Oznog's Spruce Moose Ballista
OR
Martha Stuart Goes To War

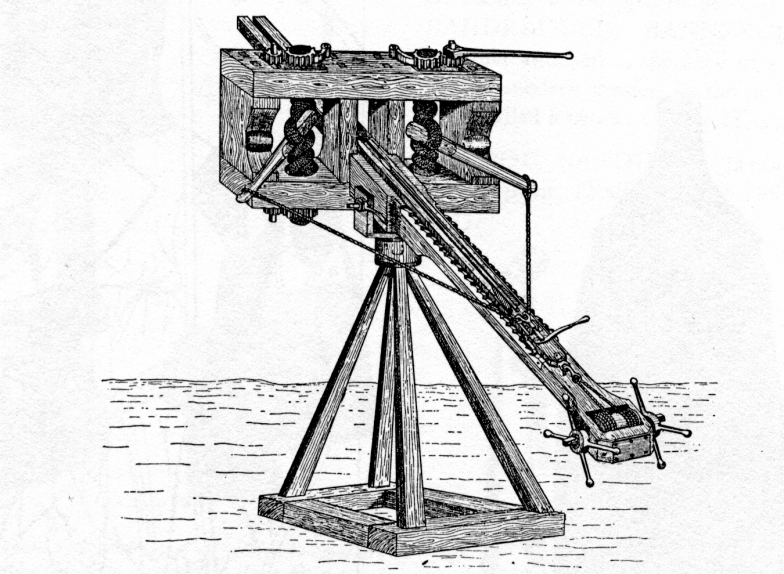


FIGURE 112. *Balista. From Payne-Gallwey, Projectile-Throwing Engines, p. 21.*

The Spruce Moose is an Amtgard-designed ballista which is technically accurate (except in power) to Greek and Roman designs, yet can be built for about $75 all from standard hardware store parts. Unlike many nonperiod designs, it derives its power from the torsion spring- a winding of rope twisted very tightly that springs back violently. It is very easy to load, aim, and fire. If the finishing touches are put on the reloading mechanism, it will genuinely require three people to operate, but will fire very rapidly. Power can be adjusted to suit local standards.

The plans are divided into three parts, the bow, stock, and tripod/U-joint. These separate for transport without tools and the entire bundle fits easily into my Honda Accord trunk.

Though it can be built from any wood, pine will be by far the cheapest. White spruce(fir), a type of pine, is also very light and therefore the material of choice. By the way, there is a common confusion of measurements- a 2-by-4 is actually measures 1 1/2" by 3 1/2". Don't ask my why. I'll try to make it clear which type measure it is- "stock" refers to the size the store calls it. If I just say drill a hole 1" from the edge, it means a 3/8" hole 1" from the edge in the middle of the wood unless stated or pictured otherwise. Bolts and all metal parts should be the shiny zinc plated ones to resist corrosion. When making a hole that need to be precise without a drill press, hammer a metal nail set or other spike to make a dent where the bit must start.

Construction will require at least a drill, 5/8" wood bit, a 3/8" and 1/4" metal bit, and a saw. If you have access to a scroll saw and/or Dremel, you're really set up. Also, standard large Vise-Grip pliers, a box wrench to tighten nuts, etc. Basically any tool you can come across will be handy. In the back is a really neat suggestion for staining the ballista- check it out.

THE BOW

Here's your shopping list:

Wood
(2) 24" from 2"x4" stock
(6) 3 1/2" from 2"x4" stock
(2) 1 1/4" x 34" American Legacy Colonial Baluster (Plain Oak) *see note

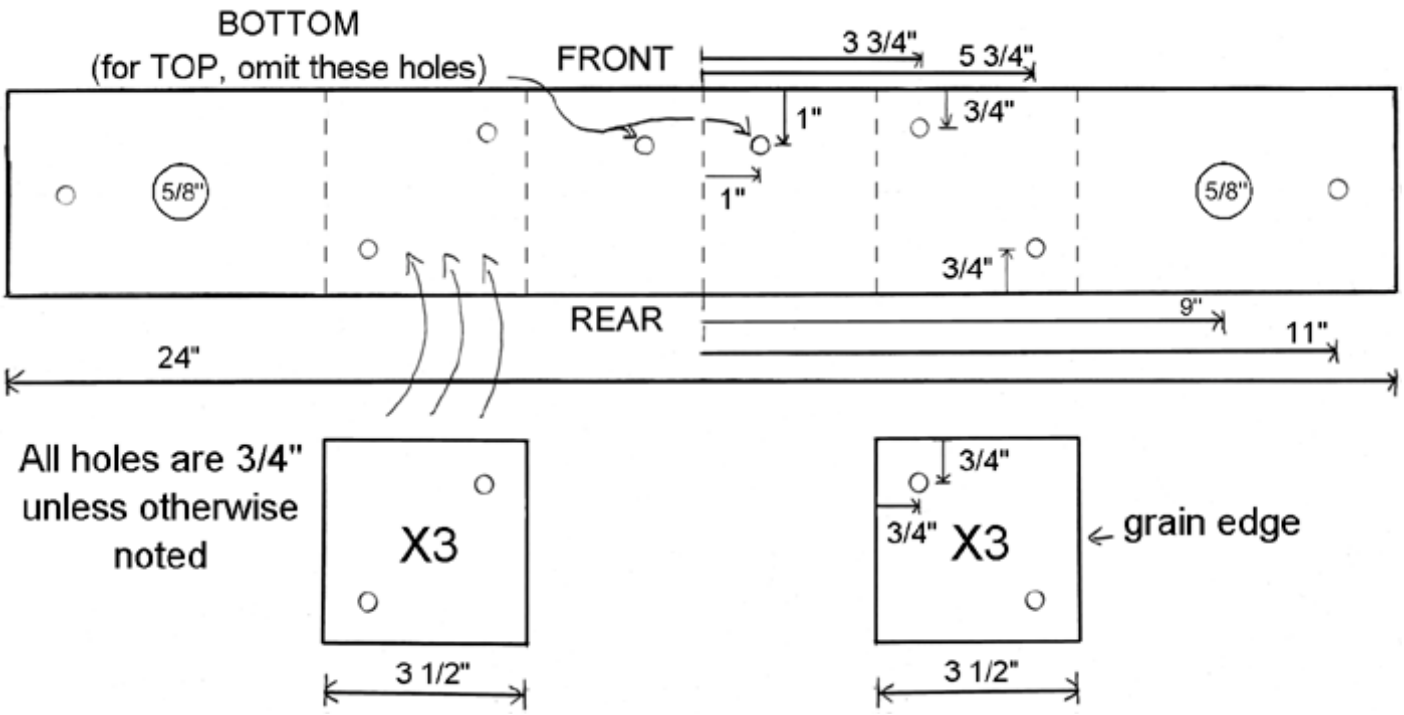
Bolts
(2) 3/8" bolts, 3 1/2" long
(4) 3/8" bolts, 8" long
(8) 1/4" bolts, 2 1/2" long

Nuts
(8) 3/8" hex
(2) 3/8" wing nuts

Washers
(8) 5/8" washers- they're about 2" in diameter with a 13/16" hole, and very thick, the largest washer you'll find
(10) 3/8" washers

Misc
(4) Blank octagonal utility box covers, with the 3/4" knock-out in the center
(4) 6 1/4" pieces of 5/8" plated steel rod
(2) 7" pieces of 3/8" allthread rod
(2) 6" square of 1/16" rubber gasket
(1) 58" bow string
20 ft of #6 nylon solid braid rope
grease
a few nails/screws

* You may be tempted to use a cheaper alternative. Hardwood dowels aren't as safe as they will crush under the strings, oak dowels are very heavy and will slow down the bow unless turned on a lathe to taper them down past the ropes the way the baluster does.

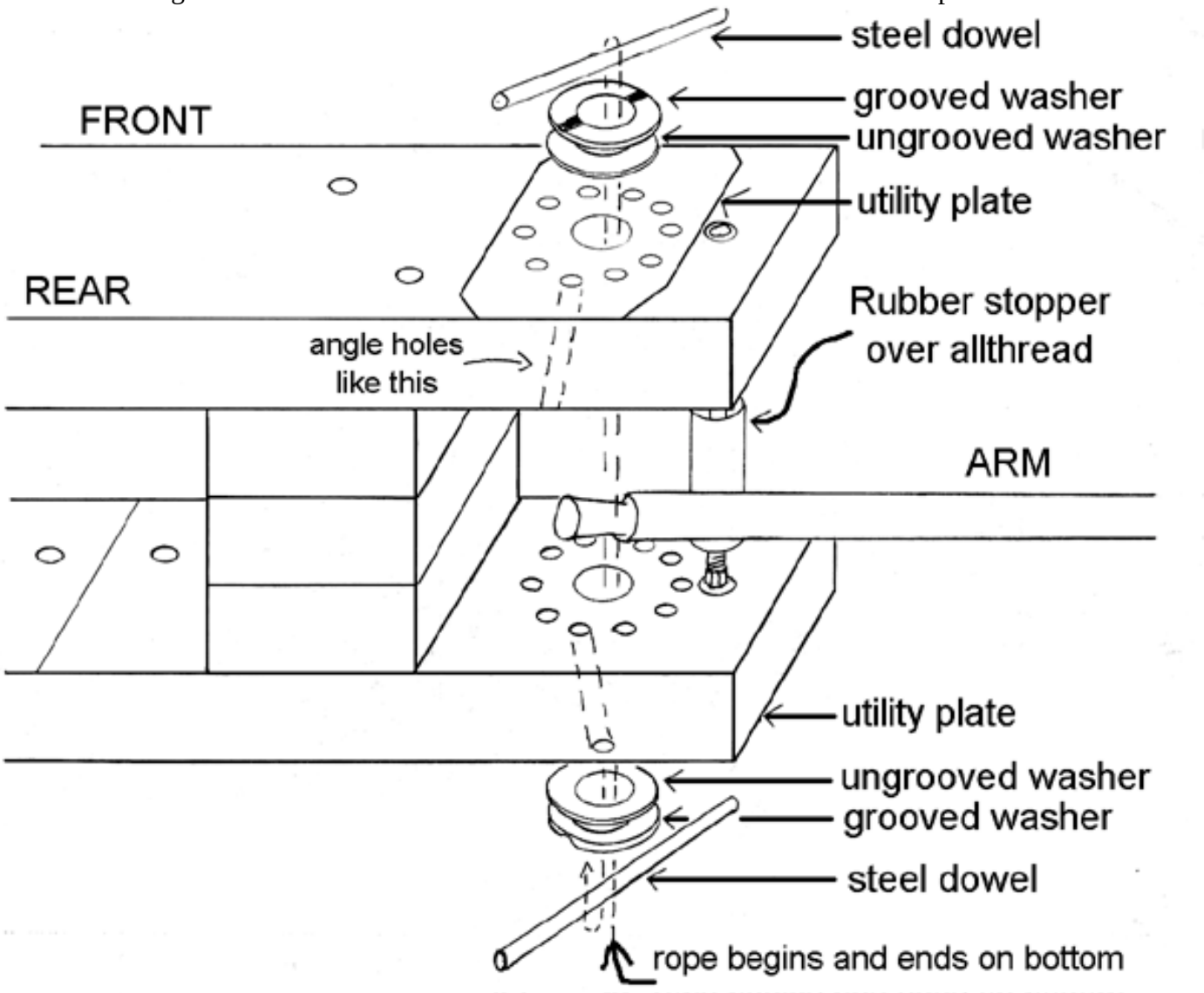


1. Take a 24” piece and draw a faint line down the center in either direction as a guide. Drill the holes as in diagram (the bottom part).
Repeat for the second piece (the top) but omit the two holes in the center.
2. Drill all 6 squares as in Fig 2. Since these holes must line up with those in the Fig 1 pieces, figure out a creative way to make sure they all line up. If you’re going to stain the wood, now is the best time.
3. Stack the bottom 24” piece, three layers of squares, and the top piece, and secure with four 8” bolts.
4. Take the utility plates and knock out the center hole, file any sharp edge off the top side of the hole. Drill a ring of ten 1/4” holes whose centers are 1 1/2” from the plate’s center. It is possible to drill all four in a stack.
5. Drill small holes to put nails or screws through to secure the plate. They must be outside the ring of holes. Four are suggested.
6. Secure a plate above each 5/8” hole on the outside of a 24” piece. The metal will be just slightly larger than the hole.
7. Cut the allthread rod into two 7” pieces. To be sure the ends of the thread are o.k., put a nut or two on before cutting and run them off the edge when done.
8. Put a rod through the outermost 3/8” hole. Put on nuts and washers in the CENTER, pushing the two 24” pieces apart.
9. Take the 6” rubber square and cut out a 3 3/4” by 6” strip. Take the remainder of the piece and cut a 3 3/4” out, duct tape to the other to make one long strip. Repeat with the other square.
10. Duct tape the strip very tightly to the allthread. Make a tight wrap with the entire strip.
11. The oak baluster should have a long, even taper, a knob taking up about 1 3/4”, and more junk. Cut off everything past the taper and knob. If you can, carve off the little ring on the knob section. Repeat with the other baluster.
12. Cut a bowstring noc 21 3/4” from the beginning of the taper. Take care not to cut too deeply. Cut off the excess 1” past the noc point. Repeat with the other.

13. If you have a Dremel, take four of the big 5/8” washers and grind a notch across the length of them with a curvature to hold the dowel in place when pulled against the washer. Cut no more than a third or halfway through. If you don’t have a Dremel, it’ll still live.
14. Set the bow right side up. Note which side is front. The arms will pivot between the spring holes, behind the allthread stops. Picture how the rope will go around a steel dowel at the bottom, through the plate and hole, around the arm, and on the top through hole, plate, and around the dowel again. If you’re looking at the right top plate from above, the arm will move clockwise, and pull against the dowel to go with it. The holes in the metal plate are for dropping bolts in to hold the dowel in place. Drill through the 10 holes into the wood with a 1/4” bit, but they need to angle against the way the dowel will turn, in this case, the hole will slant clockwise as it goes down. Be sure you have the correct slant all the way around the hole. Ream the bit through the hole a few times so a 1/4” bolt drops in freely.

ASSEMBLING THE BOW

The tricky part is holding everything together until the ropes are tightened. Pair the grooved and ungrooved washers together and grease the smooth surfaces between them liberally. Follow the assembly diagram. I went back and forth four times with the prototype (eight strands visible between the holes). I can't guarantee that it's the best number, only that it will work. Move the ends so the knot is in the center of the dowel with loops to either side. The ropes should not be tight; rather there should be enough slack evenly distributed among the turns so the washer set can be lifted 1/2" or 1" above the metal plate.



Put the arm's knob in the bundle with half the strands going on either side. Making sure the arm is in the center and rotated so that the nocs go the right way, tighten both dowels as far as you can by hand, but be sure to give each the same number of turns. Peg both dowels on either side with a 1/4" bolt. Go back and verify the arm is oriented correctly, soon it will be so tight it can't be moved. Repeat with the other side. Put on the bowstring. Be sure it fits in the nocs, if it does not some nylon cable ties may make it tighter without cutting further into the wood. You'll need some Vise-Grips or maybe a narrow piece of steel pipe to do the tightening. Proceed to tighten side by these rules:

1. Tighten top and bottom dowels on a side the same number of turns.
2. Make approximately the same number of turns on the other side.
3. Once it's fairly tight, the bow will probably sit slightly skew. Tighten one side until it centers out.
4. If it does not totally center because the position you need is between two holes, break rule #1 and advance a hole only on the top.

A satisfactory pull is something like 30-35 lbs @ 38 in from the bow. (Poundage does not correlate to a 28 in bow) May loosen up after being "broken in."

THE STOCK

The design here is wide open. The reloading mechanism I've implemented here is quite functional. The trigger is a simple gate latch from a dollar store mounted on a slider. The slider fits into a track and is held down by the cove molding that is curved to hold a "golf tube" projectile (a router can cut any piece of wood to fit this job). The slider has a pulley mounted on back, and there is a fixed double pulley at the rear of the stock. A rope with handles at both ends goes through one end of the double pulley, down the track, through the slider pulley, and back through the double pulley. So when the handles are pulled, the shuttle is winched down the track with twice the force applied to the handles, and there is no net force trying to pull the ballista over. At the end of travel, the slider pulley pops up a small ramp and wedges itself firmly between two bolts. As it goes down, it pushes a small spring but the force of the bowstring still holds it in place. The handle is pulled, firing the projectile, the spring pops the slider pulley out of the bolts, and the slider can be pushed forward by hand or a recoiling mechanism may be employed. A simple rock on a string does well. So only relaxing the ropes will bring the slider forward and it will automatically latch on the string again. An imaginative person may be able to fit a magazine above the track which drops a bolt into place every time it is recocked, making the bow fully automatic. This was done in a period design called Dionysius' repeater. If anyone comes up with a working Amtgard model, I'd be genuinely impressed.

Shopping List (includes trigger, latching, and recocking rope hardware)

Wood
(1) 48" piece of 2x4
(1) 17 1/2" piece of 2x4
(2) 3 ft pieces of 1x2
(2) 3 ft pieces of 7/8" cove molding
(2) 14" pieces of 1/2"x1 1/2"
(2) 6" pieces of 1 wood dowel
(1) 3 1/2" piece of 1x2

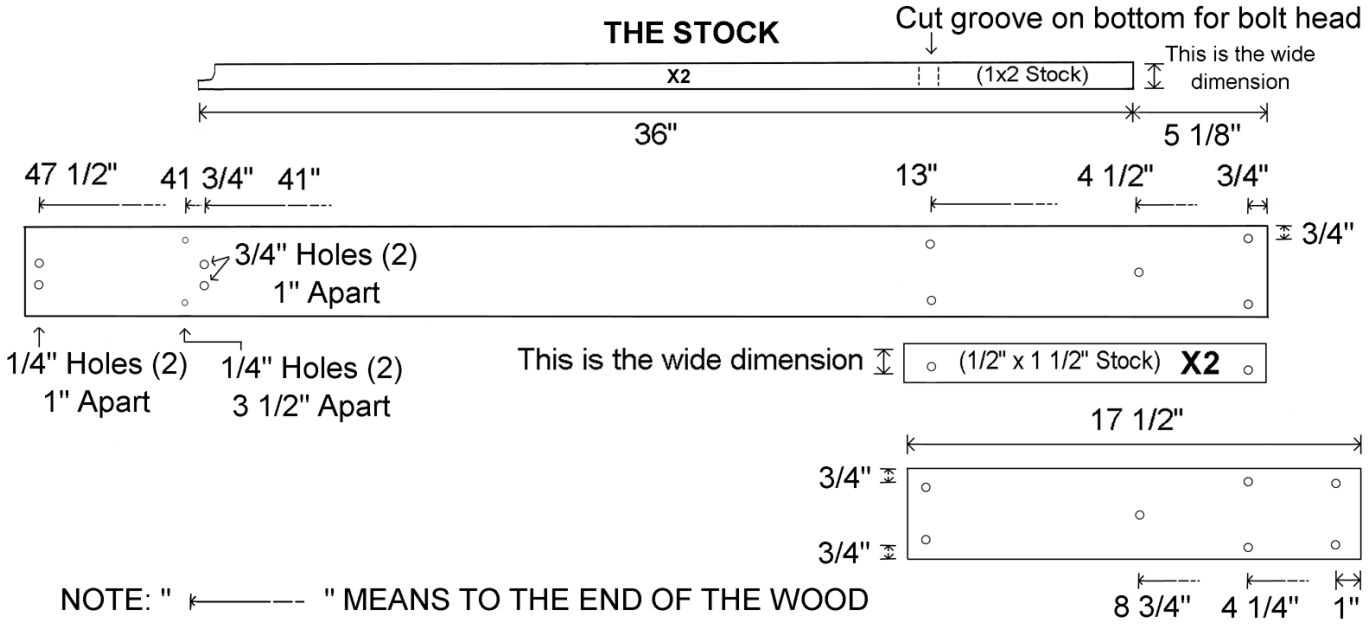
Bolts
(4) 3/8" bolts 4" long
(2) 3/8" 3 1/2" bolts (or allthread)
(1) 1/4" bolt 3" long
(2) 1/4" hex head bolts with the threads only on the last inch

Washers
(8) 3/8” washers
(6) 1/4” washers

Nuts
(8) 3/8” nuts
(2) 1/4” nuts
(4) 1/4” nylon insert lock nuts

Misc
(1) 1/4” U-Bolt
(1) 1” double pulley with fixed eye
(1) 1” single pulley with fixed eye

3” or longer “mending plate”, 7/8” wide
2 small light springs
small eyelet or small screw
7 ft Rope
4 ft nylon string, 2 lbs weight (rock, lead, or house pet)
Gate latch- buy 2 or 3 from the dollar store, it may not come out right the first time
(2) 7/8” sheet metal screws or these may come with the latch
(10) 1 1/2” Wood screws, countersunk heads, whose threads end before the head
(16) small wood screws, countersunk heads, whose threads end before the head
finishing nails (tiny heads that are hammered into the wood so nothing protrudes)



We’ll do the basic part first just in case you want to built a different type of loading/release mechanism.
1. Drill the front 4 holes on the 48” piece, these are pretty essential.
2. Take the 17 1/2” piece and drill only the two front holes to line up with those on the front of the bow. Install in on the bow with the bow’s bolts and wing nuts.

3. Set the 48” piece on top of the 17 1/2” and push its front against the rear of the bow.
4. Drill through the existing holes on the 48” piece into the 17 1/2”.
5. Fasten the 14” strips of 1/2x1 1/2 over the 4 holes of the 17 1/2” with nails or screws, and drill through the existing holes. This wood acts as a spacer, you may need more to bring a different mechanism up to the level of the string.

The Track

*It’s very important this stay straight and even, or the slider will jam!

1. Draw a very straight pencil line dead center down the 48” piece. Now draw lines parallel to this 3/16” to either side.
2. Drill the last 4 holes if you intend to install the locking mechanism as given. Cut a curve out of the 1x2 pieces so they may fit against the locking bolts.
3. Sand the inside edge of the 1x2 pieces smooth.
3. Drill 5 evenly spaced holes in the 1x2 stock. The unthreaded portion of the 1 12/” wood screw should fit snugly into the hole.
4. Drill holes in the cove molding every 4 inches for the small wood screws, through the narrow side. These will generally need to be drilled at an angle. Stain everything now.
5. These boards aren’t going to be perfectly straight. It must be bent into shape as it nailed down. Start at the front. With a single nail and a careful eye, fix the front down exactly on one of the lines. Rotate the piece so a point a few inches down also sits exactly on the line and nail it there. The rest is a matter of bending the wood so the point nearest the nail is on the line, just as the nail is hammered in.
6. Repeat with the other 1x2. Now drill through the holes into the 2x4, countersink and put the screws in tightly.
7. Fixing in the cove molding is basically the same process, but drill holes in the molding for the nails before driving them in or you risk splitting the wood. The molding sits about 1/16” off the edge of the 1x2 to hold the slider in.
8. Take a scrap of 1x2 and cut a piece just under 3/4” wide and 3 1/2” long for the slider. Sand all the faces and edges/corners. Give it a little clearance in case some mud gets in it but not so much that it may pop out. It probably won’t fit the first time, just sand until it glides in freely and be sure to stain it so it won’t take water and swell.

The Trigger

Here it’s really going to take a Dremel or some fancy problem-solving work.
The gate latch is secured to the slider by two 7/8” sheet metal screws. The one in front just drops between the two metal sides. The back is a little more complicated. Read the whole thing through before you start. I’d buy an extra latch or two in case you get it wrong, it took me three.
1. See the two “wings” in back that the screws normally go through? Cut enough off the bottom so it can stand on the slider without hitting the 1x2 and cove molding pieces.
2. On the bottom edge the wings was removed from, cut a notch 3/16” above the bottom 1/4” deep. The head of the screw will sit in this notch and the threads will fit down between the two metal sides.
3. There must also be a connection point for the pulley that the cocking ropes attach to. Drill a small hole on either wing near the center of the body, about at the level where the string will sit in the latch. Use steel wire through these holes to secure the single pulley.

4. Without anything to stop it, the latch handle falls too far back after firing, so take a small 1x1/2 scrap and screw it into the two uppermost holes of the latch with the screws that came with the latch.
5. Drill pilot holes for the sheet metal screws 3/4" and 2 1/2" from the front of the slider. Drill a pilot hole right in the center of the front vertical surface of the slider for the eyelet or small screw to make a place to attach the string to.
6. Put the rear sheet metal screw into the slider but leave the head 3/16" above the wood. Now slide that notch you cut in the rear of the latch right down around it. Screw down the front screw through the front of the latch. Pinch the two tabs of metal protruding below the head of the rear screw with, say, needle-nose Vice Grips. This makes it kinda permanent.
7. Put in your eyelet or small screw in the front (make sure you don't split the wood by putting it in too small a hole) and tie on your string. Put the slider into the track. Run the string through the unused hole in the middle near the front and tie it to the weight.

Locking Mechanism

1. Put the 3 1/2" bolts through the two 3/8" holes in the rear with washers and nuts ON BOTH SIDES, the heads will actually protrude through the bottom. This allows the height to be adjusted.
2. Drill two 3/8" holes 3 1/2" apart in the mending plate, centered 1/4" from the edge.
3. Drop a hex head bolt through each mending plate hole, a spring, the hole in the stock, a 1/4" washer, and a locknut.
4. Take the regular 1/4" bolt and put a nut then washer about midway down. Put the eye of the double pulley on the bolt, then another washer and a nut. Tighten the set a little.
5. Put the U-Bolt around the neck of the eye, behind the bolt set you just assembled. Drop through the two holes furthest back and secure with washers and locknuts.
6. Take both of the wood dowels and drill a 1/4" hole 3/4" from each edge. Tie the rope around one to make a "ski rope" handle, run it through one of the double pulley's wheels from the left, the single pulley on the slider, back through the double pulley from the left, and tie it off with another handle.
7. Build in an inclined plane to pop the pulley up enough to go over the bolts. Notice that it will have to allow some of the pulley's neck to drop in the center, and cannot stop the slider before it locks. Sorry to be vague but you can probably do it better than I did.

FIDDLING

Once assembled as a whole, the locking mechanism may require fiddling but once it's right, it should stay that way.
When pulling back holding the bowstring, the force of the rope's tension should be enough to compress the springs so the pulley jams firmly on the threads of the 3/8" bolts and stays there.
Once the bow is fired (do not "dry fire" without a projectile) the springs should be strong enough to push the pulley off the 3/8" bolts despite the pull of the 2 lbs weight.
The heights of the 3/8" bolts and 1/4" hex bolts need to be just right. My 3/8" sit 1 1/4" above the wood and are ground down on the front and insides, the hex 1/4" sit without washers and the locknuts are as loose as they can be and still stay locked down. If the springs don't seem to have enough spring, maybe you can pack a few 3/8" washers under them to precompress them some. In addition, the incline may require some recarving. Use your skills to their best.

TRIPOD/U-JOINT

This piece supports the ballista and allows it to be easily aimed in any direction. With a little modification, a compartment could be made to hold the ammo and when fitted with wheels, it becomes a mean mobile siege machine. Wheels aren't in the design yet, consider it my challenge to you.

Shopping List

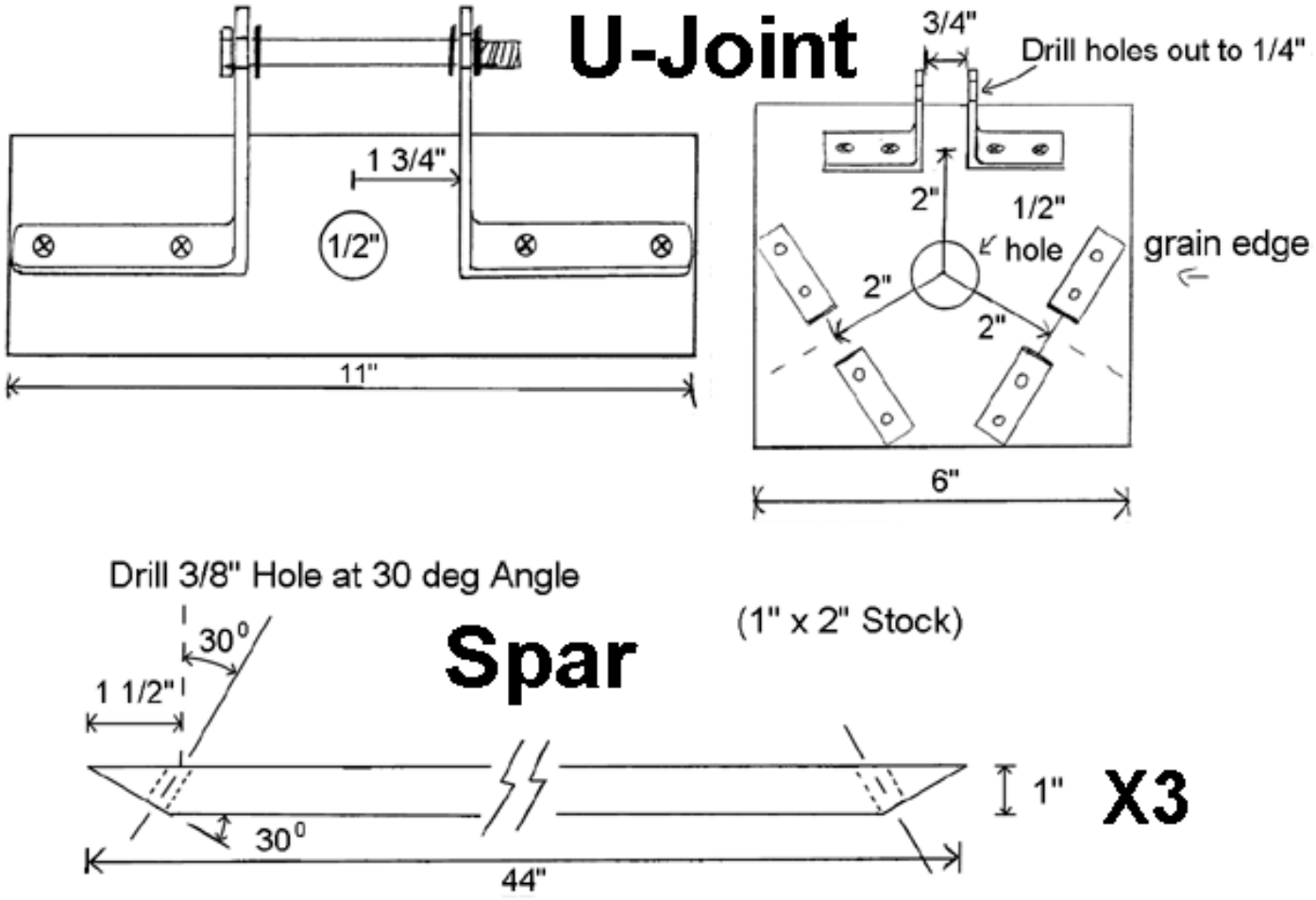
Wood
(3) 44" legs from 1x2 stock
(3) 41" spars from 1x2 stock
(1) 11 1/2" block from 2x4 stock
(1) 6" block from 2x6 stock , or you figure out a better way as this will be the only piece of 2x6 used.

Bolts
(3) 3/8" bolts 3" long
(3) 1/4" hex bolts 1 1/4" long, with threads only on the end
(1) 1/2" bolt 4" long
(1) 3/8" hex head bolt 4 1/2" long, but with threads only on the last inch

Nuts
(4) 3/8" wing nuts
(3) 1/4" nylon insert lock nuts
(1) 1/2" nylon insert lock nut

Washers
(3) 1/2" washers
(3) 1/4" washers
(6) 3/8" washers

Misc.
(6) 1 1/2" corner braces, screws
(2) 4" corner braces, screws
grease



1. Drill a 1/4” hole 1” from the top of the legs. Drill a 3/8” hole 4” from the bottom. Round the inside corner off the bottom of each leg. (Legs not pictured in diagram)
2. Drill a 3/8” hole 1 1/4” from each end of the spars (pictured), but angle the hole 30 degrees towards the outside (that means pulling the top of the drill towards the middle of the wood).
3. On the opposite side of the wood, cut out a 60 degree angle as in the picture. If you want to stain, do it now.
4. Expand one top hole of each 4” corner brace to 3/8” with a drill.
5. Drill a 1/2” hole through the center of the 11 1/2” and 6” pieces.
6. Mount the 4” braces on the 11 1/2” piece.
7. Expand one top hole of each 1 1/2” corner brace to 1/4”.
8. Draw out lines and mount each 1 1/2” corner brace as in Fig.

U-Joint ASSEMBLY

Drop the 1/2” bolt through the 11 1/2” block, 2 greased washers, the 6” piece, another washer and finish with the lock nut. Tighten so the joint has a firm resistance to turning.
Put the top of a leg into each 1 1/2” bracket. Hold with a 1/4” bolt, washer and lock nut. Tighten firmly or the table may tilt.
Bolt the spars to the legs with the 3” bolts, washer and wing nut. The head and nut will not be able to sit flush against the wood, but it doesn’t need to be tight. The tripod should stand firmly on its own.

Put the 4 1/2" long hex head through one of the large bracket holes, a washer, the ballista's pivot point, another washer, the other large bracket hole, another washer, and tighten with a wing nut.

FINISH

Let's talk stain. Sure, you COULD go to the hardware store and buy an expensive finish. It's expensive. And you'll also need wood conditioner, because pine is notorious for not taking stain evenly.
But when it comes down to it, do we really want this thing to look beautiful?
THERE IS A (PERIOD?) ALTERNATIVE!
And it's in your oil pan!
Yes, a cheap, high quality alternative oil stain, and people are practically giving it away! Knowing Amtgardians, SOMEONE in your locale has 10k+ miles of black gold waiting to be had; the older, the darker the shade. It gives it a really rough look and seems to work fine without conditioner. Just mix with some thinner or mineral spirits, dip an old sock in it, rub in thoroughly, let it sit for a day or two, and wipe off the excess (maybe with thinner.) Sure, it'll smell like a gas station for a while, but this is all part of its charm. Works well without a finishing coat (water beads off it), which is good because I couldn't get polyurethane finish to stick afterwards. Save some of the mix in case you need to stain a spare part later, but DON'T mix too much- the thinner makes the oil unrecycleable.
The trigger slider definitely needs a good finish. If the underlying wood gets very wet, it will swell and no longer fit the track and can take days to dry out (or an oven at 150 deg much faster).

PROJECTILES

When you talk ballista, you want a lot of cheap projectiles, because for a variety of reasons:

1. High rate of fire.
2. Difficult to recover ballista bolts.
3. Seldom hits anybody anyways.

Amtgard arrows do fire well as ballista bolts- but it's just not kosher. All the pleasure of Amtgard really comes from effect, and arrows just don't carry the dramatic weight a ballista should command. Many people will also argue they could be easily confused with regular arrows, perhaps rightly so.
I didn't invent it, the SCA has used them for many years- the golf tube javelin. From Wal-Mart, these thin-walled plastic tubes are supposed to go in a golf bag and keep clubs from tangling. They run about 53 cents each. Plus they make swell 1 pt javelins if your crew is rushed and their class can throw javelins. To make javelins, follow these easy steps.
1. Cut to appropriate length.
2. If it is not very straight, get a piece of steel pipe (not PVC) just small enough to fit inside and put in on you dashboard in the summer.
3. There are now two ways to go. These tubes collapse easily- if it is a concern, you can get the small pipe insulator, cut it into 4" sections, and push it inside with a ramrod. They're a little bit heavier but impossible to destroy.
4. Fins. Very necessary, though I've seen some fly without them. Starting about 1 1/4" from the tail, cut a gash about 2 1/4" long and 1/4" wide, but angle it slightly. (The Dremel's steel cutter cylinder works perfectly) Make a similar cut on the other side. Make both fins with a single piece of green military camp foam 3 or 4 inches wide, thick enough in the middle so you have to squeeze it to fit in the cut. The angle will cause it to spin in flight, increasing range and accuracy.

Pad the head heavily and carefully, these pack more punch than an Amtgard arrow. The lawn tennis ball may save the day once again, but put more padding behind it, please. A generous amount of really squishy open cell. Lawn balls come from Wal-Mart sporting goods dept in packs of 3 yellow, green, blue, and red foam tennis balls, 3 for $2, and are very aerodynamic.

TRANSPORT

If it's not a wing nut, leave it! Remove the wing nut on the U-Joint axle and remove the ballista from the tripod. Replace the axle bolt and wing nut on the joint. Take off the three wing nuts off the tripod legs, but only remove the outer spar and replace the nut. The spars will rotate upwards parallel to the leg. Remove the two wing nuts holding the bow on the stock, remove the bow. Leave the bolts and the wing nuts on the bow. It you have a small trunk, it is o.k. to leave the bowstring on since it makes it shorter. Retighten all wing nuts or they will vibrate off in the car!

CARE AND FEEDING

It is very important the arms be checked if any damage is suspected. Breaking an arm could cause a fragment on the string to swing violently in the direction of the operators, especially if it is being drawn by hand and not trigger slider. I really don't want to hear of this happening. Mine has been used a lot at around 35 lbs, but I don't know the breaking strength. Nor do I want anyone to find out the hard way.
Though I don't think leaving the bow strung will result in the arms bending, I fear it might warp if genuinely wet. If the arms do warp, it might be possible to undo the springs and rotate the arms 180 deg to reverse it.