SURFACE. FAILURE TO WAIT MAY CAUSE DAMAGE TO THE TEMPLATE AND OR PART. A footswitch allows you to stop the router without having to release the template.

Small pinions are challenging to cut. Alignment of the pin and router is very important especially for the smaller pinions. For the large gears you can most likely cut them entirely in one pass but for the small pinions and very hard wood, you should take light cuts. Make several passes raising the bit only a little each time for the hard wood parts. Take care to check pin to bit alignment each time bit is moved.

After the initial pass raise the bit a little higher and run the template again. BE VERY CAREFUL NOT TO RAISE THE BIT HIGH ENOUGH TO CUT COMPLETELY THROUGH THE GEAR BLANK AND SACRIFICIAL BOARD. Damage to the template and part will result if you cut completely through the wood. You should cut through the blank but only 1/32 to 1/16″ into the sacrificial board. This will assure the alignment of the template and the gear is maintained .

Figure 15 Microwave to remove from backer board

Figure 14 # 10 48 tooth Dial Train gear with spokes rounded ready for sanding and finishing.

Gears **must** be cut with a 1/8″ bit and a 1/8″ guide pin. Larger pins are not able to get in the corners and will not produce an accurate gear profile. Go over the template several times making sure the pattern is free of dust or wood chips that can interfere with the pin getting into the small areas. Change direction. Cut once going clockwise and go over it counter clockwise.

After the final pass you should have a cleanly cut gear. Blow out the dust and chips and inspect the gear before removing from the template. Go over any areas that are not accurately cut. When satisfied, remove the retaining screws and release the almost completed gear.

Cutting inside spokes

On the instructional DVD, a method of lowering the part onto the router is described. Bits will last longer and not be broken as easily if this new method is used.

Drill a 3/8” hole in the templates in the waste area of the spoke completely through the sacrificial board and the gear blank. The drilled hole should overlap the pin guide area but not touch the finished edge of the spokes. The assembly can then be lowered over the bit and the pin adjusted to the proper height without the need to turn on the router until you are ready to cut. Each spoke should have a hole drilled in the waste area. This will not damage the template and future production templates may have holes precut at the factory.

Removing the gear from the blank after cutting.

Double stick tape is problematic for smaller parts and for gears where little of the original material is left after cutting. The gear blank can be damaged when removing the gear from the template. I ruined several parts before I discovered a simple way of getting the tape to release quickly and easily.

Figure 16 #17 16 tooth pinion has smaller center hole. These pinions are drilled to accept a small screw. See instructions in assembly section

After cutting the part profile simply remove the screws holding the blank and sacrificial board from the template and pop the wood in a microwave oven for about 1 minute. Actual time will depend on the part and the oven used. The heat will soften the tape bond and it will easily release. Sometimes tape or residue will remain on the part. It can be removed by rubbing, scraping and reheating for a short time. After getting the worst of the tape off use some lacquer thinner or acetone on a rag and clean any remainder.

Gear Finishing and Detailing

Gears are finished by rounding over the inside edge of the spokes with a simple round over bit. Gears #12 (40DT), # 10 (48DT), #11 (48PT), #9 (64 A & B) plus the # 8 Escape gear are all rounded over inside the spoke area. This operation is best done on a router table with a simple roundover bit. For 3/8″ thick gears use a 1/8″ round over bit. Work carefully to avoid burning the wood. The bearing of the round over bit will not allow the corners of the smaller spoke areas to be rounded over. This area can be sanded or filed to a uniform radius.

Figure 17 Close up of escape gear teeth

Figure 18 Completed #8 escape gear

Once gear cutting is complete, inspect each gear carefully. Small flaws in the teeth can be filled with either epoxy or wood filler and then the gear should be sanded smooth. Fingernail emery boards are excellent tools for touch up sanding of the teeth. Pay careful attention to the spoke area and sand each until no tool marks from machining can be seen. I have successfully used a mop sander on a drill press to make sanding hard to reach places on gears easily.

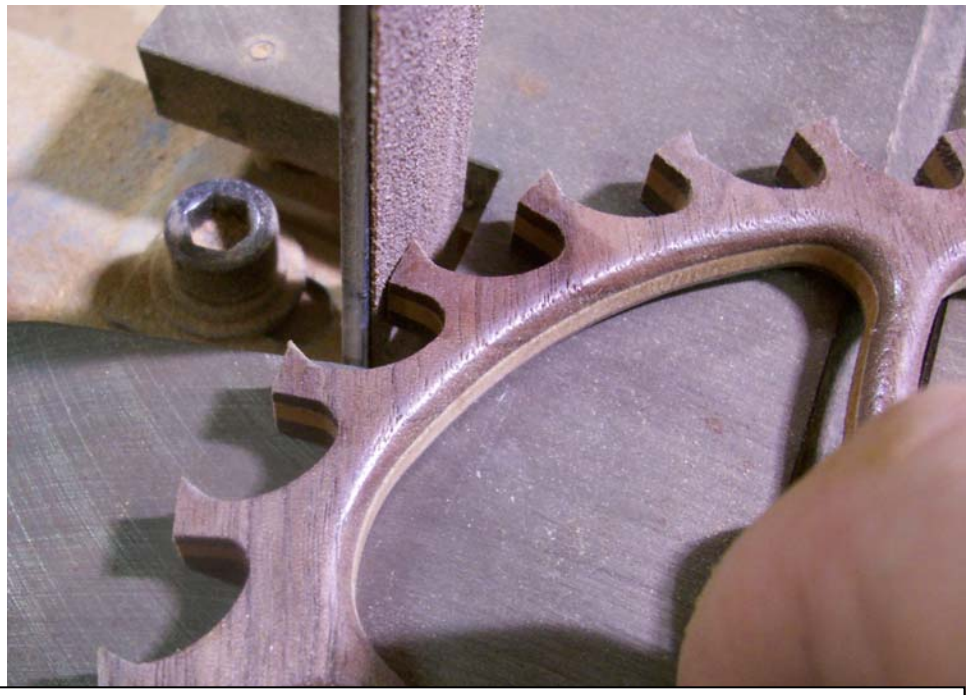


Figure 19 Use a narrow belt sander or sand by hand.

Do not scrimp finish sanding. Some wood workers skip the sanding process thinking that the difference will not be noticeable. Do not fall into this trap. Your clock will be admired and very closely inspected by all that see it.

A little extra patience will pay off. Carefully sand the edges of the escape gear #8. Sand each tooth uniformly and do not change the angle.

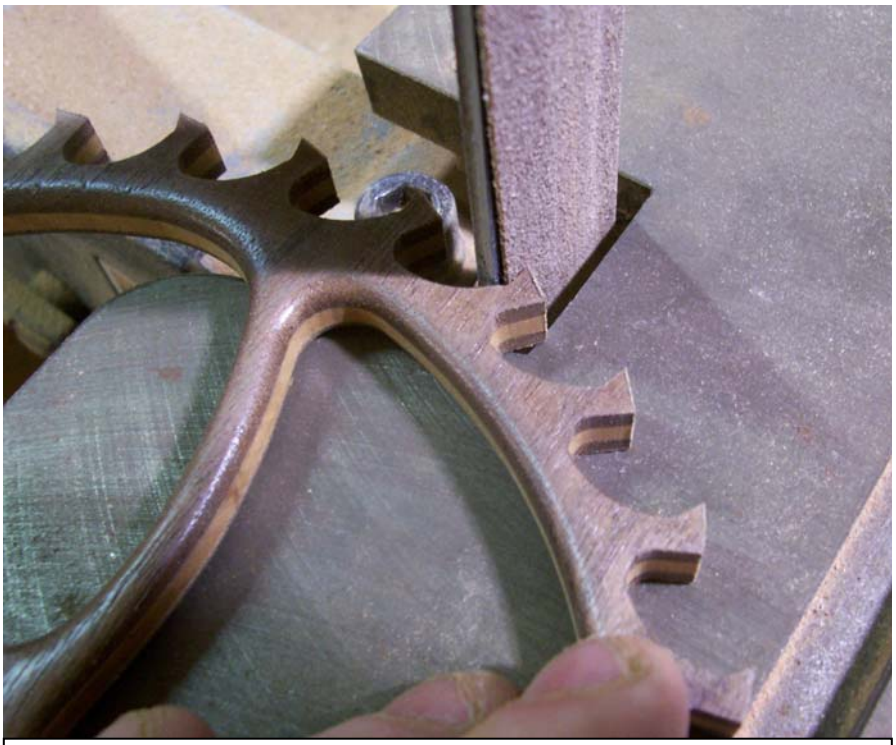


Figure 20 Sand the inside edge of each tooth on the #8 escape gear

Only the outside face and the inside slanted edge needs to be sanded. A light touch is required with only enough material removed to clean up the edges of the gear teeth. Try to sand each tooth the same amount.

Pin Routing troubleshooting chart.

Problem	Diagnosis	How to correct the problem
Poor quality teeth on gears. Some are wrong shape. May be more pronounced on smaller pinions	Too big a cut in one pass	Lower the bit and take several very light cuts to make the profile
	Movement in pin when template is pressed against it.	Tighten the pin router attachment to the router table
	Pin raising assembly is loose	Tighten all the screws in the pin raising assembly on the pin router arm.
	Lock knob not tightened	Tighten lock knob after pin lowered.
	Dull bit	Replace the bit
	Excessive pressure on pin	Use a gentle touch when making gears
Poor quality finish of completed parts particularly in the spoke area	Bit chatter possibly dull bit	Replace bit. If bit is sharp make sure the router is securely mounted and the boards are secured to the template properly. Hold firmly while cutting
	Debris in template	Clean the template and go over the part again.
I have to push hard to get the bit to cut the part.	Dull bit	Replace
	Router turning too slow	Run at maximum speed.
	Guide pin dragging on template	Raise pin slightly and try again.
Parts are not symmetrical or does not match template. Ridges occur and visible where different height cuts are made	Pin misaligned or deflecting under pressure	Align pin and redo part
Small pinions teeth break off during routing.	Poor wood quality or wrong species.	Try another piece of wood or another type.
	Not holding template firmly and chatter results which breaks teeth.	Hold template firmly during routing operation

Pinions and Small Parts

Pinions and other small parts should be cut from a solid block of wood. An excellent method is to cut all the pinions on a given template at once from a single block of ¾″ thick wood. Carefully mark the center holes before removing from the template. Once all the pinions are cut, remove the screws and drill all the center holes. All pinions and the ratchet are designed to be 3/8" thick when completed. After routing the templates into the ¾" thick stock, bandsaw the blank to produce 3/8″ thick pinions. Pinions should be sanded and finished the same as gears. The 16 tooth pinions are drilled for screws to hold them in place (see notes in assembly section)

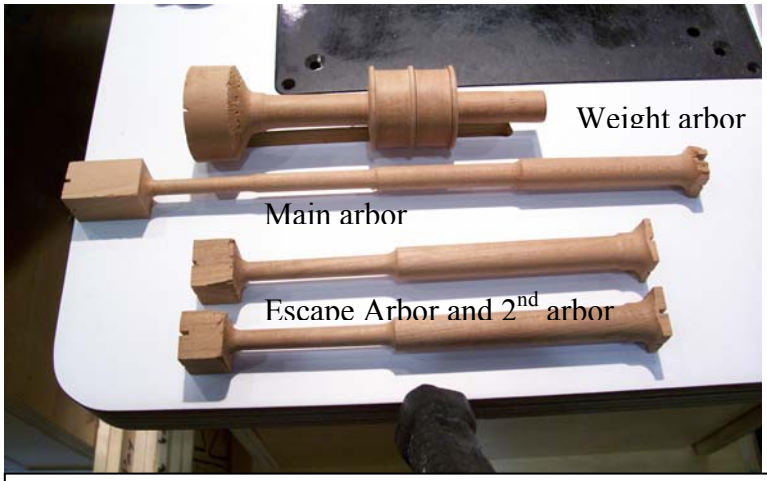


Figure 21 Unfinished arbors sanded smooth

Turned Parts

Arbors and Spacers

Clock shafts that gears and hands mount on are called arbors. There are several arbors and each is identified by its function and the parts that mount on it.

The diameter of each section of the arbors is important. Gears mount on these and must fit properly. Use the appropriate part to check the diameter. Gears should be a snug fit on the arbors unless noted. They will later be glued in place. Some of the gears are supposed to turn freely on the arbors. These can easily be sanded for a perfect fit by spinning them in a drill press or lathe. Length of the arbors is also important. Detailed arbor dimensions are given in the drawings. Do not glue the gears on the arbors until after the clock has been assembled and the dry fit interference has been checked. Some variation is normal and caused by slight differences in each part which can add up. It is easy

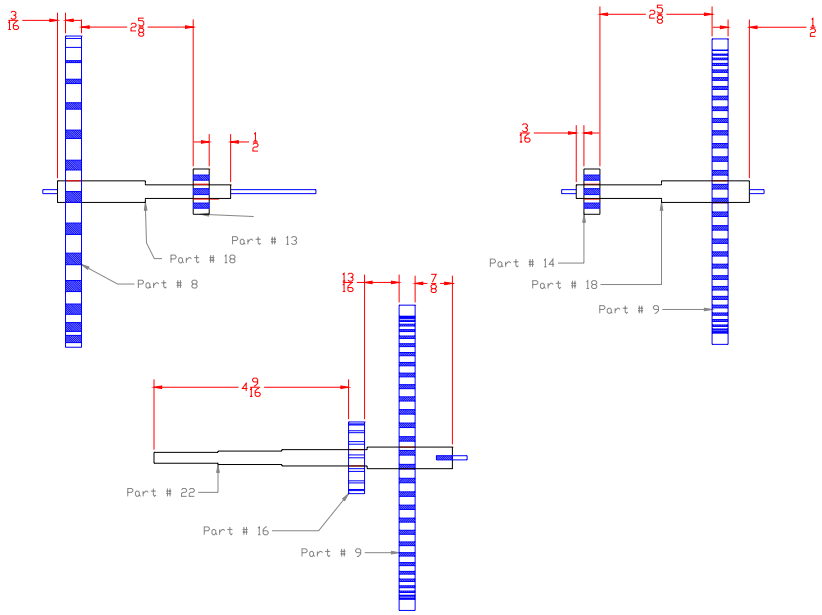


Figure 22 Gear location on arbors Note: <u>Do not glue until dry fitted</u>!

to fine tune once the clock is being assembled. After dry fitting and checking for interference you can glue them in place on each arbor as instructed.

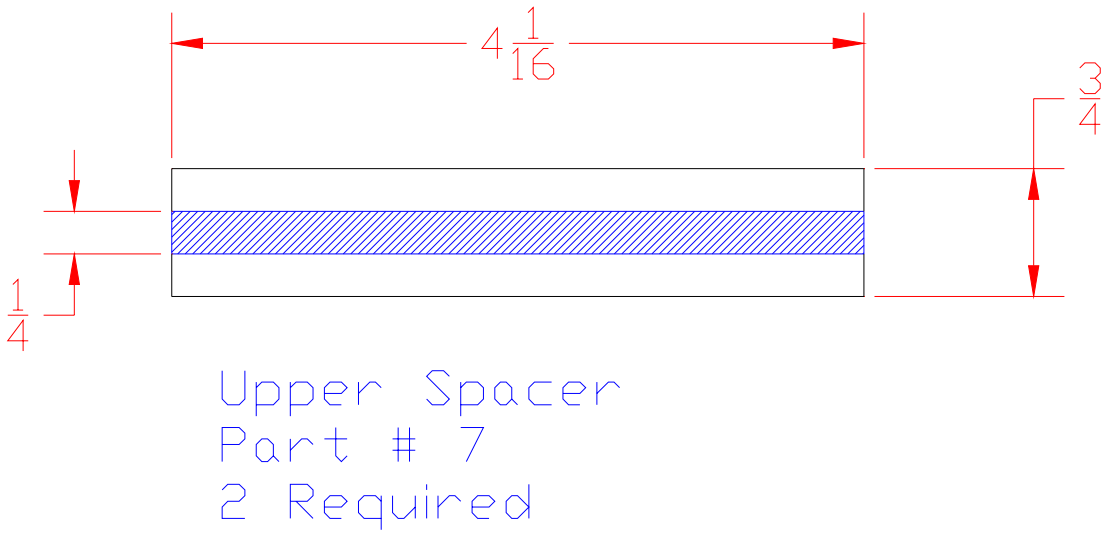


Figure 23 # 7 Upper spacers cut to identical length. Note hole shown as ¼" should be 17/64" for clearance and ease of assembly. Alternately a 7mm pen mandrel and pen drilling system can be used

The main weight arbor affects how long the movement will run between windings. A smaller diameter in the area where the weight cables run will result in a longer run time between windings but will require the clock to have heavier weights to run. Sizes given are a compromise developed by trial and error over many attempts.

Note: Wood selection for Turned Arbors and Spacer Parts.

You can use most any hardwood for the arbors and other turned parts. Pen blanks are available in many exotic species and are an excellent source of highly figured wood that will provide visual interest to the finished clock. If you select highly figured woods make sure the material is sound and will not crack or check under strain. Some of the arbors have little strain on them but some, like the escape arbor and the main arbor are subject to stress that may, over time, cause weak material to fail. Most stabilized pen blanks are great for the small arbors.

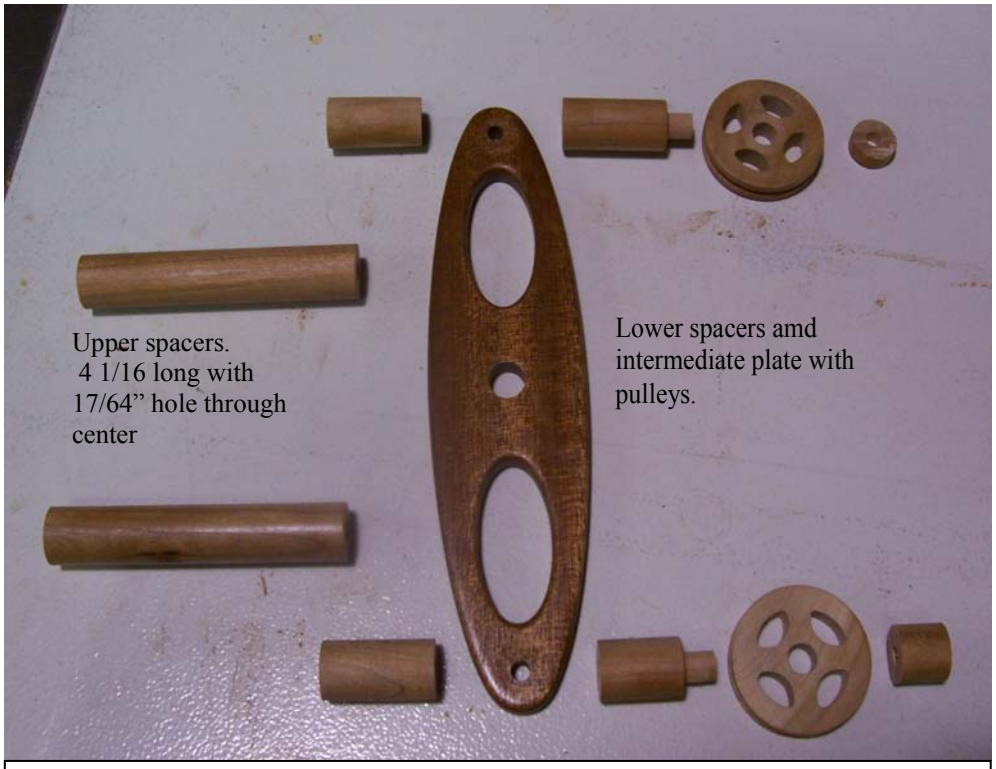


Figure 24 When assembled the length of the lower spacers and the intermediate plate must equal the length of the upper spacers so the clock will stay square when assembled.

Standoffs are not critical diameter parts but the length of each is important. These can be simple dowels or fancy turnings if you wish.

Standoffs have holes drilled the length of each part. These holes can be drilled in a drill press or lathe. If a drill press is used make a "V" block and use it to hold the part in place on the drill press for alignment. An alternate method is to use a pen drilling mandrel and a 7mm pen blank drill. .

Lower spacers are multiple sections that are assembled with other parts. The dimensions given are nominal dimensions and may require adjustment if the intermediate plate or pulleys are different thickness than the dimensions given. Each of the stand-off parts must have a 17/64″ hole drilled in it to allow the assembly bolt to be installed.

The lower standoffs can be turned as a longer dowel and then parted into the separate sections. The center 17/64" holes can be drilled either before or after turning. Make sure the ends of each of the sections are square to the diameter as this will improve the stability of the final assembly.

The pulleys should turn freely on the standoffs. The pulleys have a 3/8″ or slightly larger center hole and the spacer should be turned so the pulley turns freely. The length of the stub is slightly longer than the pulley is thick so the pulley will not be pinched when the clock is assembled.

Drill the Weight Arbor for cable and winding pin.

Carefully drill a slanted hole from one side of the weight arbor spool to the other. The drive cable will pass through this hole. Drill a 1/8″ hole ¼″ from the end for the winding pin. Do not install the winding pin until the clock is fully assembled for the last time. The weight arbor brass pin is a 1″ long length of 1/8″ brass rod fitted into a hole drilled into the end of the weight arbor. Do not glue the pin in place. It should be a push fit. If necessary you can flatten a small portion of the center of the brass pin with a hammer just enough to make it tight in the hole of the weight arbor.

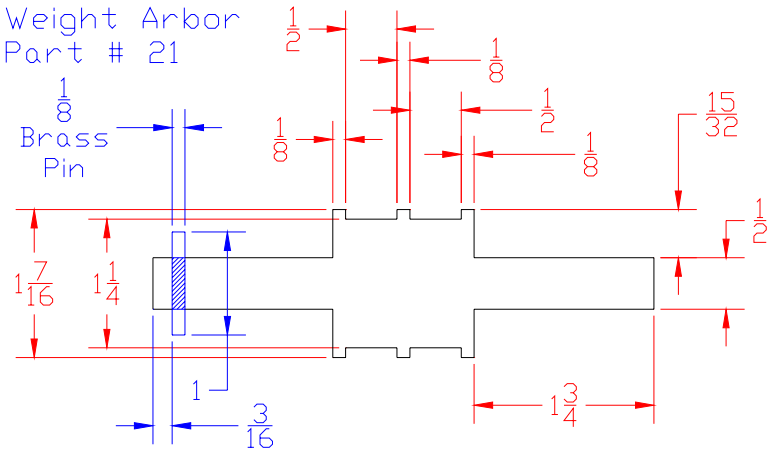


Figure 26 # 21 Weight arbor fits into front and intermediate plate but must rotate freely. Shim with washers if required.

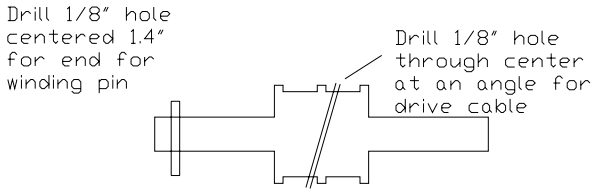


Figure 25 Drill hole through weight arbor at an angle to accept drive cable

Bearings and arbor pins

Bearings are made from ½″ diameter black HDPE plastic rod supplied by Woodline USA as part of the clock template set. Some rod supplied may be slightly large due to the extrusion process. These can be turned or carved down so they will fit in the drilled holes in the plates. Outer diameter is not critical and you can even make your own bearings using a ½” plug cutter and a suitable material. Additional hardware and bearing material kits are available for a small charge. The rod is easily cut by making a simple jig from a scrap of wood.

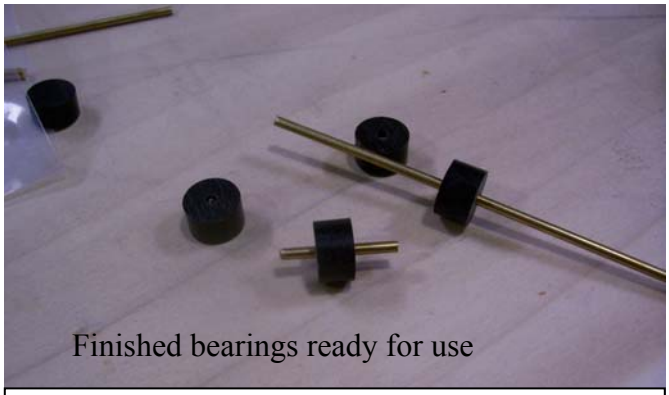


Figure 27 #36 pivot bearings. Drill centers to 7/64″ inch. Drill one bearing to 21/64″ for center arbor through front plate.

Drill a ½″ hole through a ¾″ thick piece of wood and insert the plastic rod in the hole. Set the bandsaw fence to 3/8″ and cut through the wood block and the plastic bearing material. Push out the cut off bearing

blank and repeat until 6 pieces have been cut. 5 of the bearings are drilled 7/64 to accept 3/32 brass pivot pins and 1 is drilled 21/64 ″ to be a loose fit on the second diameter of the main arbor.

Drill in a lathe or drill press using the same method described in the next section for drilling the arbor pivot pins. Bearing holes must be well centered. The slight oversize of the 7/64 allows the clock to run more smoothly with less friction and will allow it to pass free wheeling tests more easily..

The ends of the pins should be smooth with no burrs or scratches. Sand the arbor pins with fine sandpaper (600) and test in the bearings to ensure they are completely free. Do not oil or lubricate these bearings and pins. The HDPE plastic bearings and brass end pins are self lubricating and should last indefinitely

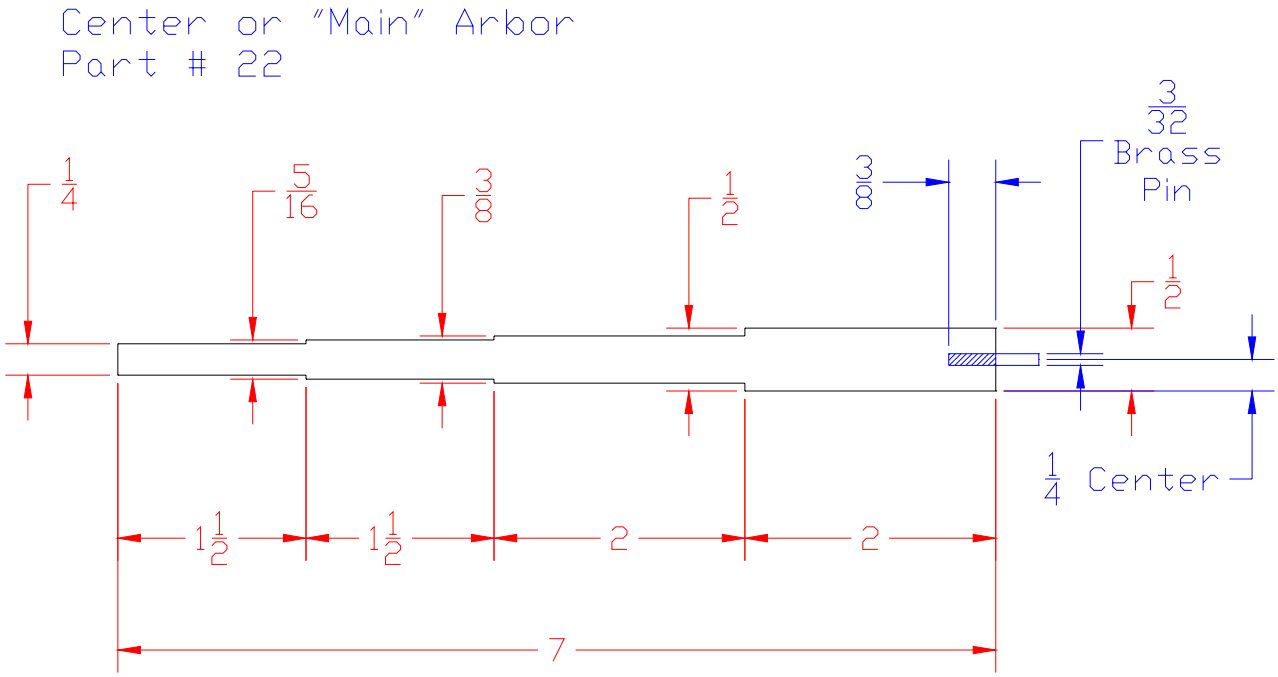


Figure 28 # 22 Main arbor. Holds minute hand. #23 Cannon tube must rotate freely on 5/16″ portion

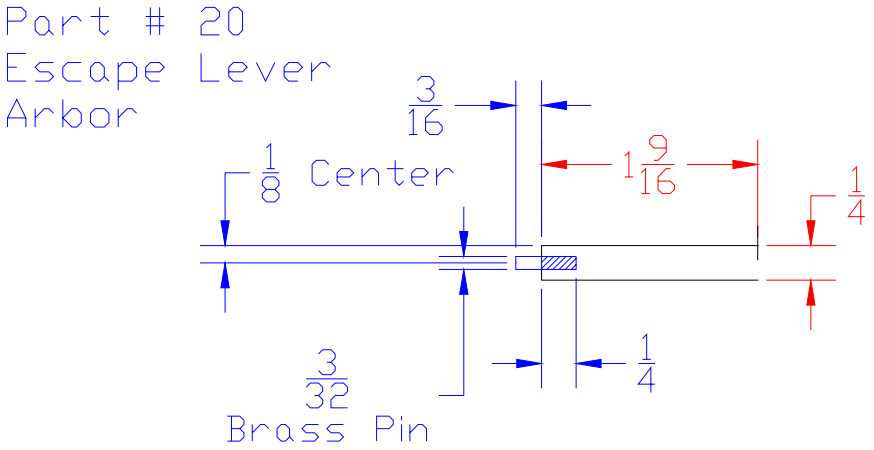


Figure 29 #20 Escape lever arbor is made from a 1/4" dowel

Cut Arbors to Length and Install Pivot Pins

Cut the second and escape arbor to the length as shown. Make sure the ends are fairly square and the transition from one diameter to another is located approximately in the center of the arbor.

Drilling the ends of the arbor is best done in a lathe with the arbor mounted in a self centering chuck and a drill bit in the lathe tail stock. Drilling in a lathe assures the pivot hole will be located in the center of the shaft. An alternative method is to place the arbor in a drill press chuck and lower in onto a bit held securely in a vice. Turning the part instead of the bit assures the hole will automatically center on the shaft.

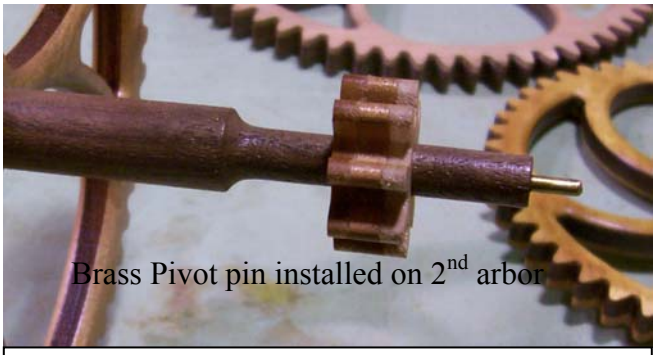


Figure 30 #18 second arbor with end pin and pinion installed

Drill both #18 arbors to receive a brass pin in each end. Pin holes should be 3/8″ deep into each end of the arbors. (Note: the center arbor only has a pin in the end of the ½″ diameter section.)

The escape and second arbor are identical except for the length of the brass pin in the small end of the escape arbor. The escape arbor turns the second hand and must have a longer pin that can pass through the front plate and hold the second hand in place. Don't glue the longer pin in yet as it will be easier to assemble by inserting from the front of the clock later.

Figure 31.

 # 20 Escape lever arbor & pin

Install the brass pins in the end of each arbor as shown in details drawings of #18 and secure with glue. Trim the length of the shorter pins to 11/32″ (just so they do not protrude through the plastic bearings when installed). Remove any burr from the ends of the pins. Polish with 600 grit sand paper. The longer end of the escape arbor is not trimmed until fitting the second hand which is one of the last steps in building the clock.

The #20 escape lever arbor is a 2″ length of ¼″ dowel and has a brass pivot pin in one end which protrudes only about 3/16″. This part will be cut to finished length during final assembly. Polish this part carefully as it can affect the power requirement of the escape mechanism.

Cannon Tube #23

The #23 cannon tube is a turned part that has a hole through the center. This part is glued to the # 10 48 tooth dial train gear and is part of the 12:1 reduction for the hour hand. The hour hand mounts on one end of the tube. This part must fit the center hole of the # 10 48 tooth dial train gear snugly and still spin freely on the main arbor. It is easier to sand the arbor for a perfect free running fit than it is to sand the inside of the cannon tube. It is recommended that the builder make the turned main arbor and cannon tube before making the hands so these parts can be fitted carefully.

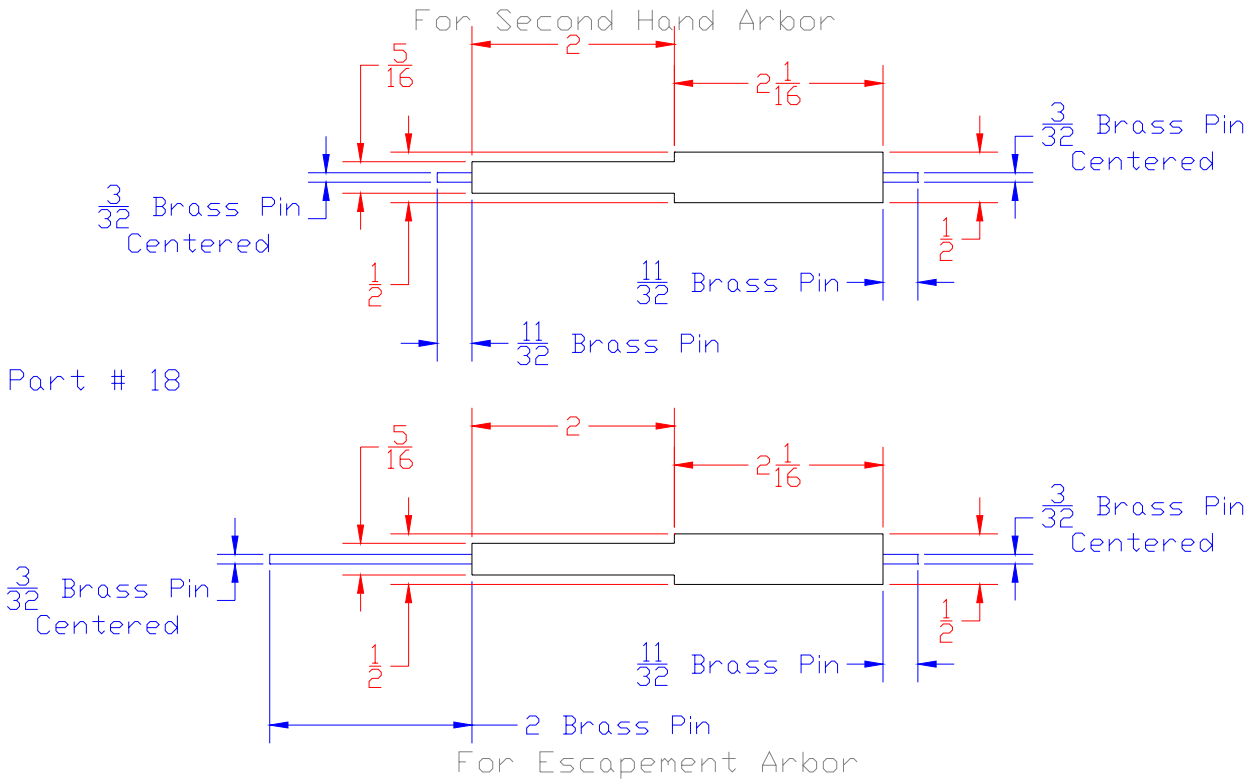
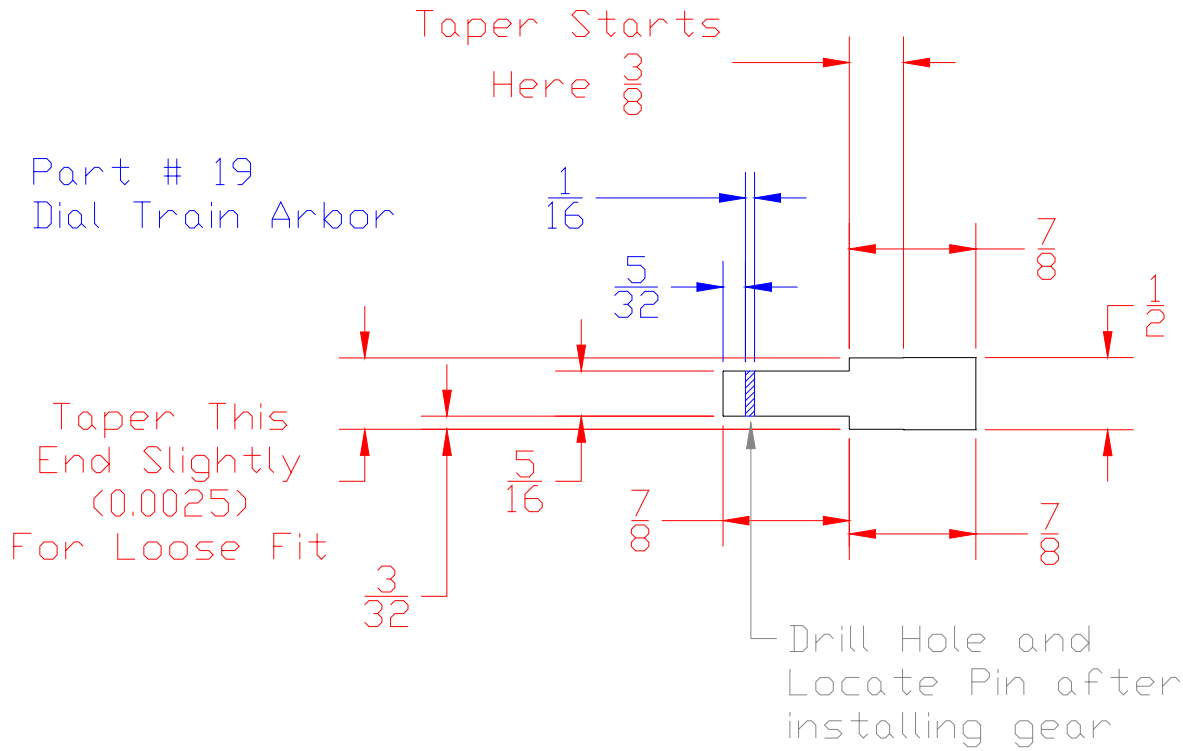


Figure 32 Escape, second and dial train arbors. Arbors can be lathe turned of any hardwood. Taper on #19 is done with light sanding



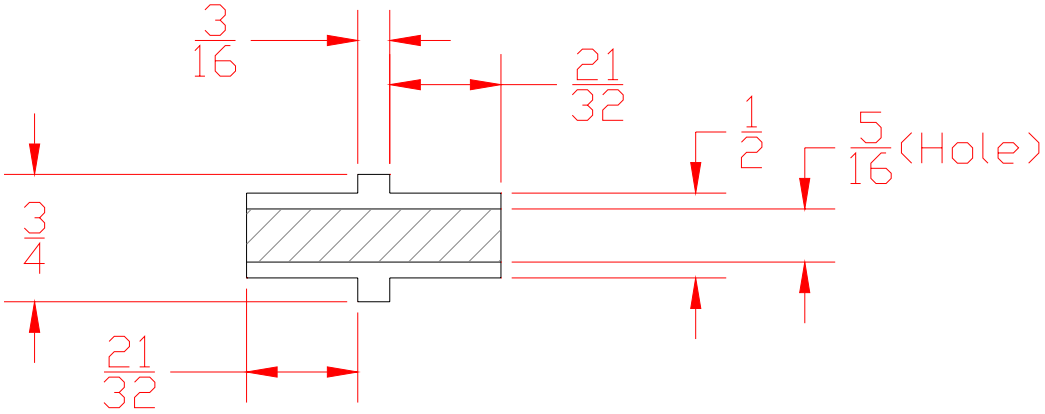


Figure 33 #23 Cannon tube fits into # 48 tooth dial train gear

23 Cannon Tube is installed on #10 48 tooth dial train gear. Glue in place. Gear with tube installed hole must spin freely on main arbor

Clock Plates

The "plates" are the front and rear of the clock movement and they provide support for all components. Full Size clock plate drawings are available. They are printed on 11 x 17 paper and must be overlapped to produce the full size drawing of the back plate. Use the full size drawings supplied by Woodline to layout directly on the wood. Do not attempt to copy these drawings or reproduce them. If you need additional copies just call Woodline and we can send you new ones for a very small fee and the cost of postage. They are printed on a calibrated printer and many customers have experienced difficulty trying to produce copies accurately using photocopiers or other methods. Note there are two options when making the plates. The dotted line on the plan indicates the Mission style and the solid line indicates the original design shown in this manual. Making the parts is exactly the same for either design.

Front (#1) and Rear (#2) Plate Layout Cutting and Drilling

The front and back plates are **½″ thick** and should be made of hardwood or a laminated material. Hole location is essential to proper mesh of the gears and other part alignment. Outside of the plates can be cut with a band saw or jig saw. The inside can be cut with a scroll saw or jig saw. Use a drill press to drill the holes to assure bearing holes are square to the plate. Once the plates are cut, use a ¼″ round over bit to round over all edges except the bottom of the plates that will support the movement when mounted. Sand and finish the plates before installing any parts on them.
Check the locations of hole centers carefully before drilling. These are critical distances and must be accurate.

NOTE: THERE IS AN INSIDE AND OUTSIDE SURFACE TO EACH PLATE.

Since they must match and holes align you must consider which side you are drilling. All holes are drilled from the "inside" surface of each plate and the drawings show only the inside surface.

Drill all holes using brad point bits or forstner bits that will not drift as the hole is drilled.

Even the corner holes must be accurate to prevent twist of the movement as the connecting bolts are tightened. To ensure proper alignment you can clamp the two plates together and drill corner and other holes common to both plates at the same time. These holes are 17/74" to allow the clock to be assembled more easily than if the hole sizes matched the bolt exactly.

Drill the bearing holes first. Drill the bearing holes 3/8″ deep using a ½″ diameter forstner or brad point bit. After the bearing holes are drilled drill the through holes at the proper locations.

Note that only two of the bearing holes in the front plate also have through holes in them. One hole is slightly larger than the brass pin (drill it 3/16″) for the escape arbor pin to pass through for the second hand.

Plastic bearings with holes are pressed into the plates and need not be glued in. The arbors will hold the bearings in place. Shaded holes in drawing get the bearings. The center hole in the front plate gets the bearing with a 21/64″ hole in it.

Pulleys

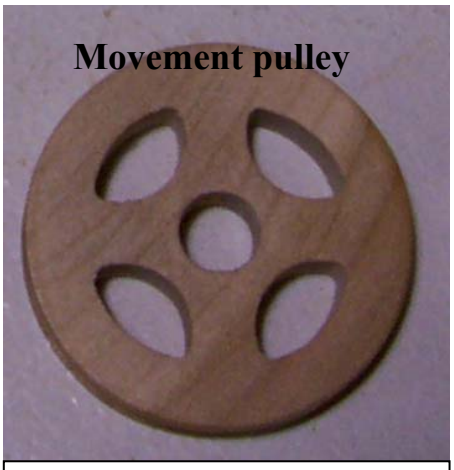


Figure 35 #52 Movement pulley with 3/8 center hole

There are two types of pulleys and two of each required. The movement pulleys have a 3/8″ center hole and ride on the lower spacers to carry the drive cable out of the movement.

The pulleys on the movement are identical except for the center hole size. Make the pulleys out of a dense wood such as hard maple, walnut, ebony, rosewood, lignum vita or similar.

Figure 36 #53 Weight pulleys serve to double length of run time for movement.

Pulleys can be made using the same procedure as gears. Alternately you may make them on a lathe. Pulleys are not critical parts and any change in diameter or design is acceptable as long as they turn freely. If the template method is used a groove must be carved in the edge of each pulley either with a router and small core box bit or by sanding or filing a small groove around the entire edge of the pulley for the drive cable to ride on. The groove is approximately 1/8″ deep

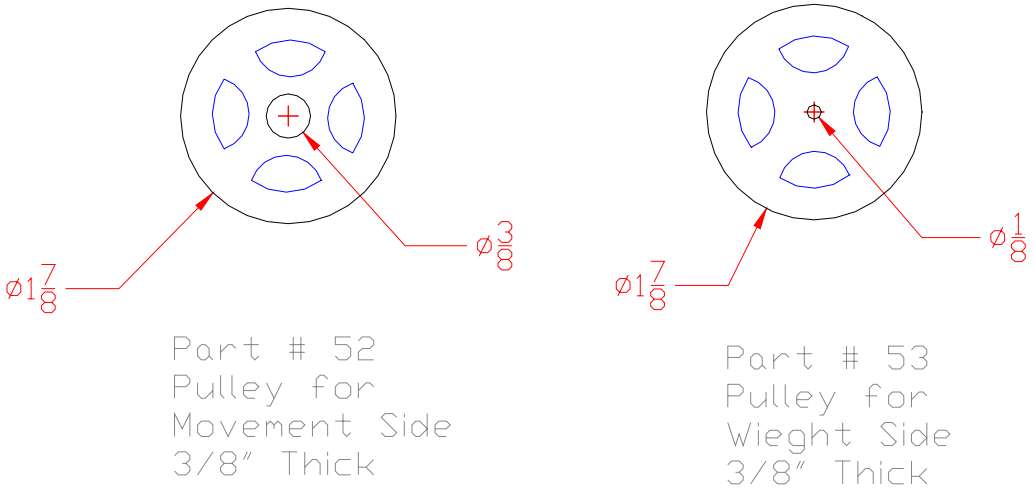


Figure 37 Pulleys are identical except for center hole and can be template turned or lathe turned.

Pulleys are made of 3/8″ hardwood and links are made of 3/16″ thick hardwood.

Weight pulleys are optional and allow the drive cable to be looped and thus the run time of the clock is doubled between windings.

Links and weight pulleys are held together by 1/8″ brass pins glued in place then sanded flush. Cut and drill the links for the weight pulleys from a piece of ¾″ thick material using a scroll saw then resaw them into a matched pair of links. Glue a 1/8″ brass pin as a connecting link pin and when dry sand the entire assembly to make the ends of the pins flush with the link sides. The finished thickness of the links should be about 3/16″.

Initially and until the clock is tuned and run for awhile you may wish to not use the weight pulleys preferring instead to hang the weights directly on the cable as to provide additional drive power. Without the pulleys and using direct attachment of the weights, the clock will run for approximately 28 hours on each wind. With the pulleys installed it will run twice as long.

Weights must be heavy enough to drive the clock. The exact amount of weight required depends on the degree of care exercised during construction. Two weights of about 13-16 pounds each should be sufficient to run the movement with weight pulleys or two weights of 7-8 pounds each when hung without weight pulleys.

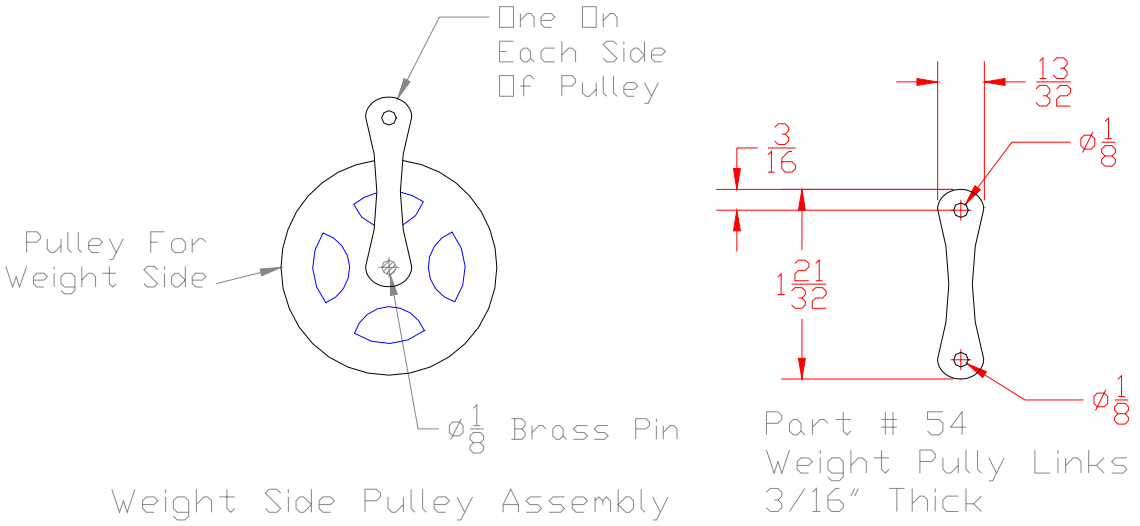


Figure 38 Weight pulleys are optional. If longer run time is desired weights must increase and pulleys must be used.

Intermediate plate (changed in Mission Style movement see drawing)

NOTE this illustration Figure 12 has changed in the drawings. Center hole is ½" Please refer to line drawing for exact dimensions. I have included a revised drawing at the end of this document.

The intermediate plate supports the back side of the weight arbor and is held in place by the two lower bolts and lower stand off assemblies. The exact dimensions of this part are not important as long as the holes all line up with the holes in the front plate. You can use the front plate as a lay out guide to drill the holes in the intermediate plate. There are oval shaped holes shown in the intermediate plate which serve no horological purpose but add to the aesthetics of the design.

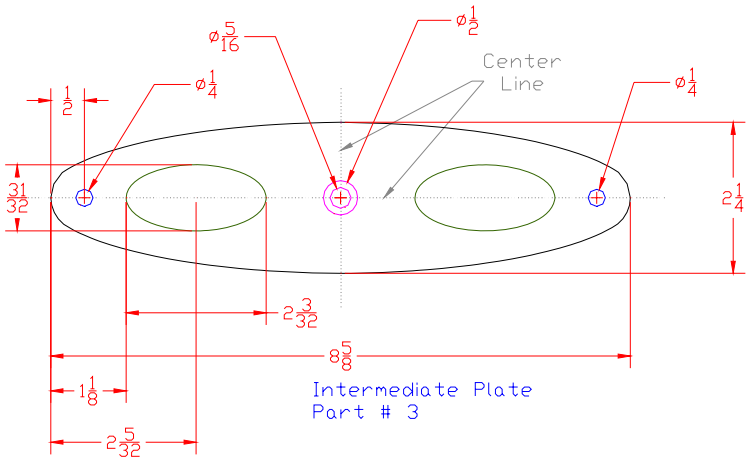


Figure 12 Intermediate Plate can be drilled referencing front plate to assure alignment

Figure 40 Inlay on hands is optional but attractive

Rounding over the outsides and the oval holes with at 3/16″ round over bit adds noticeably to the visual design of the intermediate plate. Rounding over is best done in a router table for safety.

Hands (changed in Mission Style movement)

Wood selection

Hands are one of the most visible parts of the clock and should be constructed carefully with attention to color of the material, grain orientation and how they will look in relation to the gears behind it. For this reason I recommend you wait until other parts are made and the movement partially assembled before selecting the hand material. The finished thickness of the hands is 3/16″ Great looking hands have been made from burl or other very highly figured wood. They can be cut from a thicker block and then band sawed to thickness when separated from the pattern.

Cutting slot and installing the hand clamp screws.

I recommended making the center arbor and cannon tube before making the hands. The holes in the hands should be a snug fit but should allow a little turning movement on the cannon tube and main arbor so the time can be set by turning the hands independent of

Figure 41 Small screw provides tension to hold hand in place.

the gear position. Fit the holes to the arbors before cutting the slots and installing the screws. Also drill the hole for the clamp screws before cutting the slots in the hands. Drilling the holes first and test fitting the screws will reduce the chance of breaking the delicate ends of the hands. The clamp screw is a small #2 x 3/8″ brass wood screw from the hardware kit. The end of the clock hand template receiving the clamp screws is longer than the finished piece so that the screw hole can be added more easily. After the screw is installed the end of the hand can be sanded to the desired proportion.

A slot is cut into the end of each hand. The slot allows the hand to be tightened on the arbor with a clamp Screw. The slot should extend through the hole and approximately 3/8″ beyond. Rounding over the outside edges of the hands with sand paper adds a finishing touch to the appearance of the hands.

Optional inlay:

The hands are an excellent opportunity to add accent to the clock by adding a contrasting inlay to the tip of each hand. The hands shown have real elephant ivory inlay (from an old piano key). Brass or a combination of contrasting woods also makes excellent inlay material. Excellent inlay materials can be obtained from a celluloid pen blank and they are available in a wide variety of colors. The same pen blank can be used to make the second hand for a coordinated design.

Alternate hand design Alternate hand designs can be found in clock catalogs. Alternate hands can be made using a scroll saw. Photocopy the desired plan and enlarge to the desired size then glue to a

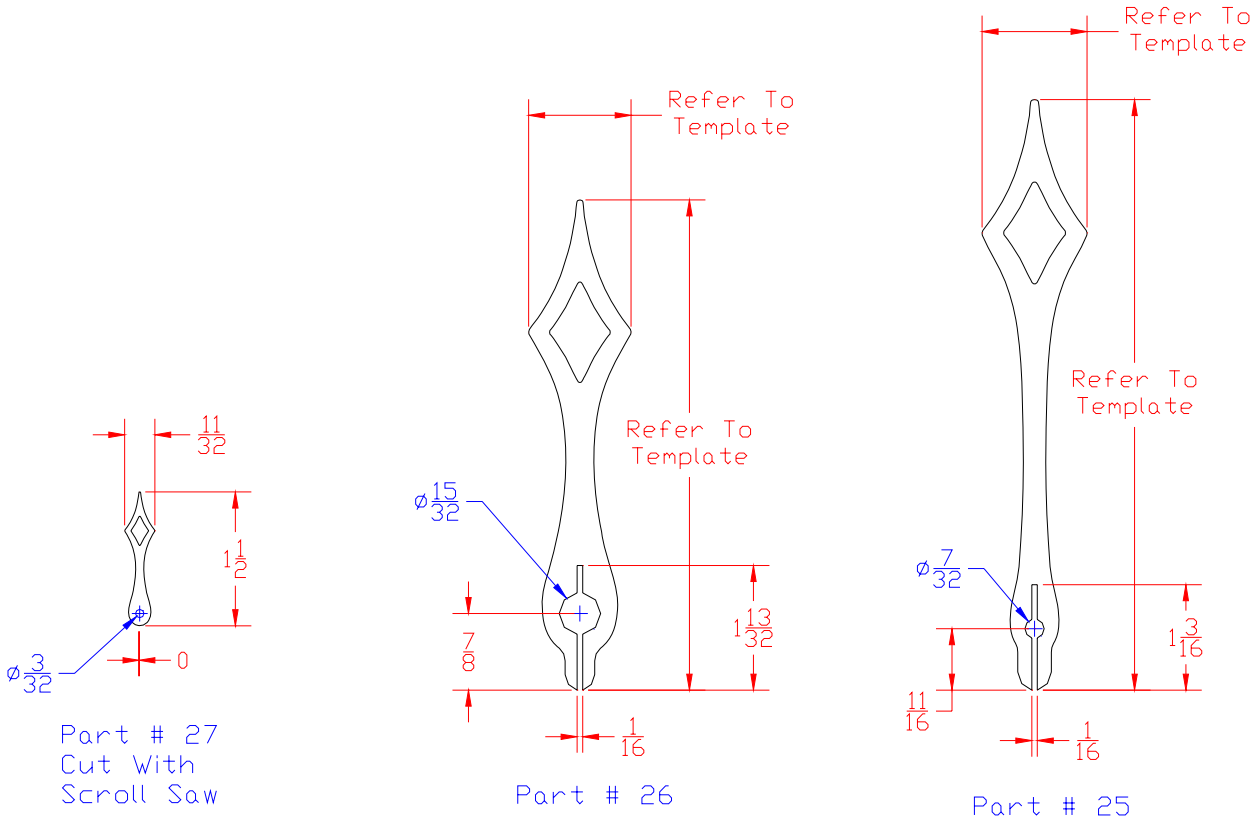
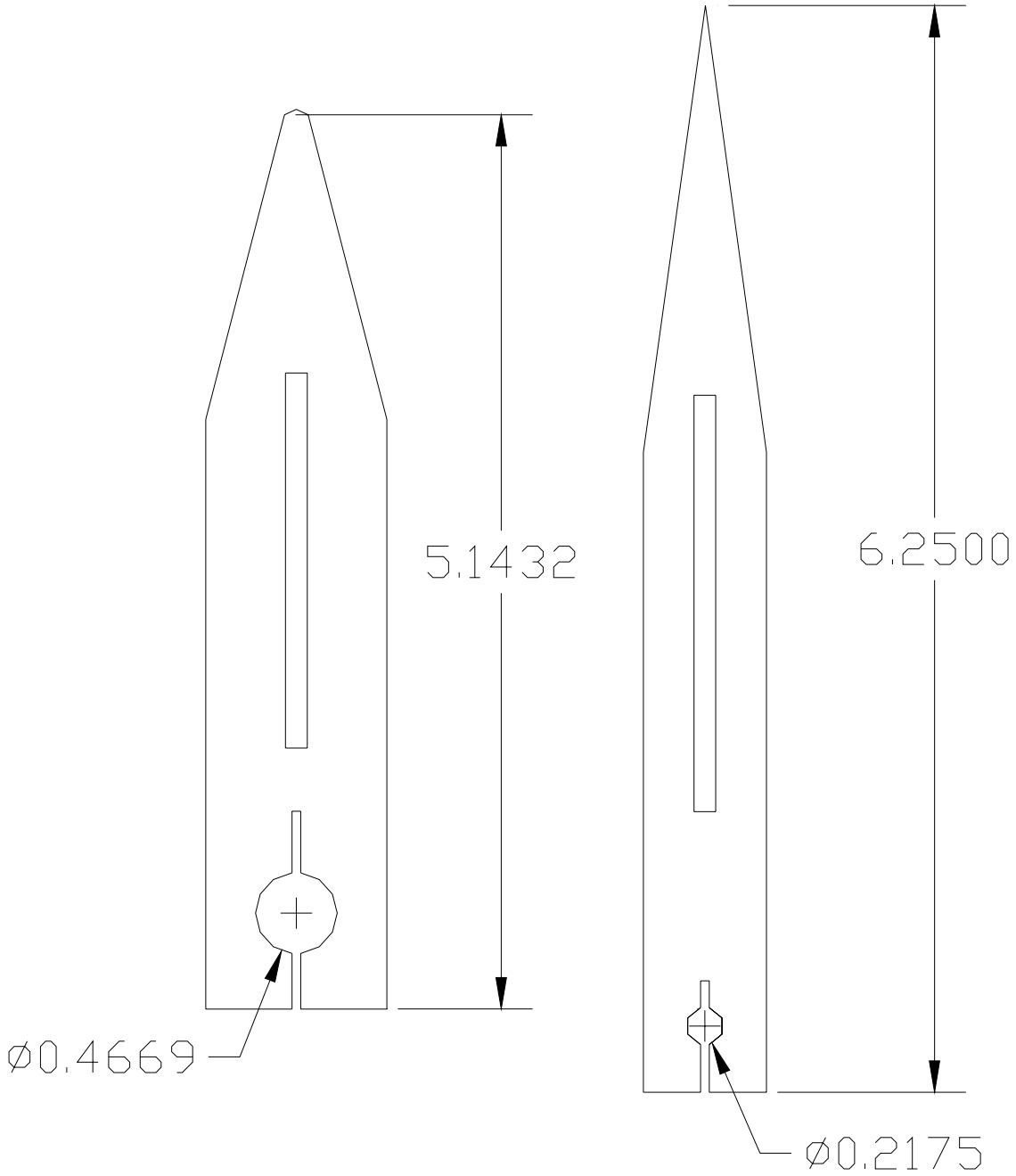


Figure 42 Hands can be cut with scroll saw if desired. Templates can be used to cut minute and hour hand with pin router. Other hand styles can be used if a different look is preferred.

piece of material and scroll saw to produce the hand. Sand off the paper when complete. New for this version of the instructions we have included some alternative hand designs near the end of this manual.

Mission style hands

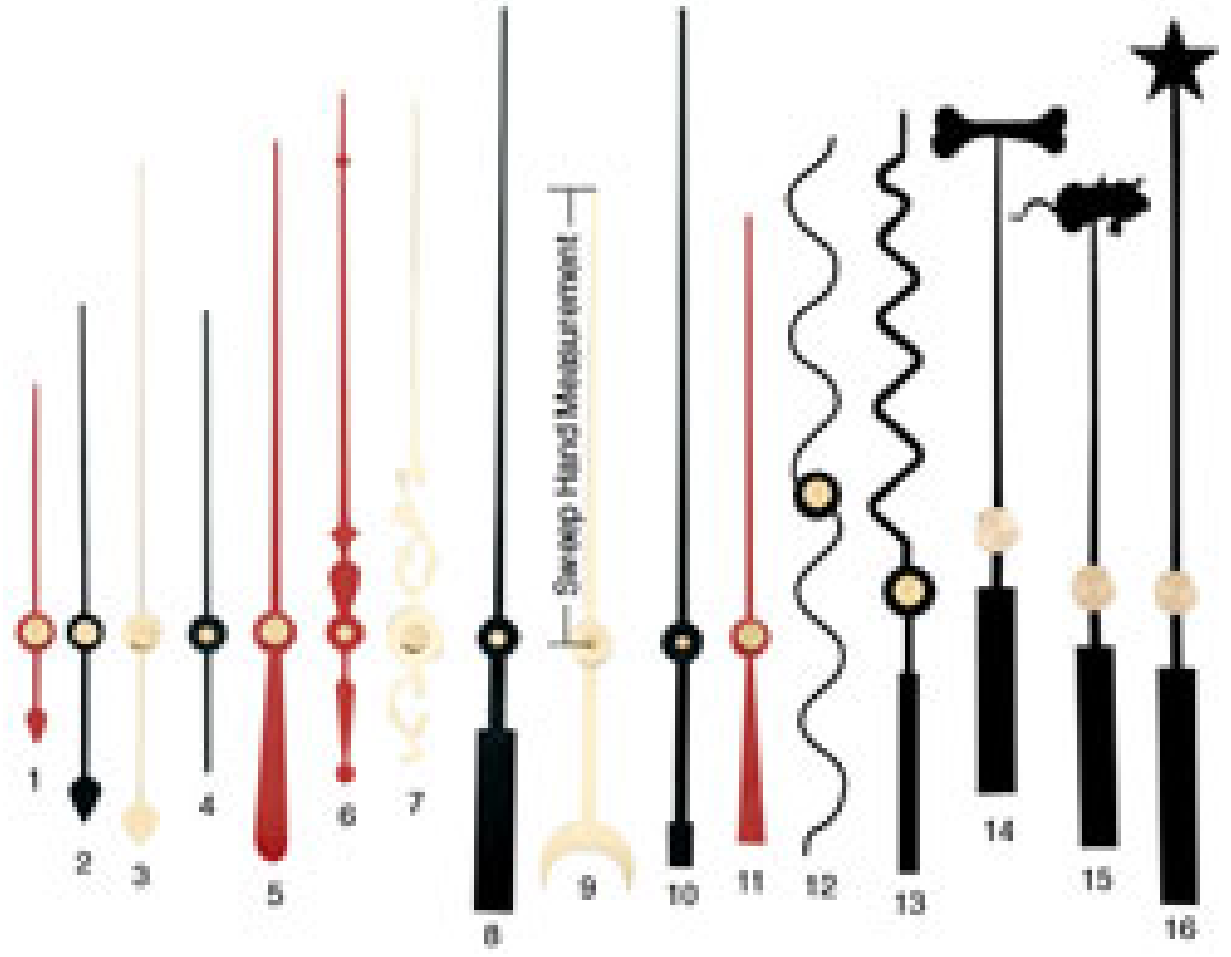
Mission style hands are **a** simpler design and the exact size is not critical. They can easily be cut on a band saw or with a scroll saw. Templates are not provided for Mission style hands. Make a photocopy of this page and paste on to the desired wood. Drill the holes in the hands first and then use a saw to cut them out. Sand all edges until you are satisfied with their appearance. The holes are intended to be one size smaller than the shaft of they go on so a friction fit will occur.



Second hand

The second hand is cut from thin material with a scroll saw or fret saw. The mounting hole is drilled with a 3/32″ drill bit. There is a full size pattern included in the plan section. The pattern shown is only one option and may be changed to suit the builder. One method of making the hand is to make it out of a thicker piece of material and then resaw or sand to the desired thickness. Do not install the second hand until the clock is completed. The second hand is held in place by a drop of glue applied to the back side of the second hand where the shaft enters the hole. Do not glue the hand until the clock is in the final location. When you do glue it in place use glue very sparingly only to the back side of the hand in case you ever have to remove it. If fit is snug enough, it may not be necessary to glue it at all. You may also choose to use a celluloid pen blank that matches the inlay on the hands if you chose to inlay them.

The hands are an excellent opportunity to express your own artistic talents. It does not have to be of the same design shown. Anything will work. Many designs can be found in clock catalogs and online. Different hand designs will change the entire appearance of the clock and can add elegance and a sense of personal design.



Ratchet and winding pawls

Figure 43 Second hand glued in place after final assembly of clock

Figure 44 Second hand cut from ivory recycled from an old piano key

Cut ratchet using a solid hardwood blank. The ratchet and small gears can all be cut at the same time using the template. The ratchet is 3/8″ thick and will be glued to the weight arbor. Do not glue in place until ready for final assembly. The ″direction" the teeth point is important or the clock can not be wound. The clock is wound by turning the crank clockwise thus the teeth should point to the left when viewed from the front of the clock.

Figure 13 Ratchet is cut from hardwood

Make the ratchet using a process identical to the pinions and other small parts. This part could also be made using a scroll saw if desired. The tooth pattern is not critical.

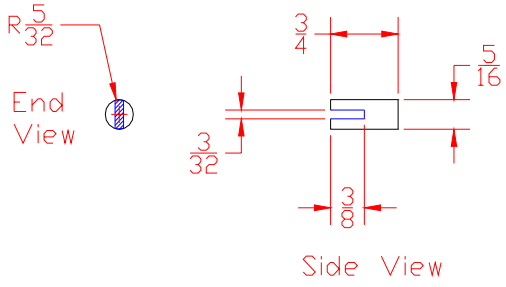


Figure 46 Pawl Retainers (2) for 48 tooth power train gear

Fit pawls to 48 tooth power train gear

Note" figure 46 shows a diameter of 5/16" this should be 3/8" as indicated on the line drawings.
There are two holes near the outer edge of the 48 tooth power train gear. These holes hold the pawls in place. Pawls are simple strips of wood that engage with the ratchet to only allow the weight arbor to rotate in one direction when wound. These components must be well made because they transmit all the force of the weights to the movement and thus the operation of the clock.

The pawl mechanism consists of two small 3/8" diameter dowels # 40 with slots and the # 39 pawl strips. Make these dowels a tight slip fit in the pawl retainer holes in # 11 gear. The dowels should be about ¾″ long with slots cut to match the pawl strips. The pawl strips are 3/32″ thick x 3/8″ wide and about 1 ½″ long. Actual length will be determined at final assembly. Make the pawl strips from a strong clear hardwood. Maple works well but any hardwood will do. The slotted dowels should be a snug fit into the pawl retainer holes and the pawl strips glued into the dowels as shown in the picture. Use an alignment dowel or one end of the weight arbor to hold the ratchet in place on the #11 48 tooth power train gear and rotate the pawl holders until the angle is as shown in the picture. Trim the pawl strips until they properly engage the ratchet. Both pawls should "click" at about the same time as the ratchet is rotated. The pawl strips are then thinned by sanding or carving until a gentle but firm ratchet action occurs when the ratchet is rotated. The pawl retainers should be glued securely when adjustment is complete.

Figure 14 # 39 Pawl Strips are glued in # 40 pawl retainers and Gear # 11

Assemble ratchet and glue to weight arbor

Glue the ratchet onto the back side of the weight arbor. Make sure the teeth of the ratchet are facing to the left when viewed from the front side of the weight arbor as shown in the picture of the # 11 48 tooth power train gear. DO NOT GLUE THE GEAR TO THE ARBOR. The gear must rotate with a ratchet action. If you install the ratchet reversed it will be impossible to wind the clock and new parts may have to be made. DO NOT GLUE THE 48 TOOTH POWER TRAIN GEAR TO THE ARBOR. The gear must turn freely on the weight arbor as the ratchet teeth operate on the pawls. .

Figure 15 Completed assembly mounted on the #3 intermediate plate

Escape lever and lever bracket assembly

The escape lever bracket is a curved piece of wood with a slot in the end and two different sized holes in it. It holds the escape lever and the escape lever arbor. This is the portion of the clock that produces the ticking and regulates the release of the power stored in the weights. Drill the ¼″ hole 3/8″ deep and then drill a 3/32 hole completely through the piece in the center of the ¼″ hole. The slot is then cut with a band saw. New in this instruction version: the full size plate drawing now features a full size drawing of the escape lever bracket

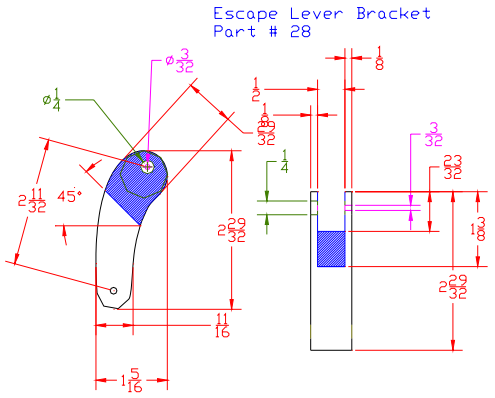


Figure 15B #28 Escape lever Bracket. Full size plan is included on front & back plate drawing.

The escape lever arbor is a 2″ long length of ¼″ dowel rod with a 3/32″ pin protruding 3/16″ from one end

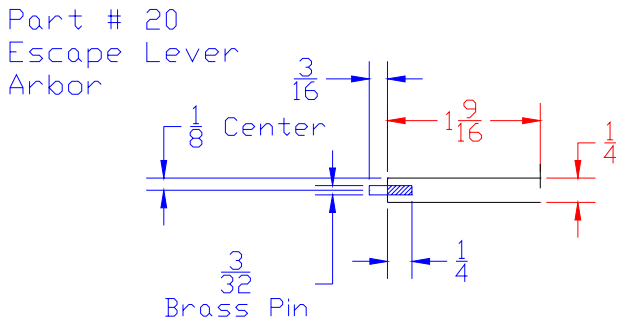


Figure 16 #20 Escape lever arbor MUST pivot very freely in #28. Brass pin should be polished and burr

The escape lever is a "C" shaped part that allows the hesitating rotation of the escape causing the clock to keep accurate time. A template is included in the templates for cutting this part. Full size drawings are also included in the drawing section. Make this part from a tight grained hardwood that is dense and will hold dimensions well. This part delivers the pulse from the escape wheel through the escape arbor then the crutch and crutch pin to the pendulum to keep it swinging.

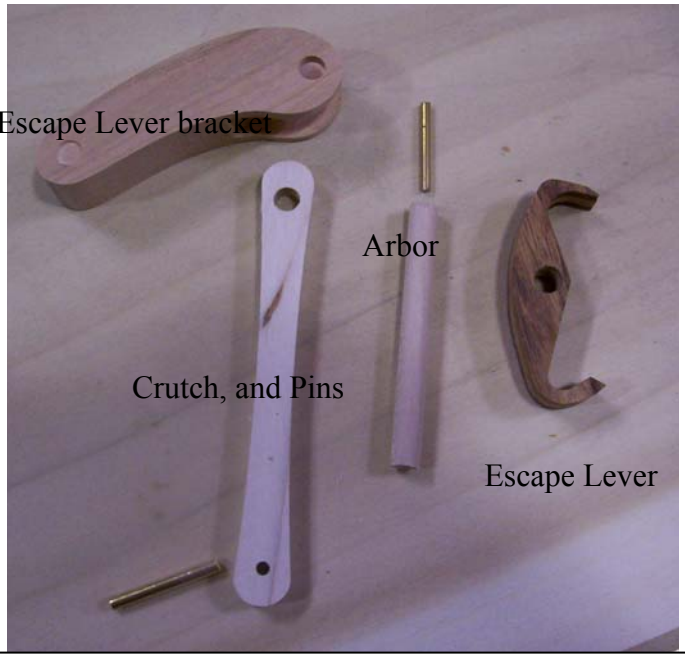


Figure 51 These parts are assembled and control the ticking of the clock.

The escape lever bracket holds the escape arbor and escape lever in close proximity to the escape wheel and is adjusted so the "beat" of the pendulum is equalized. (more about setting up the clock in the "setup and fine tuning" section. The escape lever arbor must be fitted to both the escape lever (snug fit) and the escape lever arbor support (must rotate freely). When installed the entire

assembly is held in place with a single #8 x 1″ screw through the rear of the back plate into the escape lever bracket.

Crutch

The crutch is a dog bone shaped part that transmits the rotational force of the escape lever arbor to the pendulum rod via a 1″ long 1/8″ brass pin glued in one end. The end that attaches to the escape lever arbor has a hole, slot and #2 x 3/8” screw similar to the hand assembly. This allows the adjustment of the escape lever to adjust the ticking of the clock. Drill the screw hole before cutting the slot to prevent breakage.

DO NOT INSTALL THE ESCAPE LEVER OR LEVER ASSEMBLY ON THE BACK PLATE UNTIL ALL GEARS ARE FITTED, AND THE CLOCK WORKS HAS PASSED THE FREE WHEELING TESTS.

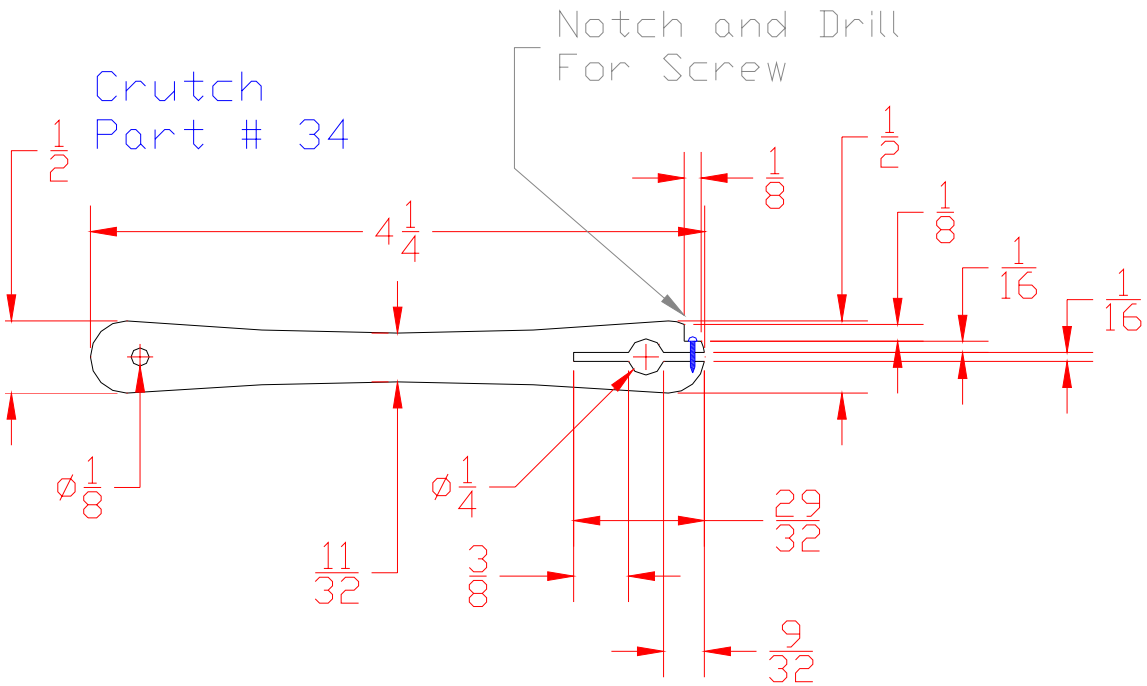


Figure 52 #34 Crutch is cut from hardwood and screw added to allow adjustment.

Figure 53 Completed crutch assembly

Pendulum

The pendulum is a disk or “bob” at the end of the rod with provision for length adjustment. A builder may choose to decorate the bob by turning a pattern or carving an initial into it. A simple wedge holds the bob in place.

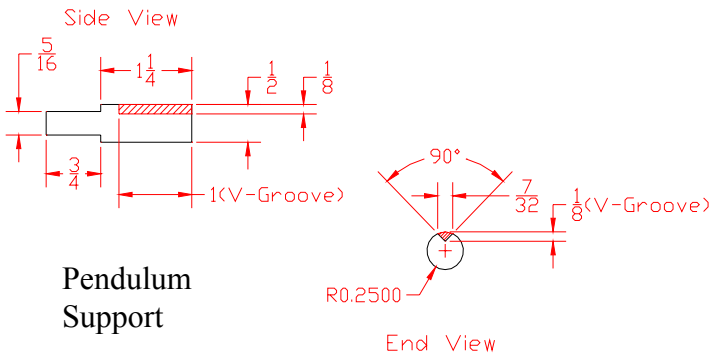


Figure 54 #43 Pendulum hanger mount installs in rear plate

The pendulum is an important piece as it will determine the “period” of the turning escape gear and thus the time keeping ability of the clock. A longer pendulum will slow the clock and shorter will make the clock run faster. Contrary to what you may think the total weight of a pendulum does not affect the time keeping of the clock. A heavy pendulum takes more power to maintain motion but will swing at the same rate as a lighter pendulum. Our efforts to produce an optimum weight pendulum reduce the power required to making the clock run.

Figure 55 Cut groove in #43 with "V" chisel

The length of the pendulum is relative to its center of gravity and has a direct effect on the time keeping of the clock. A small length adjustment will have a great effect on the accuracy of the clock. We will make the pendulum rod longer than the finished dimension and trim it to the proper length later. During setup we will discuss the fine tuning of the pendulum in greater detail.

Pendulum Hanger mount for rear plate

The #43 pendulum hanger mount is a simple turning with a v groove cut in it. The pendulum pivot rests in the v groove and allows the pendulum to swing freely. Make the hanger mount turning and cut a v groove in the ½″ portion. Mount in the top hole on the back plate on the back side of the plate. Do not glue firmly in place. Rotating the pendulum hanger mount allows a small adjustment in the relationship of the pendulum to the escape lever for equalizing the “beat” of the clock. When adjustment is complete the part can be locked in place with a drop of super glue.

Figure 56 #43 Pendulum hanger mount installed with "V" groove up

Pendulum Rod

The pendulum rod (not shown) should be ¾″ wide and 1/8″ thick by 40″ long initially. A straight pendulum rod with highly figured wood is desirable. I have used wenge and figured mahogany with success but any wood will do. Sand the rod and break the edges lightly ("breaking" means to sand off the sharp edges lightly). Finish the rod only after it is glued to the pendulum support hanger. The final length of the rod will be determined after the time setting operation during the final assembly and setup.

Figure 57 Pendulum and pivot hanging on mount

Pendulum support and pivot

The pendulum support holds the pendulum pivot and pendulum rod. The pendulum rod is glued into a slot on the support and the pivot is placed in the top slot. The pivot should be sanded to a sharp wedge before gluing in place. The pendulum support is made by drilling a ¾″ hole in a piece of hardwood then band or scroll sawing the part to the desired shape. The pendulum pivot wedge is a piece of the pendulum rod material that has been sanded to sharp edge and glued so the edge will be in the proper orientation as shown in the drawings and photographs.

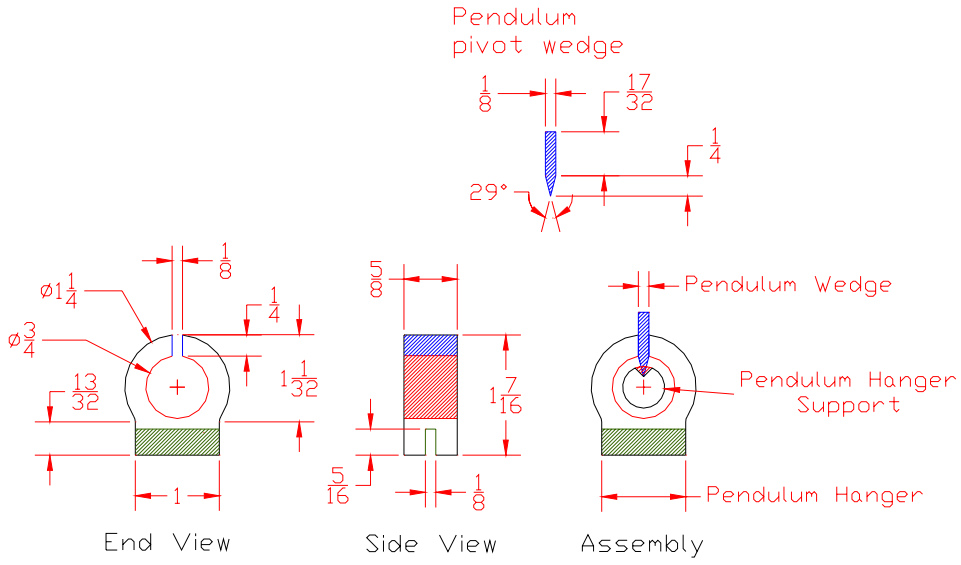


Figure 58 #44 Pendulum support and pivot

Pendulum bob

The bob (the round part of a clock pendulum) should be relatively light. The weight of the pendulum will not affect the period of the pendulum swing and thus the time keeping accuracy, it will greatly affect the power required to maintain the swinging of the pendulum. A heavier pendulum smoothes out movement of the pendulum and delivers the momentum to pull the escape lever throughout its range of motion. A heavy pendulum may also make the clock not run due to lack of power and too light will allow the pendulum to lock up in the escapement and stop ticking. Exact weight is not important and you can always adjust the weight as required during setup. A few pellets of lead shot may be added to a pendulum that is light and some material may be removed from a pendulum that is heavy.

Figure 59 Completed pendulum assembly

To lighten the bob we will turn it into a hollow shell. The exact diameter is not important and the shape can be anything. We are showing a 5″ diameter circle turned to a thickness of approximately 1/8″.

The bob is adjusted along the length of the pendulum rod to control the time keeping of the clock. It must be free to slide on the rod.

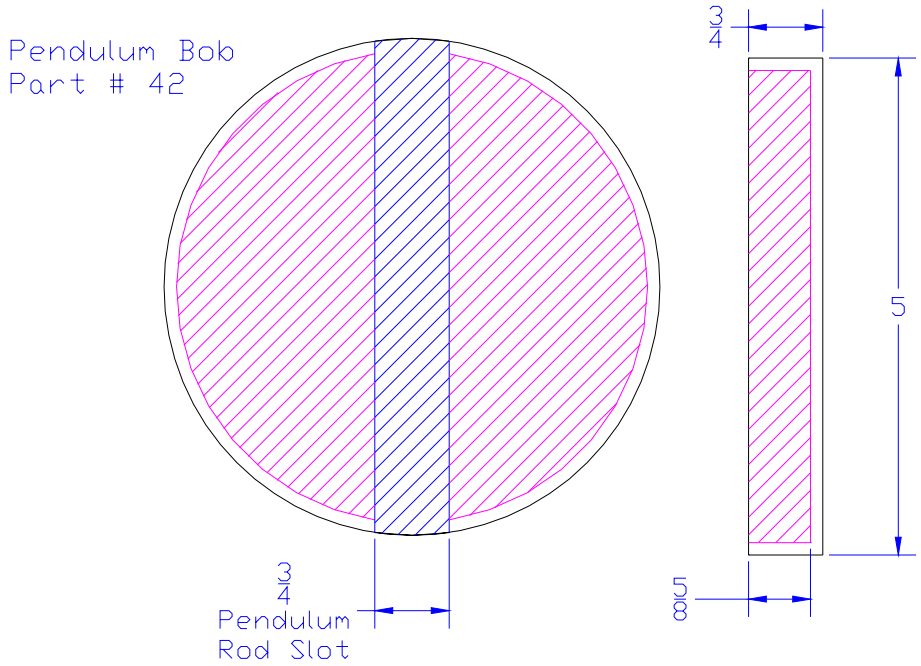


Figure 60 # 42 Pendulum bob can be turned on lathe or fabricated. Shape and weight is not critical

Cut a slot at the top and bottom of the bob and fit the rod to the slot. The bob retainer or “lock bracket” holds the rod and wedge so the bob can be locked in position.

The pendulum offers an excellent opportunity to customize your clock. The pendulum Bob shown here was carved up by a customer in Belgium. They sent it to me as a gift. I think it makes a distinctive appearance for the clock and I plan to incorporate it into a clock I will build in the future.

The bob of the pendulum does not need to be around. It could just as easily be square or triangular or oval or any shape desired. The purpose of the pendulum bob is to allow the center of gravity of the pendulum to be adjusted and thus change the timing of the pendulum swing. A small amount of vertical movement in the pendulum bob can translate to a significant change in time keeping. Once you get the clock running adjust the pendulum in small increments and let it run for several minutes before changing it again. Once you get the clock to run correctly Mark the pendulum bob position on the pendulum rod with a pencil so it can be returned to this position quickly in the event it is removed.

Length adjusting wedge and retainer

The bob is held on the pendulum rod by a simple wedge between the bob inside surface and the pendulum lock bracket. Glue the pendulum lock bracket in the center of the bob using the rod to align it. The bob must be free to slide on the rod until the wedge is installed. The wedge must securely lock the bob in place. We will start with the bob about 2″ from the tip of the pendulum. Do not trim any excess rod until the initial timing is completed. After the initial timing adjustment of

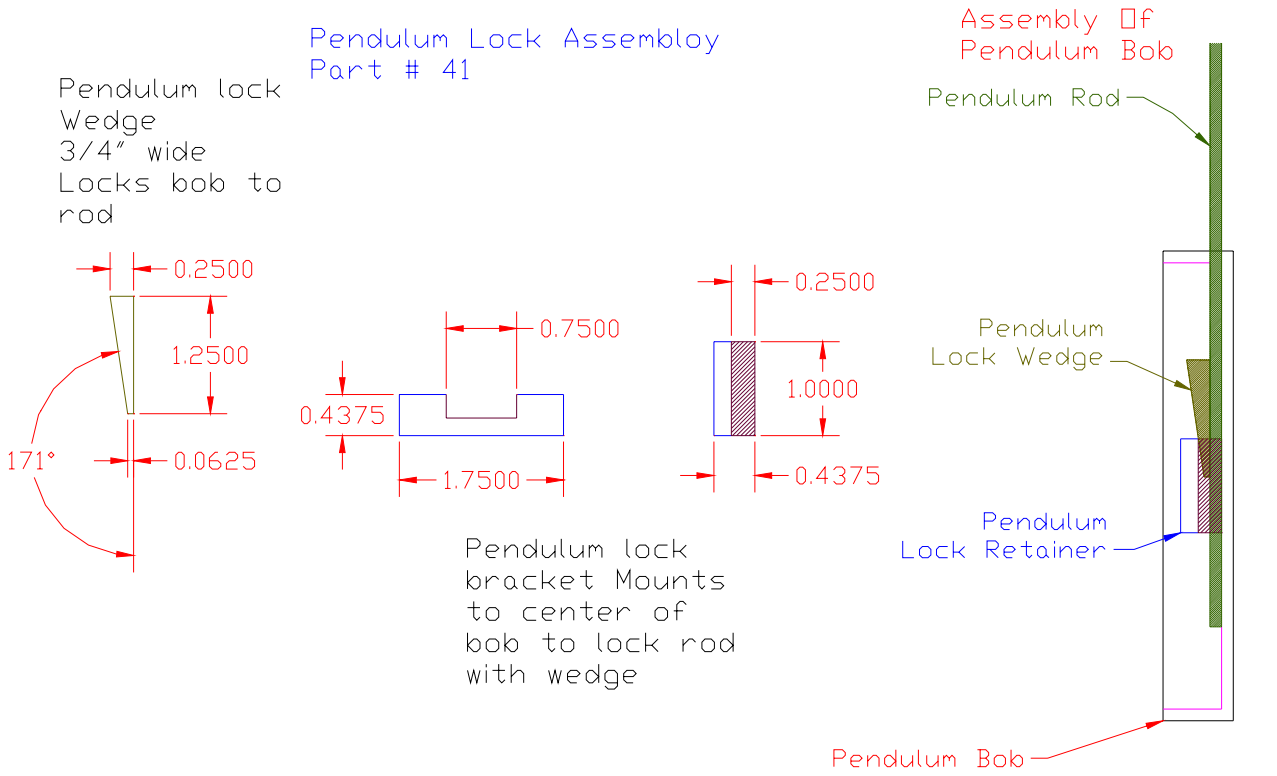


Figure 61 Bob is locked to rod with a simple wedge

the clock, trim the pendulum rod 1 ½″ below the bob and make any final timing adjustments over a period of several hours. When you are satisfied with the accuracy of the time keeping you may want to place a pencil mark on the pendulum rod to indicate where to place the bob in case it is moved in the future.

Alternate bob design

An attractive alternate pendulum bob can be made by turning two half disks and gluing them together to form the bob. Any method of holding the bob in place is acceptable as long as it can be adjusted along the length of the rod.

Carving can also add character and personal design elements to the bob. Perhaps a family initial or some scroll work to reflect the tastes of the builder.

Weights

Clock weights can be almost anything. I have seen clocks that use iron sash weights or even rocks to drive the clock. An attractive river stone can be drilled with a through hole and hung with a loop of wire. Also many cabinet shops that install granite can provide scraps of granite countertops cut and polished to make very attractive weights. Brass cased clock weights are also available from the Klockit Company and work perfectly.

Average weights are about 7 to 9 pounds each but more or less may be required for a specific clock. More weight gives the pendulum more power and will run more forcefully. Excess weight will cause excessive wear on the gear train and make the clock harder to wind.

One simple way to make great looking weights is to turn cylinders and drill them with a 1-½″ spade bit. Fill with lead shot and install a cap to retain the lead. (lead shot is available from sporting goods stores that sell shotgun shell reloading supplies.) install a screw eye in one end to attach to the weight pulley. A drawing of the weights shown is included with the drawings. Note: Melting the lead and pouring it into a wood cylinder will increase the weight by 33% for a given volume of lead versus using loose shot. ALWAYS BE VERY CAREFUL WHEN HANDELING LEAD. Wash your hands every time after handling lead.

Drilling a long hole can be difficult. The processed can be made easy by preparing your blank as follows:

Using 4 pieces per weight 1 ¼” square and as long as the weight will be, make a 45 degree1/16” chamfer on one corner of each piece. Glue the four together with the chamfered edges in the center of the blank. The resulting hole will guide the spade drill bit and improve your chances of success greatly.

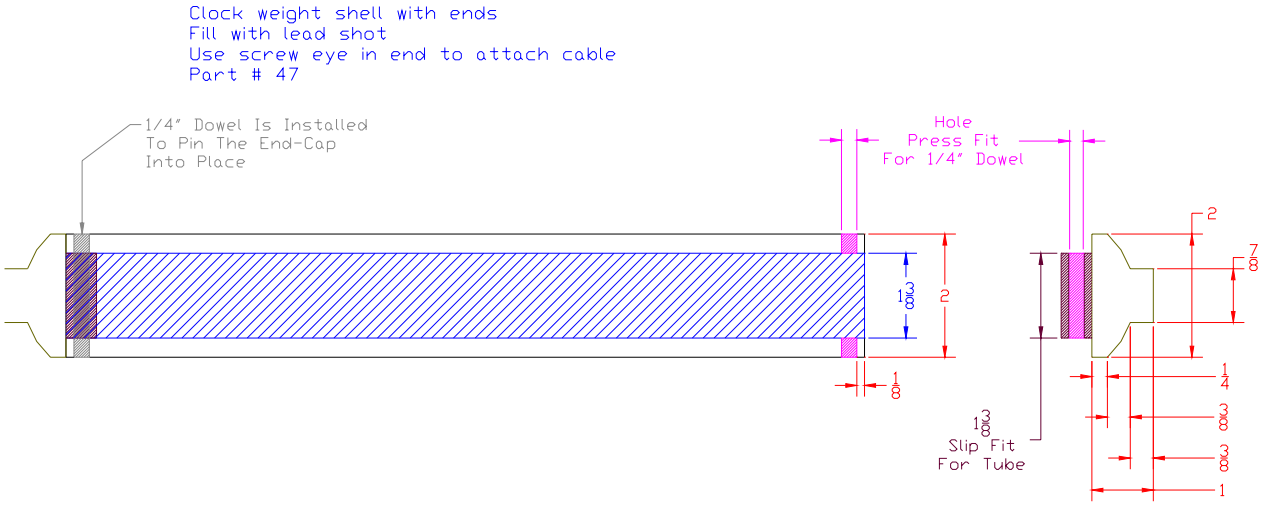


Figure 62 # 47 Weights can be turned. Almost any style of weight is acceptable

Bolt head and nut covers (changed in Mission style)

Bolt covers are simple turnings with a hole in the back side to fit over the hex bolt head or nut. The easiest way to make these parts is to drill a 1/2″ hole 3/8″ deep in a small block of wood. Then chuck a scrap of wood in the lathe and turn a stub that is a press fit into the 1/2″ hole just drilled. Jam the block onto the stub and turn to the desired shape. The same stub chuck can be used to make all 8 parts required.

An alternate method is to drill a 1/2″ hole 3/8″ deep in the end of a ¾″ dowel and then cut it off at 5/8″ and round over the edges with sand paper.

The bolt head and nut **covers** for the Mission style clock are simple squares of wood with recessed holes. See the picture of the Mission clock at the end of the instructions. The Mission are 1 inch square and 5/8 of an inch thick.

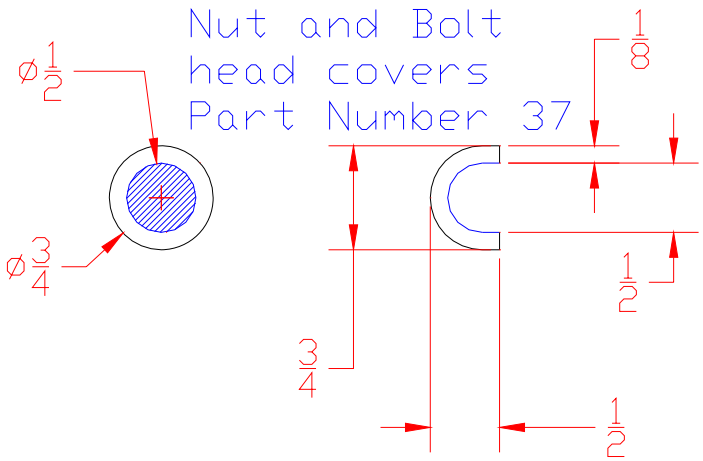


Figure 63 Suggested shape for # 37 Nut covers

Figure 64 Turn nut covers by using a stub chuck on a lathe

Winding Handle

The engagement cylinder is a ¾″ dowel that has a ½″ hole and a slot cut in the end to mate with the weight arbor brass pin. The knob is a simple turned knob or can be a purchased from a hardware store. Some builders have designed a large "key" as a winder and find it easier to use. Look at the end of this manual for an optional design for a winding key. I have come to prefer the winding key. You can use a copper ferrule made from a plumbing fitting for the key in place of the brass.

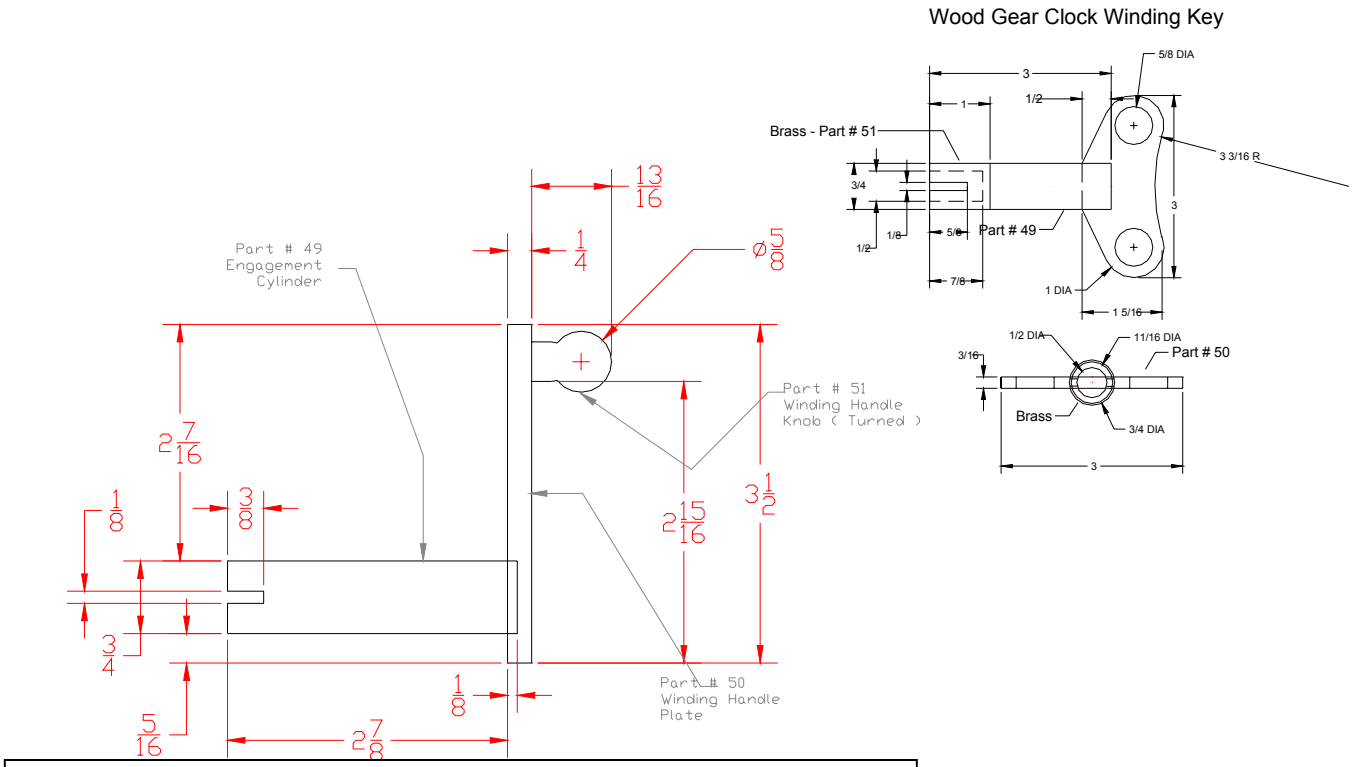


Figure 65 Completed winding handle. Knob can be purchased or turned

Figure 66 Winding handle must fit the end of the weight arbor

Initial Assembly and parts fitting

Cut bolts to length

The clock is held together by 4 ¼″-20 x 5 ¼″ hex head bolts. These bolts may require cutting as bolts of the exact length are not available (common size is 5 ½″). Put a nut over the threads before cutting the bolt with a hack saw. The nut will help clean up any threads damaged during the cutting operation. The heads of the bolts and nuts will be covered by wooden caps which are glued on after final assembly. No part of the bolts will show in the completed clock.

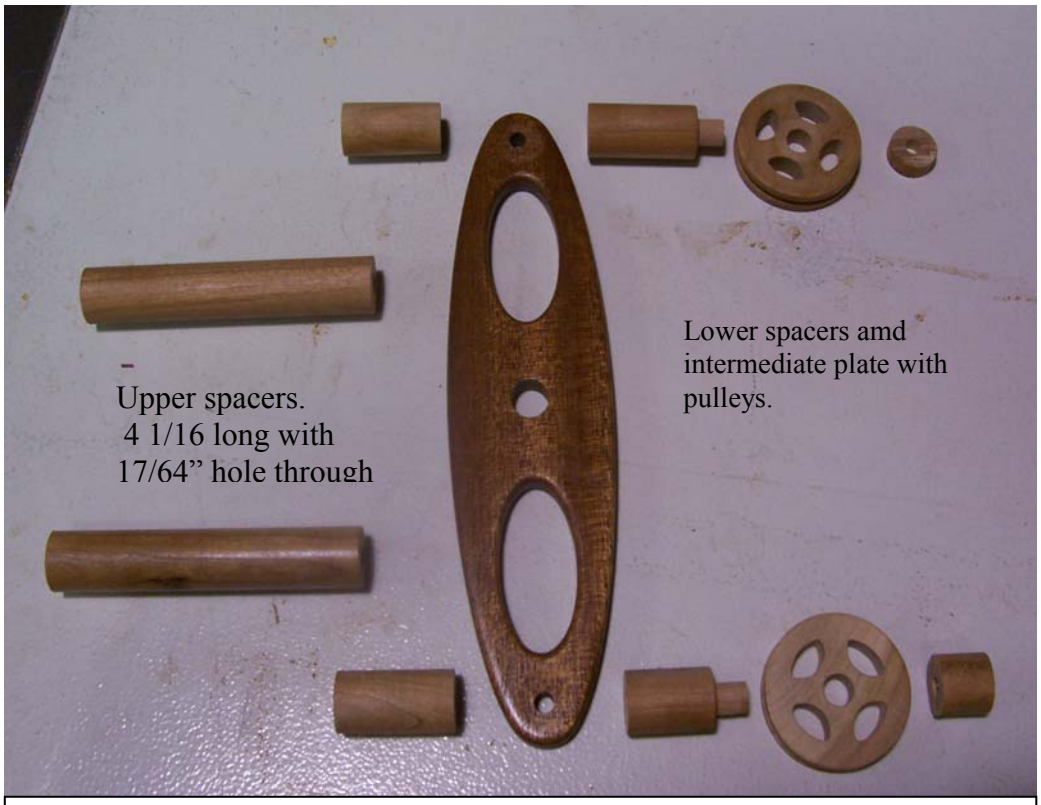


Figure 67 Length of spacers is important so that plates will not twist at assembly.

Optional wood spacers with wedge tennons

If desired you can eliminate the bolts by using dowel rods with tapered wedges inserted into each end. This will produce a more traditional look but is more difficult to make and does not hold as securely. I do not generally recommend this method for the novice builder because of the large number of times the clock will be assembled and dismantled during the building and fitting process.

Install top plate spacers

Install the top spacer first by cutting the top spacer dowels to the proper length and inserting over the retainer bolt. During initial assembly do not tighten any parts securely in place as they may need to be fitted with additional parts installed. The length of the top spacers must equal the length of the combined bottom spacers plus the intermediate plate thickness. Measure carefully and adjust as required. Failure to have them the same length will cause the clock plates to twist as the bolts are tightened.

Assemble pulleys and lower spacers. Assure that the assembled length of the lower spacers with the pulleys installed and the intermediate plate installed is equal to the top spacers. The ideal length is 4 1/16″ Any length adjustment should be done at this time to assure the top spacers and lower spacer assemblies are the same length and the arbors are not binding when the gears turn.

Mount escape gears and 64 tooth gears on arbors with 8 tooth pinions.

Figure 68 Refer to drawings for exact gear placement on arbors

Assemble the escape gear on the escape arbor. The escape gear has a front and back side. It can only work if installed correctly. Viewed from the front of the clock the point of each tooth should point counterclockwise as shown in figure 69.

There is a drawing called "arbor spacing" included that indicates the position of each gear and pinions on the various arbors. These are approximate dimensions.

The smaller end of the arbor is the "front" and should have the longer pin installed for mounting the second hand later. Mount the escape wheel 3/16″ from the back edge of the large end of the escape arbor. Install the 8 tooth pinion but do not glue in place at this time. This will make assembly easier when you disengage these gears by sliding them on the shaft instead of removing the arbors completely.

Do not glue the gears in place on the arbors until the relationship of the gears is finalized.

Once the alignment is correct from one gear to another (gears and pinions mesh and are centered one to another and rotate without interference). Glue the gears and pinions to the arbors by using a drop of "super glue" where the gear meets the arbor. Do not over glue as you may someday have to disassemble the clock. Refer to the line drawings for approximate locations.

Once the gears and pinions are installed on the arbors they should be balanced. Support the arbor at each end and spin the gear freely, note the part of the gear that is down when the gear stops rotating. If the gear is balanced, the stopping point is random for several spins. If the same spot continuously stops in the down position this indicates the gear is out of balance. A small piece of lead shot pressed into a 1/16 ″ hole drilled in a gear edge area opposite the "down" spot will frequently balance the wheel. Carefully balance all gear assemblies and repeat the spin test until you are satisfied the stopping point is truly random.

Figure 69 The gear teeth must face the correct direction or clock will not run

The center arbor has two 16 teeth gears mounted on it. One mounts on the 3/8″ diameter and one on the 5/16 diameter on the front side of the clock. The gear on the 3/8″ diameter portion must undergo great stress as it transmits all of the power from the drive gear to the movement.

This gear must be securely glued in place as well as screwed. The other 16 tooth

gear should not be glued in place but should be held on by a small screw countersunk in the gear. If this gear is glued on, the clock could not be disassembled.

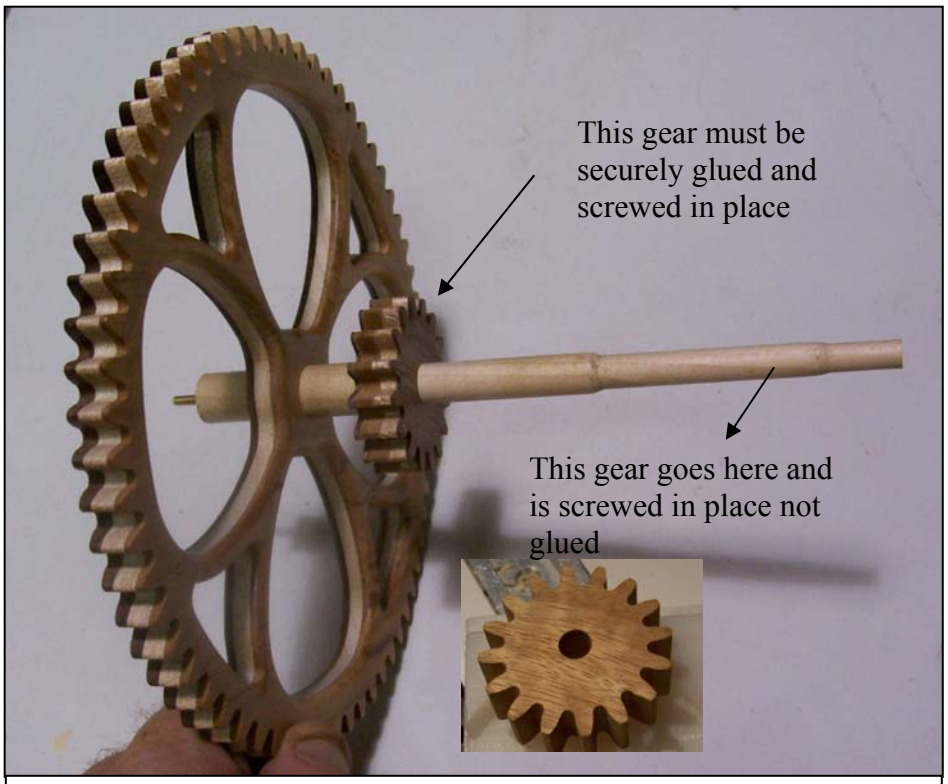


Figure 70 Center arbor assembly with 64 tooth gear and 16 tooth pinion

Drill and countersink a hole in the bottom of one of the teeth of both 16 `tooth

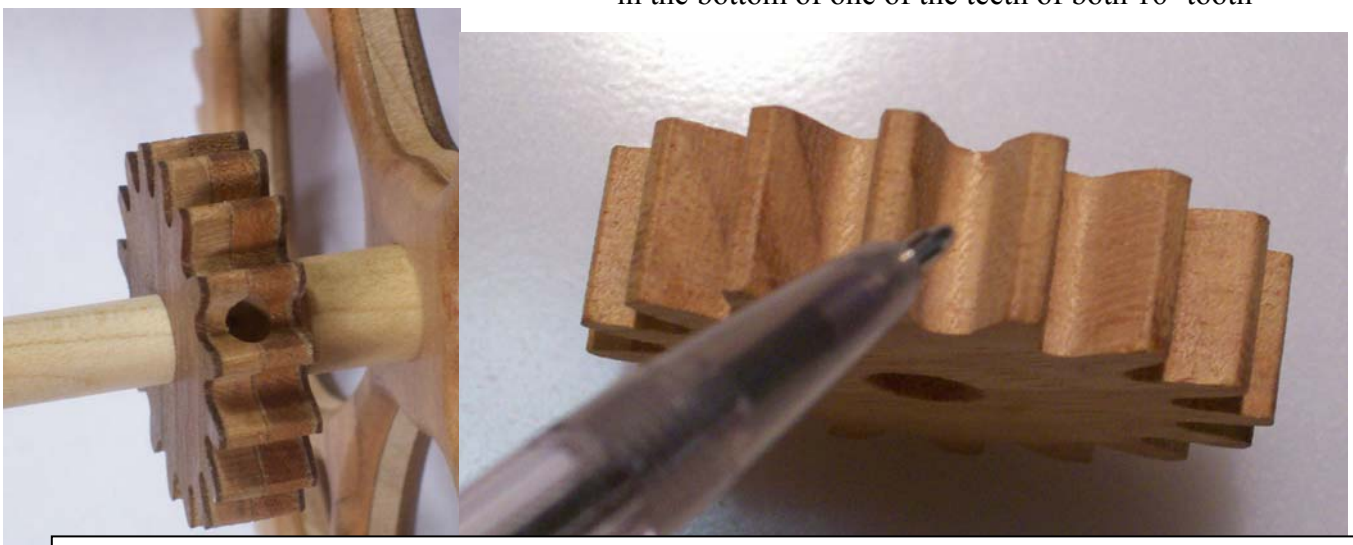


Figure 71 Drill and install a screw to secure pinion to arbor

pinions and use a #1 x 3/8 wood screw to hold it in place on the center arbor.

Gears should spin freely without excessive wobble. A wobbly gear may be caused by either a warped gear or by the center hole being slightly off square. If the hole is the problem this can generally be corrected by holding it carefully straight when the glue is applied to hold it on the arbor. When the clock is running gears turn very slowly and wobble will not be noticed.

Install dial train arbor 40 tooth gear, 10 tooth pinion and complete dial-train assembly

Mount the dial train arbor in the through hole in the front plate with the small end out. Do not yet glue in place. Place the #12 40 tooth dial train gear over the arbor and then place the #15 10 tooth pinion over the small end of the arbor. The 10 tooth arbor is fixed to the 40 tooth dial-train gear so the two rotate together. Carefully glue the 10 tooth pinion to the 40 tooth dial train gear but be very careful not to get any glue on the shaft. They must rotate freely on the dial train arbor. If desired you can insert a couple of very small screws through the 40 tooth gear into the 10 tooth pinion from the back side of the gear to add strength to this joint. If you add screws be very careful they do not chip out the teeth of the 10 tooth pinion when tightened. Always pre-drill screw holes before inserting and tightening screws.

Figure 72 #12 40 tooth gear with #15 10 tooth pinion

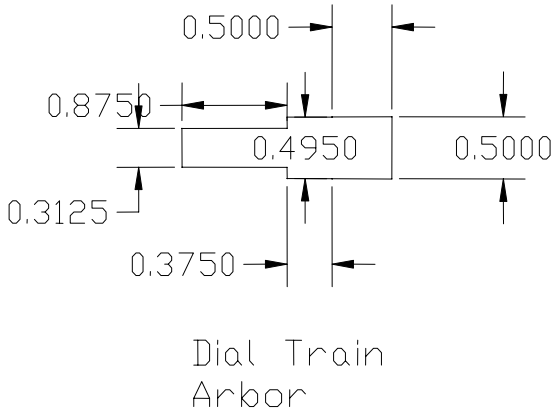


Figure 73 #19 Dial train arbor has a small step to allow #12 40 tooth gear to spin freely on the arbor

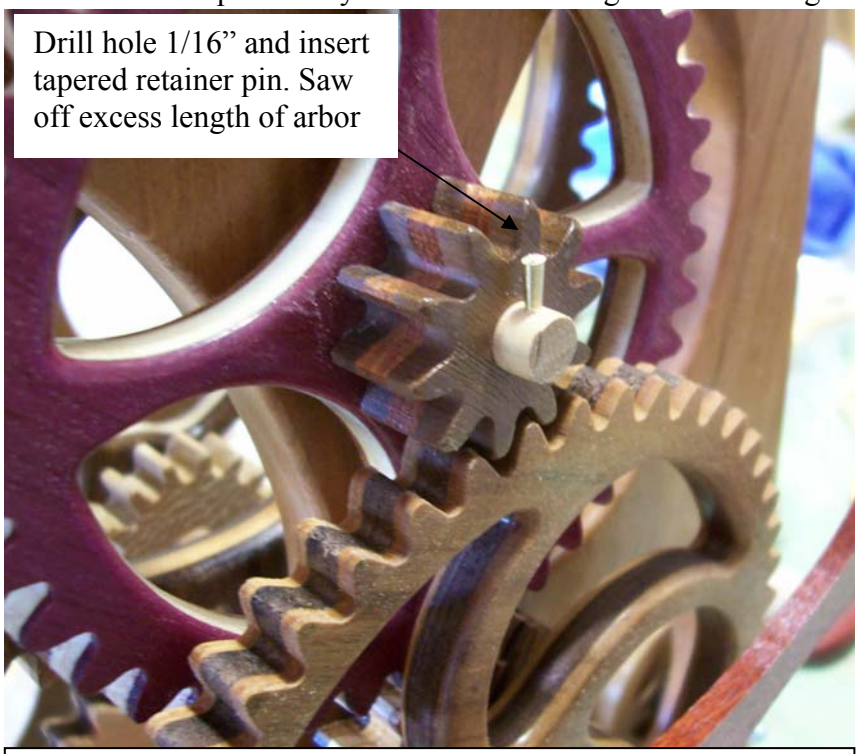


Figure 74 A tapered pin of brass or wood holds the #12 gear in place.

Once the gear and pinion are firmly attached, check again that the assembly will rotate freely on the dial-train arbor. When satisfied the gears will turn freely, you may glue the dial-train arbor in place on the front plate and cut flush with the inside surface of the front plate.

Place the #12 40 tooth dial-train and #15 10 tooth pinion assembly on the dial-train arbor and drill a 1/16″ hole through the small diameter of the dial train-arbor to secure the retaining pin. The retaining pin can be a sliver of wood or a tapered brass pin. Tapered pins are easy to make by turning a piece of brass rod against a

sanding disk then cutting to length. Insert the pin and check to assure the gear assembly will still rotate freely.

Install #23 cannon tube in #10 48DT gear and mount hour hand

Figure 75 # 10 48 tooth dial train gear with #23 cannon tube and #26 hour hand installed

Select the most attractive side of the 48 tooth dial-train gear. Install the cannon tube from this side. The cannon tube should protrude through the back side of the gear about 1/16″. Sand any remaining portion of the tube until this is achieved. Do not trim the front side until the hour hand is installed. The hour hand should be a slip fit until the hand clamp screw is tightened and then it should be snug but still able to rotate with firm pressure. With the hour hand installed, trim the front side of the cannon tube 1/16″ beyond the hand.

Install minute hand

The minute hand mounts over the ¼″ diameter of the center shaft. Place the hand in position and cut the shaft so that 1/8″ shaft protrudes beyond the minute hand and there is about 1/16″ between the cannon tube and the inside of the minute hand. The minute hand will assure the cannon tube is held in place. Tighten the retainer screw until the hand is held firmly but can be moved with steady finger pressure. The hands are rotated on the center shaft and cannon tube to set the correct time. Do not turn the hands excessively on the shaft as it can wear the shaft and lead to loose hands.

Gear Backlash

Gears should have some play in them called backlash. They must not mesh fully or they will bind and eventually wear or fail. You should be able to feel a small amount of “play” between the gears when they are rotated back and forth by hand. Since clocks only run one direction gear backlash has no negative effects on the clocks performance.

Sand the gears for perfect mesh.

Once installed the gears should “run true” which means they should rotate smoothly with no “catch” or hesitation in the gear interaction. This is easier to do once the gears are installed and there is less chance of damaging the gear once they are installed in the plates. To sand the gears for proper mesh simply place a strip of sand paper between the teeth of the meshing gears and rotate the gears. By folding the sand paper and pulling it through the rotating teeth you can sand most gears to perfect alignment easily. Sand only enough for the gears to run smooth with no trace of hesitation. Many times a gear will not require this type of sanding. Sometimes sanding is easier if you remove the main arbor allowing the remaining wheels to spin more freely. Take your time when sanding the gear teeth. This is not a rush job and a little patience will pay off. An emery board makes an excellent sanding tool for the errant bump or imperfection.

The next section shows assembly of the clock as a unit. Assembly and disassembly will be done many times before you are finished. Take your time and stay organized. Lay parts out in order and be methodical. Fit parts as you go and the end result will be much better understanding of the clock and how it works. The final product will only be as good as the effort expended in the fitting. The free wheeling test can be passed on the first attempt if all steps are followed carefully.

Add gear assemblies intermediate plate, ratchet and spacers with pulleys

It is easier to assemble the clock by laying it down and adding the parts, then installing the front plate. Do not glue any gears or parts in place until you have dry fitted the parts and are sure they fit properly.

Front plate with dial train arbor

Install 40 tooth on dial train & 16 & 48DT over main arbor

Free Wheeling test and alignment

Do not install the escape lever bracket # 28 until the clock has passed all free wheeling tests.

When assembly is completed the movement must operate smoothly and without any trace of binding. You should be able to rotate the weight arbor with mild finger pressure and cause the entire movement to operate smoothly in either direction. When the movement is completely smooth you can cause the escape wheel to turn by rotating the shaft holding the minute hand manually from the front of the movement just by twisting the main shaft with your fingers.

Making the gear train run smoothly will often require some detective work and some hand work to resolve interference. You will disassemble and reassemble the clock many times before you are satisfied with the operation. Choose an uncluttered clean work space so no parts are damaged or lost.

Rotate the gears through the entire range of operation and note any binding or catch at any portion of rotation. Binding can be caused by an arbor that is too long or a spacer that is too short. It can also be the result of a warped gear or a gear binding on the intermediate plate. Note the position of the hands when the binding occurs. Refer to the trouble shooting chart for time errors to help eliminate possible causes.

Once done with assembly, tighten the ¼-20 nuts and test again to assure no binding occurs. Occasionally you may have to trim the length of the arbors to eliminate binding. Clock must be disassembled to trim the arbors.

Minor gear wobble is usually not a problem. Excessive gear wobble may lead to binding and stopping of the clock. Some gears are more sensitive to wobble than others. The escape gear needs to be fairly straight and the#12 40 tooth and # 10 48 tooth dial train gears must be fairly straight because they run in close tolerance to each other and the front plate of the clock.

How do I know when it will pass free wheeling?

Give the 48 tooth gear mounted on the main shaft a firm push as shown in the video. All gears should rotate quickly and smoothly. Release finger pressure on the gear and the gear train should continue to coast long enough for the minute hand to move through a minimum of 30 minutes of time shown on the movement face. If carefully built and running smoothly a clock can easily run for a movement equal to 45 minutes of minute hand travel. Failure to pass freewheel is the number one source of customers calling for technical support. If you are unable to get it to pass try sliding the 8 tooth pinion on the escape wheel shaft until the gear is not engaged. This removes the escape wheel from the mechanism and allows you to test only part of the system at a time.

Once it has passed the above, you should be able to hold the winding arbor in the front and rotate it by hand causing the entire movement to run in either direction.

Unit must pass both tests to operate without requiring excessive weight.

Figure 76 Assemble clock by laying on the back and adding components.

Free Wheeling Test

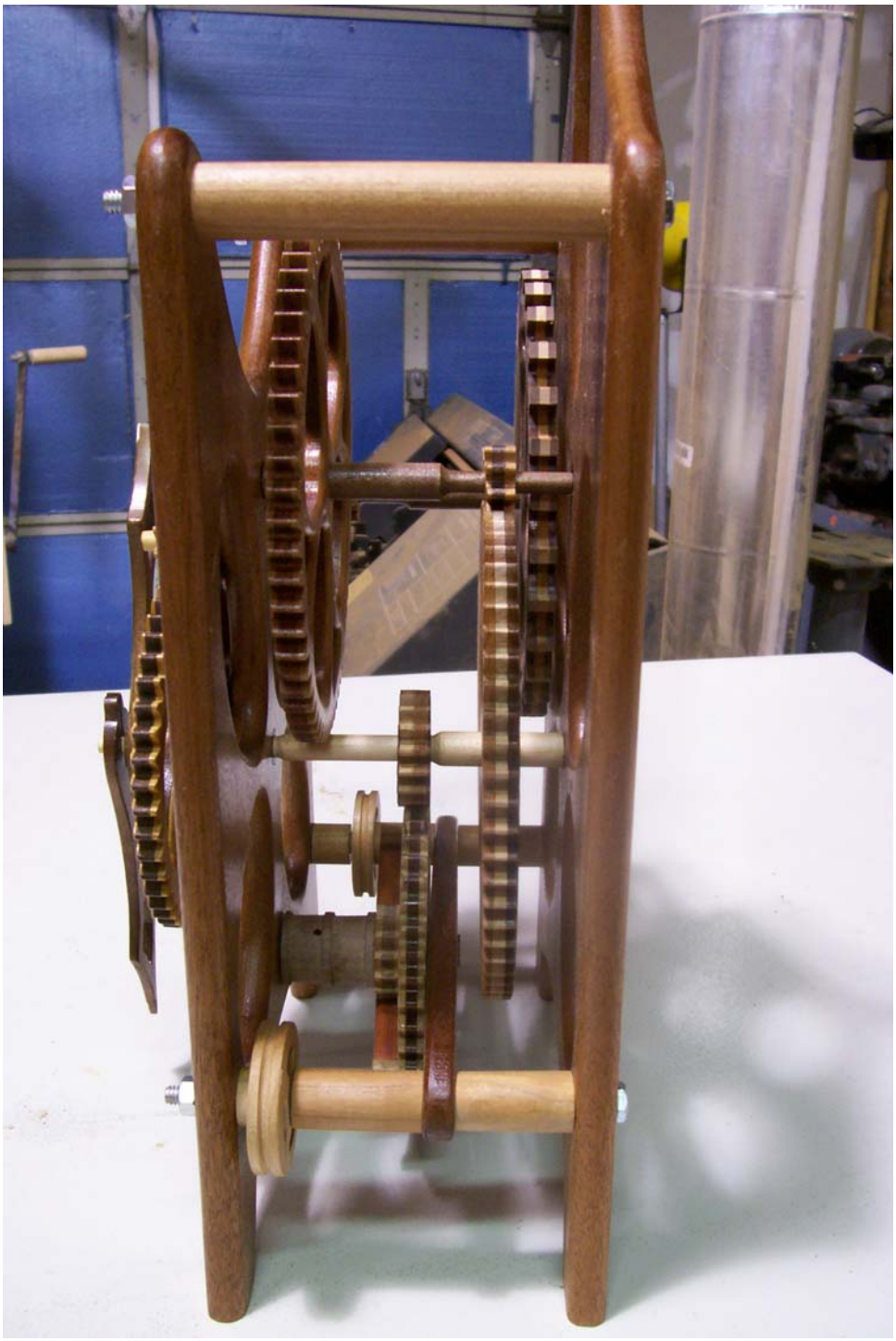


Figure 77 Apply light finger pressure to edge of # 11 gear and the clock should free wheel without the slightest trace of binding. It should coast to a stop when pressure is released. Minute hand should move a minimum of 30 minutes shown on face. Then apply light rotational pressure at the weight arbor and all gears should rotate freely. Must pass both tests!

Install escape lever pivot holder and escape lever

This is one of the last parts installed and should only be put in place when the gear train is adjusted and running freely. The escape lever bracket is installed via a screw holding it in place.

The escape pivot is then threaded through the holder and the lever. This is a friction fit. Note the thinner side of the escape lever goes toward the top of the movement.

The mounting screw is inserted into a countersunk hole on the back side of the back plate. Screw must hold the lever in place securely. If the lever slips during operation the clock may stop. A small disk of sand paper on the inside edge of the escape lever bracket will "grab" the rear plate and stop any movement. Make sure the sandpaper does not show.

Figure 78 Escape lever assembly ready to mount

The crutch fits over the pivot pin and should fit snugly. When adjustment is complete the crutch pin can be glued to the pivot shaft but the lever must not be glued to the shaft.

Install and adjust crutch on escape lever pivot for approximately the proper beat. (See beat adjustment section)

The crutch delivers the power pulse from the escape gear to the pendulum via a 1/8″ brass pin that fits into a slot cut into the pendulum rod. Hang the pendulum in place and note the position of the brass pin in the crutch. Mark the pendulum rod and cut a 1/8″ wide slot 1″ long centered on the rod and the crutch pin. This slot must accept the crutch brass pin easily without binding. Sand the inside of the slot very smooth to reduce friction.

Installing the drive cable or cord.

With a 57 inch high case as shown in the case instructions you will need 17 feet of drive string. Drive cable can be any type of strong cord, string or wire cable that is flexible enough to wind and unwind any number of times. Woodline includes an excellent weight string. After many attempts we found a source for the perfect string and it is now included in the hardware kits. Additional string is available for a minimum cost. The drive cable must be able to support a load of at least three times the amount of the weights as a minimum.

Measure and mark the center of the drive cable. If string or cord is used you should tie a knot in the center of the cord as a marker. Thread the drive cable/cord though the center hole in the weight arbor. If string is used you can work some glue into the end of the string and let it dry to make it stiff and easier to thread into the hole. Pull the string until the center of the string is inside the weight arbor. A drop of glue in the hole from each side will secure the string.

Adjust for length.

Put the weights on a book to hold them above the floor and attach the pulleys (if used). Adjust the length of the cord by threading it over the pulleys and through the weight pulleys (if used) and back to the case. Fasten the ends of the weight cord to the case or support shelf. Tie the cord so that when the weight arbor is completely wound down the weights do not touch the floor. Exact length will vary with each installation. Wind the arbor while maintaining tension on the cord to wind the cord equally on each side of the weight arbor. Fully wind the clock. The weights should be equal in height and near the top shelf of the movement mount when the clock is fully wound.

Beat adjustment

There are two adjustments that determine if and how well the clock will run. They are the escape lever position and the crutch position on the escape lever arbor. These are sensitive adjustments and make take a bit of trial and error to work correctly.

ONCE COMPLETE AND THE CLOCK IS TICKING PROPERLY MARK THE PARTS WITH A SMALL PENCIL LINE SO YOU CAN RETURN TO THIS POSITION LATER IF CHANGES OCCUR.

An escape mechanism releases stored energy in a controlled manner. The escape wheel is not able to rotate freely because the teeth "catch" on the ends of the escape lever stopping the rotation. As the escape lever moves it allows the teeth to disengage and the wheel to rotate until the next tooth hits the other end of the escape lever and the process starts all over again. The escape lever is attached to the pendulum. The swinging of the pendulum provides the alternating engagement and disengagement of the escape lever. The action of the escape wheel and the escape lever makes the characteristic "tick-tock" sound. The shape of the escape wheel teeth and the ends of the escape lever are such that as the end of the lever "slides" past the turning escape wheel a small amount of kick is given to the escape lever and passed on to the pendulum to maintain the swinging action. The teeth have a sloping edge and the lever also has a slope that interacts to provide the power transfer to the pendulum

The escape lever is adjusted first and is done without the pendulum in place. Snug the screw holding the escape lever bracket in place and manually attempt to rotate the escape gear. The position is correct when the escape gear will not turn freely but will rotate if the escape lever is "rocked" back and forth while attempting to rotate the escape wheel. The amount of rocking should be about 3/16″ measured at the tip of the escape lever. The exact adjustment will vary from movement to movement so an exact specification can not be provided. The important thing is that the escape lever only allows rotation of the escape gear when a rocking motion occurs. The escape wheel teeth should engage on one end of the escape lever and then the other as the lever is rocked back and forth. If your clock will only beat for a few seconds you may have the escape wheel installed backwards. It is easy to do. Carefully check against the pictures and reverse wheel if required.

IF YOU ARE HAVING PROBLEMS BUILDING YOUR CLOCK OR GETTING IT TO RUN SMOOTHLY, PLEASE CALL Woodline USA. A little help is always better than a lot of frustration! We are anxious to help you be successful and we want to hear about your experience in clock building. This manual has been updated many times because of builders telling us of issues they have had. Please help us make it better by sharing your experiences. Also please call if you

figure out a novel design or a better way of doing something. I have found that woodworkers are a very creative bunch and all the good ideas in this book have come from a variety of wood workers.

Adjustment:
With the movement sitting on a level surface and manual rotation force applied to the movement via a finger on the 64 tooth second gear. The escape lever should rock on the pivot and allow the escape wheel to turn in increments. This only works with all the parts installed. The clock may not "tick" unless the pendulum is installed and the escape lever is adjusted properly.

Left picture shows lever in left most swing of pendulum. Note the escape wheel will not turn freely and can only turn as the escape lever is rocked back and forth by the pendulum. (Parts removed for clarity of these pictures). Note the thicker end of the escape lever is on the bottom.

Hang the pendulum in place. With the clock at rest, the crutch and the pendulum should hang straight down. Gently move the pendulum to one side then the other about 2″ at the base of the pendulum in a swinging motion.

Figure 80 Swing of pendulum should be equal on each side of the center line. Adjust the escape lever arbor to make the adjustment.

The escape lever should allow the escape gear to turn at each extreme of the pendulum swing. If the escape wheel does not move at approximately the same extreme on each side of center then adjust the position of the crutch on the escape lever arbor.

With the clock ticking observe the swing of the pendulum viewed from the back of the movement. Note the position of the swing of the clock relative to the center of the clock plate. The pendulum should swing an equal amount on each side of center. Adjust the crutch attachment to the escape lever arbor to equalize the amount of swing.

YOU MUST ALWAYS START THE PENDULUM SWINGING MANUALLY. Do not force the pendulum. If it binds and is forced to move the escape lever adjustment and or crutch adjustments may be forced out of alignment

Once the pendulum is equalized the clock should work assuming proper weights are installed.

Certain problems can stop the ticking of the escape movement at specific intervals. Check the trouble shooting chart at the end of this document to find and cure the problem.

CASE or Wall Mount

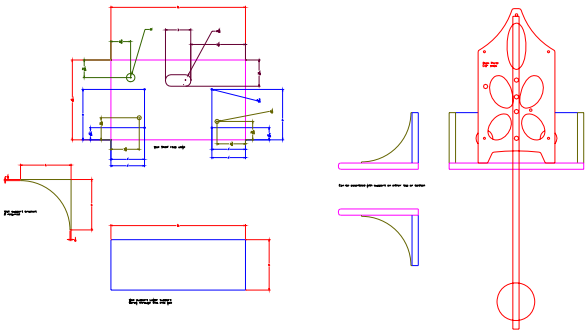


Figure 81 Wall mount is a simple shelf with same hole pattern as case top. Refer to detailed drawings

The clock can be installed on a simple shelf like mount or on a free standing case. The drawings and pictures show examples of both. There is nothing critical about the mounting except that it must be sturdy, level and free of vibration. The builder is encouraged to alter the mount or case design to suit their specific taste.

The recommended height of the movement is 57″ minimum from the floor to the base of the movement. This height will allow for adequate fall of the weights to allow just over 1 day of run time or 2 days run time per wind provided the weight pulleys are used. Higher mounting will allow the clock to run longer but will require longer drive cable.

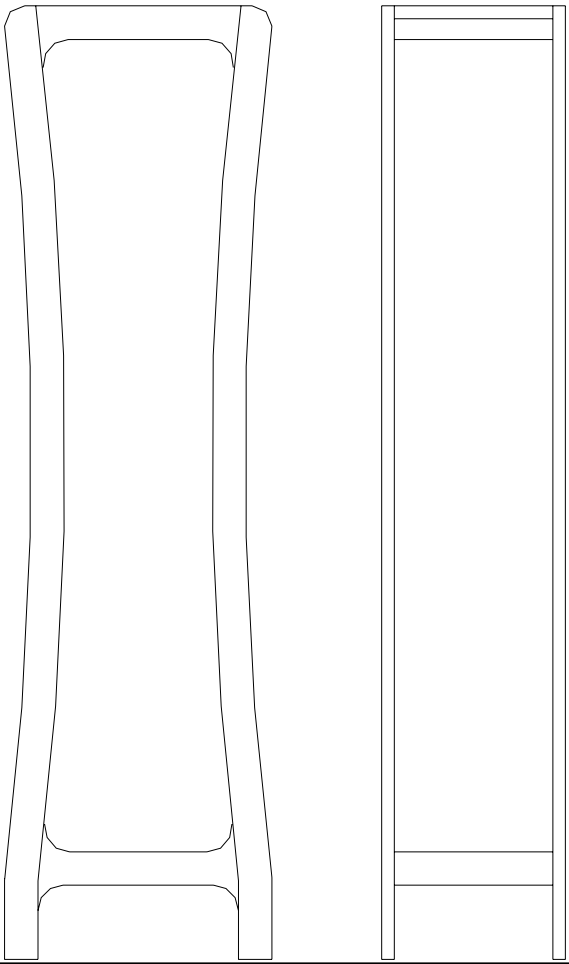


Figure 82 See drawing for case part dimensions

The case shown is a very simple design. The case shown consists of two face frames supported by a top shelf and lower separators for stability. The lower separators are screwed into the legs via 2″ deck screws and the holes plugged in the face of each leg.

The clock must be fastened to the mounting shelf or case with screws through the bottom into each leg to securing it in place. Carefully locate the holes the weight cables pass through. Use a square to align the center of the pulley on the lower spacer to the hole location in the base. The weight holes are ½″ diameter.

The hole for the pendulum is oblong. It is typically made by drilling holes in each end and then using a saber saw or scroll saw to make the inside cuts. The hole is then rounded over both top and bottom with a ¼″ round over router bit. The other large

hole is for the storage of the winding handle when not in use.

Layout of the case parts for curved case

Use the 1″ grid drawing to lay out the case parts. Use similar method as you used on the clock plates. Use care when cutting the curves of the separators as the ends of these parts can become fragile due to the sharp ends grain of the wood.

The top is drilled to allow the weight cables to pass and The case is held together with # 10 biscuits at all junction points. Make two leg and rail assemblies first and then use a 1/4″ roundover bit to round the inside edges inside of each leg assembly. You must do this prior to assembly because it will be difficult to reach the inside top edge after the case is assembled. Do not round over the outside edges until after legs and top are joined and the entire case unit is assembled.

The lower separators are screwed into the legs via 2″ deck screws and the holes plugged in the face of each leg. By using tapered plugs the holes will become almost invisible

Figure 83 Movement support is a simple construction to show the movement

The top shelf is rounded to blend in with the curves of the legs. It is easier to do this after the top is assembled on the legs and the filler blocks put on each side of the case. Use a plane or belt sander with coarse grit to round over the edge of the material and then switch to finer sand paper to complete the blending. Refer to the picture on the front cover of this manual for the finished look.

Once fully assembled you route the edges with a ¼ round bit to ease the edges.

Shelf mount: The top of the shelf mount is the same as the top of the case part. The mount features two shelf brackets and a back piece to allow it to be attached to the wall. Cut all parts per the plan and glue together with biscuits. Refer to the detailed drawings for the layout of the brackets and other components.

When mounting the shelf mount to the wall, make sure it is securely attached to a wall stud and level. Use large drywall type screws when mounting the shelf.

Bolt head and nut covers

Bolt covers are simple turnings with a 1/2″ hole in the back side to fit over the hex bolt head or nut. Epoxy these parts in place being careful not to get any glue on the threaded portion of the bolts which would prevent future disassembly.

Figure 84 Nut cover # 37 glued onto hex nut

Install the second hand

Cut the escape arbor long pivot pin ¼″ beyond the front plate. Sand or file the end of the brass rod to remove burrs and gently round the end of the pin.

Once the clock is installed in the case and all other steps are completed you should install the second hand. This is the last step because the hand is fragile. It is simply pressed over the end of the escape lever long pin and held in place with a drop of glue from the back of the hand. Do not use excessive glue in case you have to remove the hand later for repair or maintenance of the clock.

Locating the clock in its permanent home.

The clock is now complete and ready to install in a permanent location. Choose a location out of direct sunlight and excessive drafts. The clock is not overly sensitive to humidity or temperature changes but a draft may stop the swinging of the pendulum, Bright sunlight can fade wood colors and damage finishes prematurely. The clock was designed to require little maintenance and should last for many generations. The wall mount or case must be level and free of vibration. Adjust the bob on the pendulum up or down to make the clock keep accurate time. It can take several days to fine tune the length of the pendulum Remember if you must have absolutely accurate timekeeping buy a $5.00 watch, this is a work of art! Sit back and enjoy the rhythmic sounds and motion of your new masterpiece.

Figure 17 Second hand #27 installed

TROUBLE SHOOTING

Gears do not turn freely	General binding of some shaft. Locate and eliminate the interference.
Gears wobble on shaft	Some wobble is acceptable since the gears turn slowly none will notice a small amount. Wobble may be caused by a warped gear or a center hole that is not running true to the arbor shaft. If the problem is the center hole sometimes pressing the gear into proper alignment and placing a drop of super glue at the arbor and holding until dry will improve the situation.
Weight arbor is stiff or binding	May bind either on the arbor shaft or against the intermediate plate. If the arbor is too long you must either trim the face of the weight arbor or make new upper and lower spacers to allow more room. If loose you can add wooden shims between weight arbor and intermediate plate.
Arbors move back and forth in bearings excessively	Spacers are too long or arbors are too short, bearing holes may be drilled to deep. Place a small wooden or #6 brass washer over the end of the arbor pin to remove excessive play or trim the arbors if they are long.
Arbors bind against face of insert bearings	Length of one or more arbors is long. Remove from clock and trim as required.
Gears do not mesh properly to tight/ to loose	Caused by either warped gears or poor layout of the front and back plate. If too tight and the amount is very minor you may be able to sand the gears until they run freely. If too loose you must plug the bearing holes with a piece of dowel and relocate the holes in the proper location. Gears are not designed to mesh fully. There must be some play in the way they fit or binding will occur.
Winding is difficult requires excessive force.	The pawl strips may be too thick making them overly stiff thus making winding difficult. Thin pawl strips down by sanding or carving. Weight arbor may be binding on the intermediate plate or 48 tooth power train gear. Locate and eliminate the binding. Lubricate the shaft of the weight arbor with graphite where it passes through the front and intermediate plate. Take care not to get any graphite on the plates of the clock. **<u>Never lubricate the clock in other locations.</u>**
Clock will not tick Clock will not tick or	The clock may not be level, level the mounting and try again. Failed freewheel test. Repeat test and adjust until it passes. The position of the escape lever relative to the crutch and escape wheel may need adjustment. Check the "beat adjustment" per the assembly instructions. Pendulum is too light and does not have the momentum to pull the escape lever out of the escape wheel. Try adding a ½ ounce of weight at a time to the pendulum. Tape a couple of quarters to it for the test. Check slot on the pendulum and assure the crutch drive pin moves freely in the slot. Inadequate weight. Add weight and retry. Assure the escape lever is installed in the right orientation and the escape wheel is installed with the teeth pointing the correct direction. Try hanging the weight without the pulleys. Do not exceed a weight of 12 pounds per weight. Most clocks should run on two weights of 8 pounds each without weight pulleys and 12 pounds with weight pulleys. Excessive weight requirement is a sign of binding in the movement. Check free wheel tests

stops ticking quickly.	per instructions. Also the level of the clock may be off. Check the level and shim the base. Also check the attachment of the crutch to the escape lever arbor to see if the "beat adjustment" is correct and the beat is equal on both sides of center. Engagement of the escape lever may be excessive. Adjust and try again.
Weights fall and wheels spin quickly	A pinion or gear is not glued to an arbor properly and is spinning on the shaft. Locate the loose part and glue in place.
Clock will not tick or stops ticking after less than 1 minute. If the clock will operate for a complete minute the escape gear and escape mechanism are working and the problem probably lies elsewhere	Escape gear may have a binding tooth. Note if it stops on the same tooth every time. Sand or file as needed. Also the escape lever may be engaged too far and the pendulum can not pull it out far enough for the movement to operate. Adjust and try again. Binding in the clock movement causes excessive loss of power in the gear train and the clock movement can not run. Remove the escape lever assembly and recheck the free wheeling test with weights removed. You should be able to cause the escape wheel to turn with hand pressure applied to the weight arbor. Any binding is unacceptable. Find cause and fix it.
Clock stops ticking after about 16 minutes	Binding of the escape arbor 8 tooth pinion on the 64 tooth gear on the second arbor.
Clock stops in a little less than 1 hour	Binding of the main 64 tooth gear on the 8 tooth pinion of the second arbor. Possible interference with the 16 tooth pinion on the main arbor and the 48 tooth power train gear. Possible binding of the intermediate plate and the 64 tooth gear attached to the main arbor.
Clock stops at about the same time every 12 hours	Binding of the 48 tooth dial train gear against the 10 tooth pinion attached to the 40 tooth gear at the front of the clock.
Clock runs fast/slow	Raise the bob to make the clock run faster, lower to run slower. Move in small steps, a little movement makes a large difference over time.
Minute hand moves but the hour hand does not	You forgot to put a screw in the pinion gear behind the hands on the main shaft and it is slipping on the shaft.
Clock runs but is very inaccurate to the tune of 15 minutes off every 2 hours,	The 8 tooth pinion and the 10 tooth pinions have been switched. Check and fix.
Children fight over who gets the fine heirloom clock	Build one for each of them. Contact Woodline USA at 800-472-6950 for additional hardware kits!

TOOLS:

Tools required to build the clock include:

Bandsaw with resaw blade and a blade for cutting curves.
Router Table with Router
Pin Router attachment for table
Router bits
Lathe and lathe tools
Drill press
Brad point drill bit set
Gear templates and hardware kit are available exclusively from Woodline USA Inc.
Assorted hand tools.

A scroll saw makes some tasks easier.
A planer is required to plane the front and back plates or if the builder chooses to manufacture the gear plywood

COMMON ISSUES AND COMMENTS BY BUILDERS

This section is new with version 10 of the instructions and is intended to share experiences and observations, if you have comments or think something should be added or changed contact techsupport@Woodline.com

1. On the individual part line drawings, a measurement of 13/32 on the front plate cross section "A" should be 13/16" This error will not be fixed until a new version of the drawings are produced and this is not scheduled at this time. If you use the supplied full sized drawing as instructed this will never be an issue.

2. The escape gear part number 8 can hit the end of the second arbor preventing it from turning. This can easily be remedied by proper sanding of the tips of part # 8 or by turning the end of the arbor slightly smaller.

3. DO NOT GLUE GEARS ON ARBORS UNTIL DRY FITTED. Some builders have experienced problems by gluing the gears in place as the instructions show but not allowing for variation caused by their building techniques. Assemble and check for interference and then mark the arbors.

4. Call Woodline when you have a problem. They will help and you will not be nearly as frustrated! When in doubt call 1-800-472-6950 and ask for Wayne. Wayne travels a great deal and is only in the office a couple of days per week. You may also reach him via email at techsupport@Woodline.com .

5. The DVD and CD included with the clock were current at the time of production. All updates will be published on the web at Woodline.com under the "instructions" heading. Every builder should check the revision code on the drawings and instructions against the website to assure the latest instructions are followed.

6. If you print the drawings from the website or the DVD be careful. Your printer will probably distort the actual full size drawings. This is only important on the plate drawings and perhaps the crutch and escape lever. A measurement of 9 1/8" was included on the front and back plate drawings to check and confirm they are printed correctly. If you need additional full size drawings of the plates, Woodline can provide them for minimal cost.

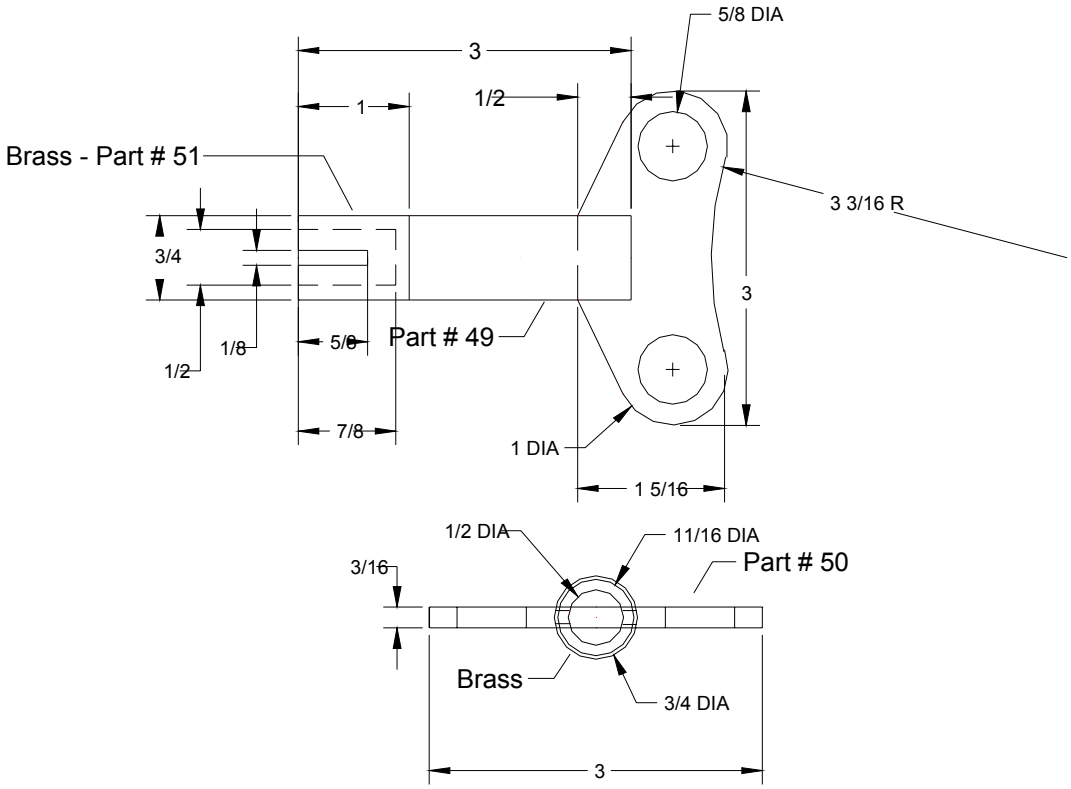
7. New clock string is available from Woodline. Early versions did not include clock string but it is now included in the clock hardware kit. The string is gold colored and very strong. It actually works better than commercial clock cable and costs very little.

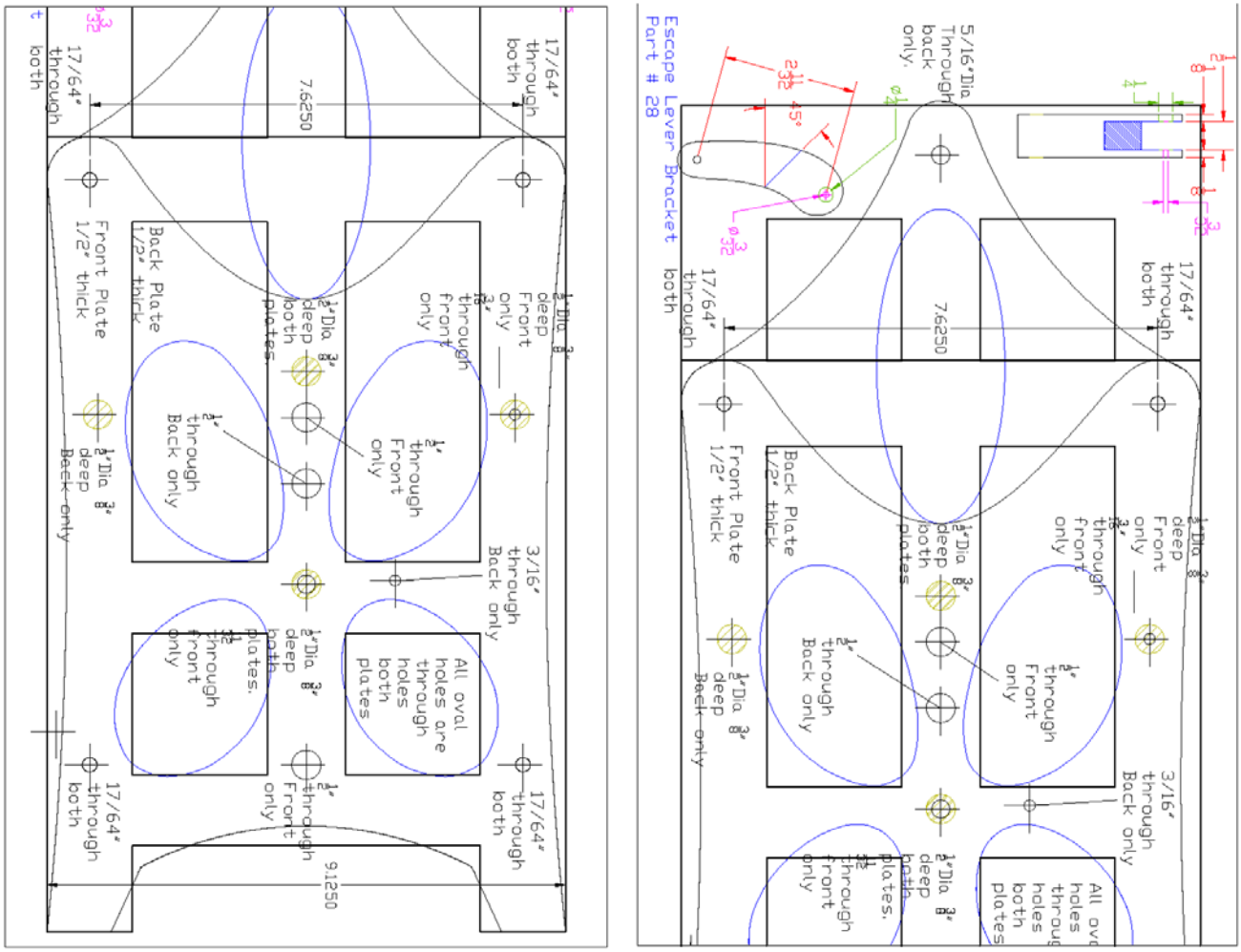
8. Please send your comments if you find errors in the instructions or find a better way to do a process described herein. We try to update the instructions and make it better for everyone. We have found that most of the good ideas come from customers!

9. Do not depend on the drawings in this instruction manual. Use the line drawings for all measurements. When making a part check the line drawings every time. The drawings in the instructions are for reference only. They are seldom updated if changes to the master drawings are made.

10. Please email pictures of your finished clocks to Wayne@woodline.com. I want to include them in future releases of this manual.

Wood Gear Clock Winding Key



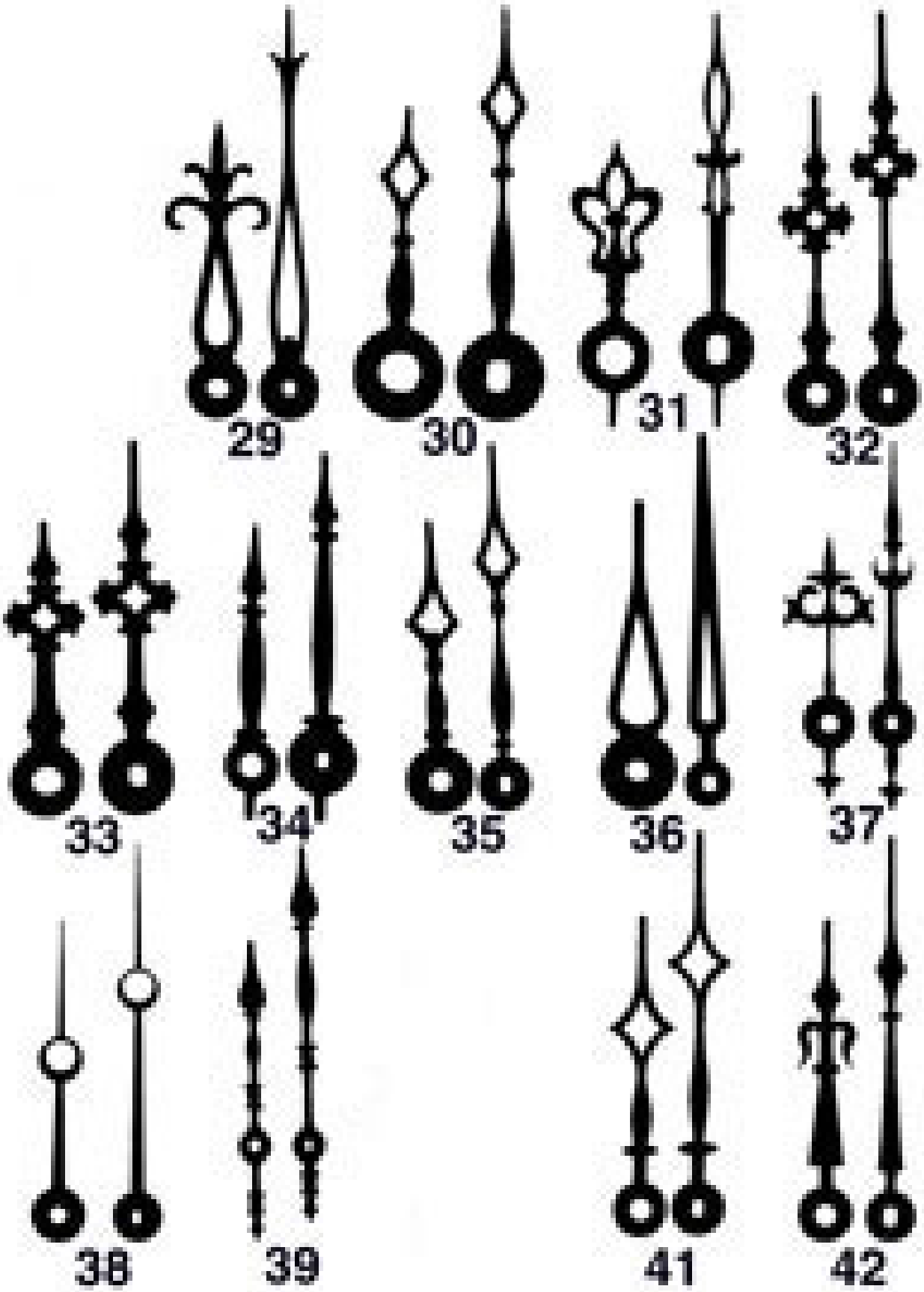


this is a reduced version of the front and back plate drawings for the clock. It is printed on two drawings because the paper was not large enough to get it all onto one. You should be able to tell from the picture and the sub drawings which part is which. It can be a little confusing but pay careful attention to what holes go where. Not all holes go all the way through the clock plate. Any hole that has a bearing inserted typically only goes part way through. Note that the front plate is smaller than the back plate. Each plate has a couple of holes that are unique to it.

It is strongly suggested that you do not make copies of the full size drawings. Most copiers change size slightly. This may not be noticed until the clock is ready to assemble and nothing fits or excess binding that cannot be removed occurs. We use a special calibrated printer to print the drawings and we suggest you use originals for each clock you build. Additional copies are available from Woodline for a very reasonable cost

Please send in your pictures for possible inclusion in our next release!

Lou Gatch created this beauty. He is adding sound on the hour to it also.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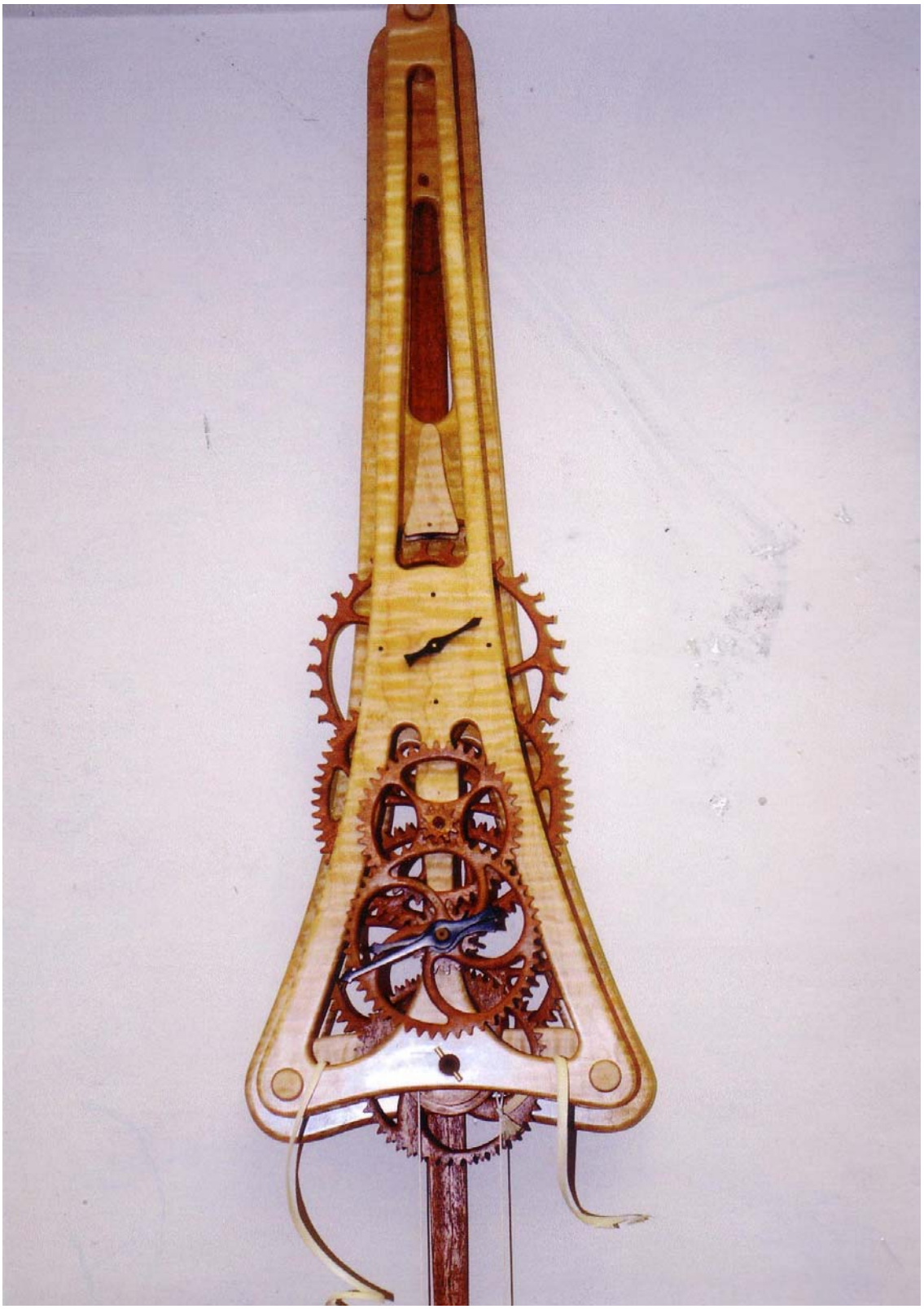

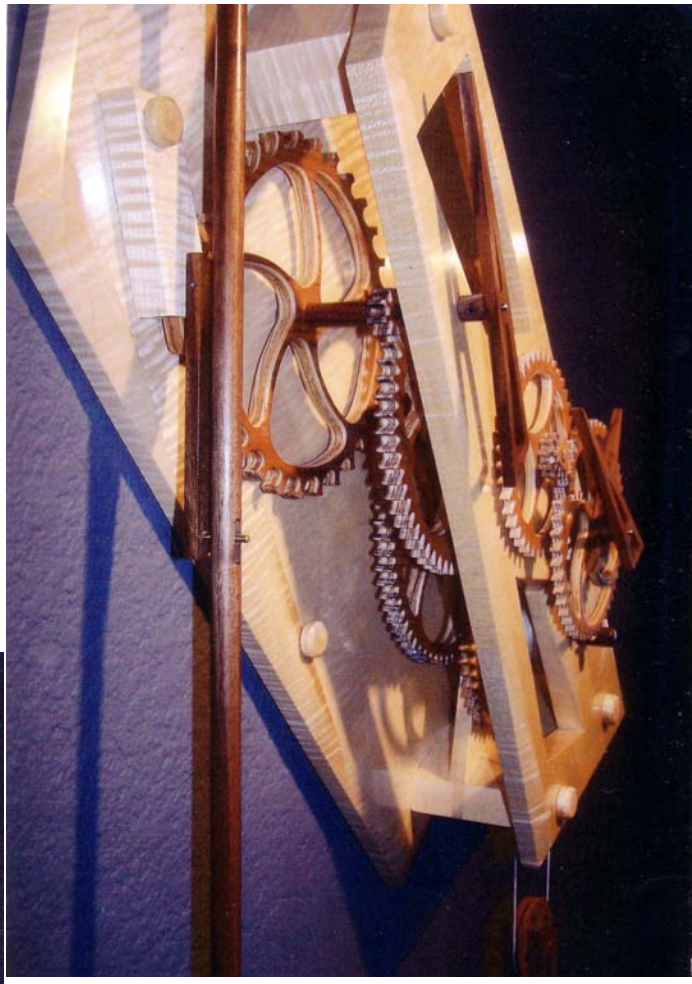

Customers are such clever people! This was done with the templates from this kit.


ANSWER IS
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