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Technical Bulletin - 02

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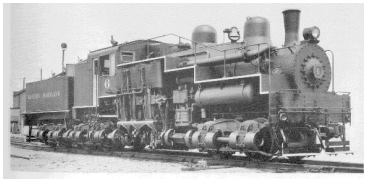


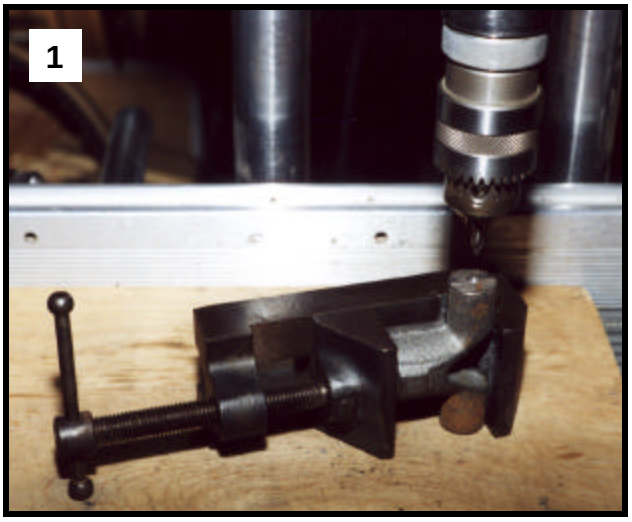
Machining Instructions for Line & Crank Shaft Couplings and Boring Fixture Lima Card Number 742-C-5461

The following instructions are a step by step description of the process for machining the Line & Crank Shaft Couplings (Lima Card Number 742-C-5461). Six of these couplings were used on the **Western Maryland Railway #6.** These couplings are part of the universal joints connecting the crank shaft and line shafts in the power transmission system on the Shay. A modified original drawing of this part with scale dimensions is available from ***LocoGear***.

It should be noted that the center bore on these couplings vary with their location. Each should be made to a press fit with about 0.001" interference. They are also keyed to their respective shafts. The crank shaft is 0.875" diameter and the line shafts are 0.810" diameter. To make the center bore, a fixture is needed to hold the coupling in position. Instructions and a drawing to make this fixture are also included on page 4 and 5.

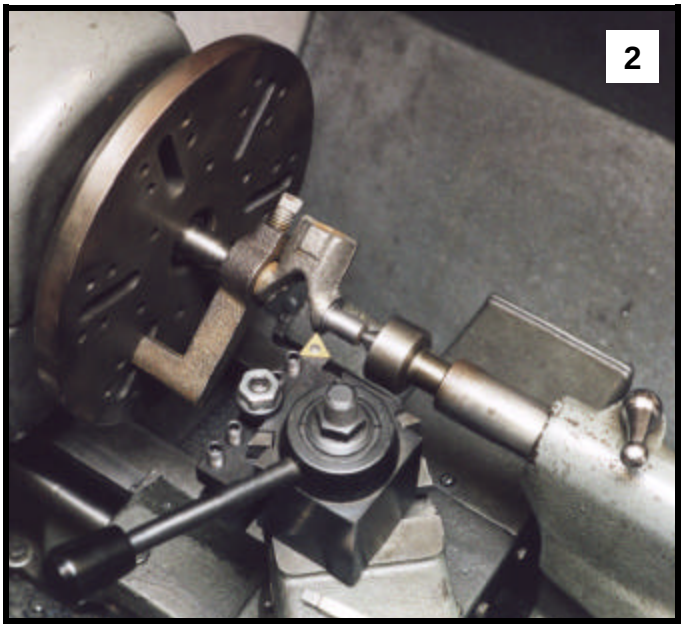
The following steps from 1 through 8 can also be used to turn the horns of the other six coupling parts. These include the 7" square shafts both long and short (742-A-5464 and 742-A-5466), and the Slip Coupling both long and short (743-A-5143).

1. To start, hand file the end of each horn, taking off any rough spots along the parting line. Do not remove too much material as you need to see where the parting line is on the casting. Measure the center point of each horn along the parting line and center punch each point. Also hand file smooth the parting line along the barrel of the coupling casting.

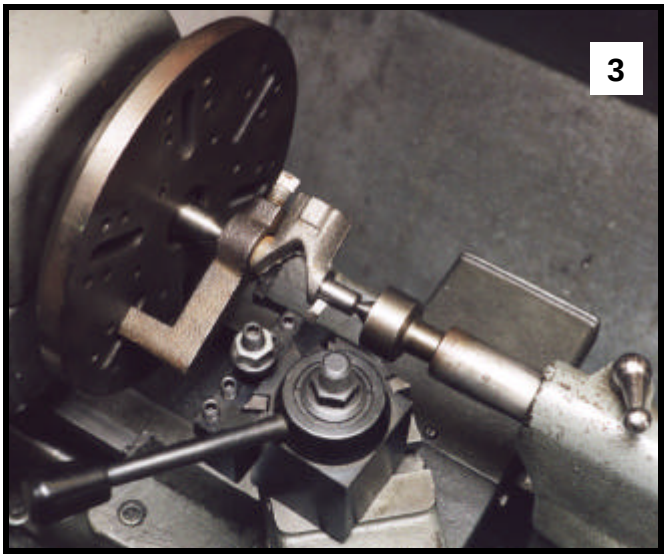


2. The next step is drilling center holes in each horn. Place the coupling casting in a drill press vise with the horn facing up (photo #1). With a #2 center drill, drill a hole at the center punch on each end. It should be deep enough to firmly hold the casting between centers on a lathe.

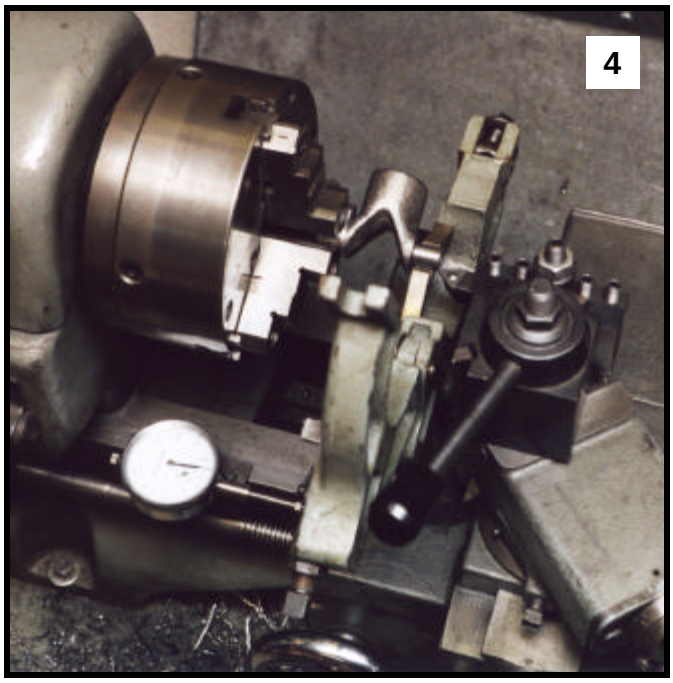
3. Turning the horns between centers on the lathe is the next step. Clamp a lathe dog on one horn and place the casting between centers on the lathe. Tighten the tail stock only enough to have a firm grasp of the casting without flexing the horns. Too much tail stock pressure can flex the horns and an untrue turning can result.
4. Lining up the lathe cutting tool so that the casting is cut properly is the next step. Measure the diameter of the casting at the part line along the straight part of the barrel near the horns and subtract 1.500" from that diameter. Next position the cutting tool against the barrel of the coupling at the parting line at this point. Divide the difference between the barrel diameter and 1.500" and set your dial indicator or DRO to this dimension. This is now the distance to the finished face of the horn shoulder.



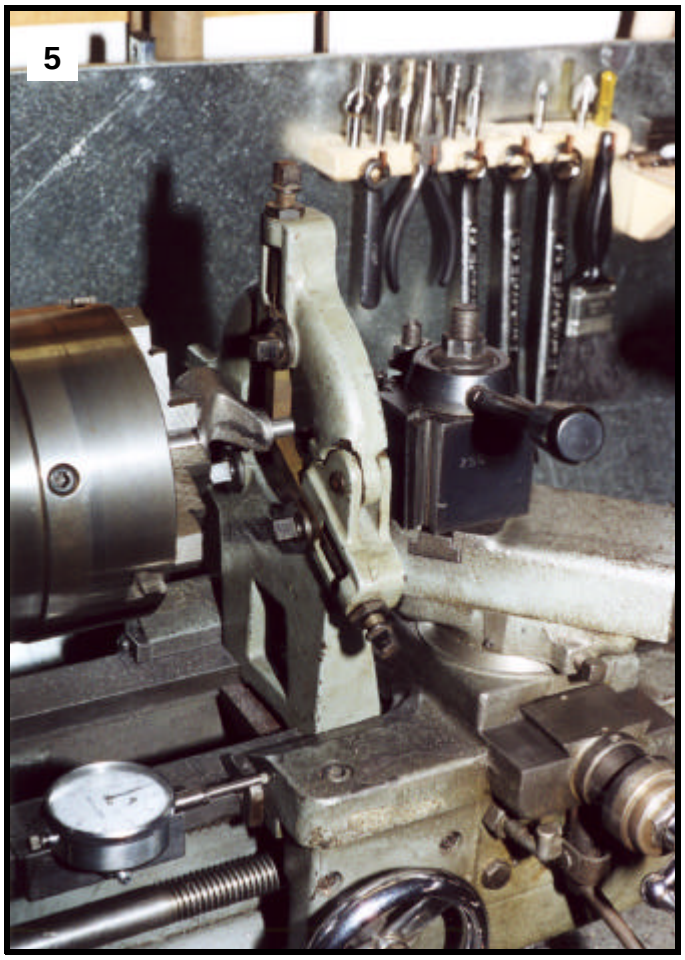
5. Begin turning down the horn to 0.500" diameter and over to the finished shoulder face. Leave about 1/16" of material near the base of the horn for a 1/16" radius fillet (photo #2). Use a 1/16" radius tool to cut the fillet (photo #3). Since the casting has more material than needed between the horns, turn down the casting to 0.781" about 1/16" beyond the face of the horn shoulder towards the center of the casting. Emery paper all machined surfaces. Remove casting from the lathe, switch the lathe dog to the opposite end and repeat this step on the opposite horn. The finished distance from horn shoulder face to face is 1.500".



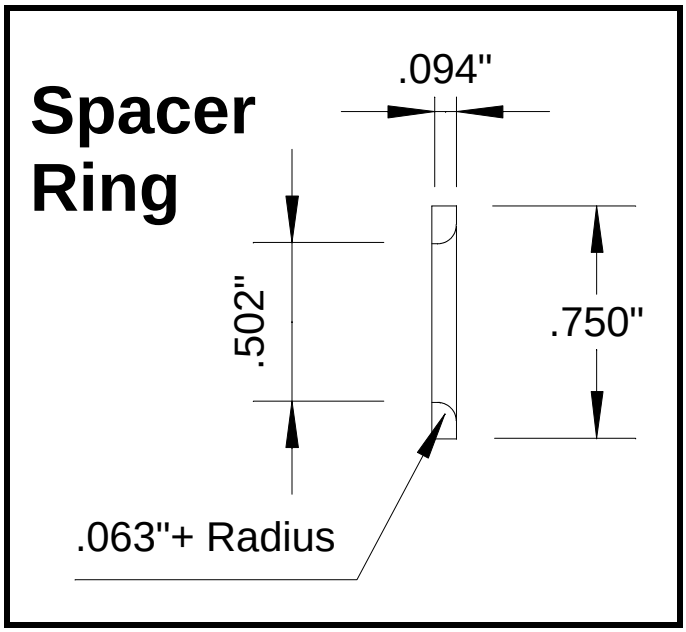
6. Once the horns have been turned, place the barrel of the casting in a vise and finish hand filing the base of the horns between the horn shoulders as needed to match the 0.781" diameter and taper this out to the barrel giving it a finished appearance. Touch up any irregularities in the casting with a round file at the transition of the horns to the barrel.



7. Facing the ends of the horns is the next step. Mount the coupling so that one horn is held in a three-jaw lathe chuck and the other end by a steady rest (photos #4 & 5). So that the setup can allow for repeatability for each horn of the six line and crank shaft couplings, place a spacer ring (see sketch page 3) around the horn



between the shoulder and the jaw faces of the three-jaw lathe chuck. This ring should allow the horn shoulder to be the datum surface and not the fillet. The spacer ring can be made from any scrap material. Special care must also be given to the steady rest and its jaws so that they do not interfere with the swing of the coupling and that they allow for the facing of the horn to 0.563" from the horn shoulder. After facing the horn, bevel the end of the horn about 1/32".



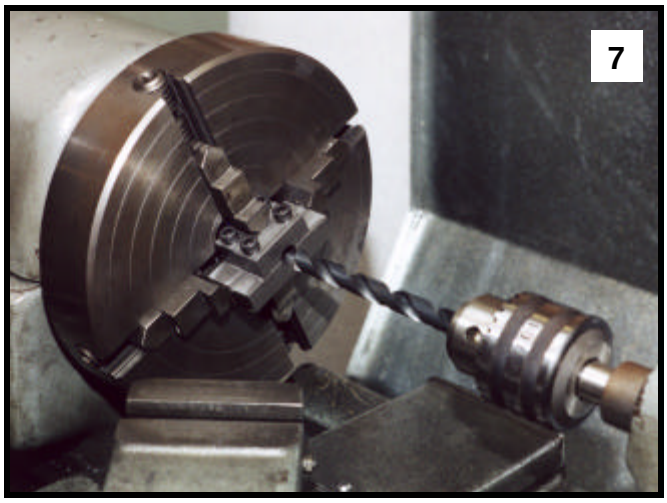
8. The last step to finish the coupling horns is to make a small cut across the face of the horn with a triangular file. Cut a grove about 1/32" deep perpendicular to the axis of the line shaft or crank shaft. This will allow lubrication to flow between the coupling horn and the Coupling Ring Bushing (742-A-5462).
9. The center hole in the Line and Crank Shaft Coupling that fits onto the ends of the line shafts and crank shaft is bored using a fixture as described on page 4 and 5. To align this center hole properly requires careful setup of the boring fixture in a four-jaw lathe chuck so that the axis of the center hole intersects the axis of the two horns. Begin by placing either a live or dead center in the lathe tail stock. This center is used to align the fixture in the center of the four-jaw lathe chuck. Hold the boring fixture on the end of the live or dead center, with the center's point in the center hole drilled into the center of the boring fixture base. Advance the tailstock screw so the center holds the boring fixture flat against the four-jaw lathe chuck body. Gently advance each of the chuck jaws contacting the boring fixture at the mid-point of each side of the fixture. Hand spin lathe chuck and fixture to check for proper alignment. Alternately tighten each jaw until a firm grasp of the fixture is obtained.
10. Mounting the casting in the boring fixture is the next step. Position the horns into the horn holes of the bottom horn clamps and attach the top horn clamps with two bolts each. Check that the top horn clamps have the hole chamfer facing the casting and that the top and bottom horn clamps are properly paired. Leave the horn clamp bolts loose for now. Advance the side plate bolts contacting each side of the casting. These two bolts will allow for the final alignment of the casting. Use a lathe cutting tool positioned near the end of the casting as a reference point to help lineup the center part line of the casting, while held so that the part line is vertical with respect to the horizontal center of the lathe chuck. By hand rotating the

(Continued on page 6)

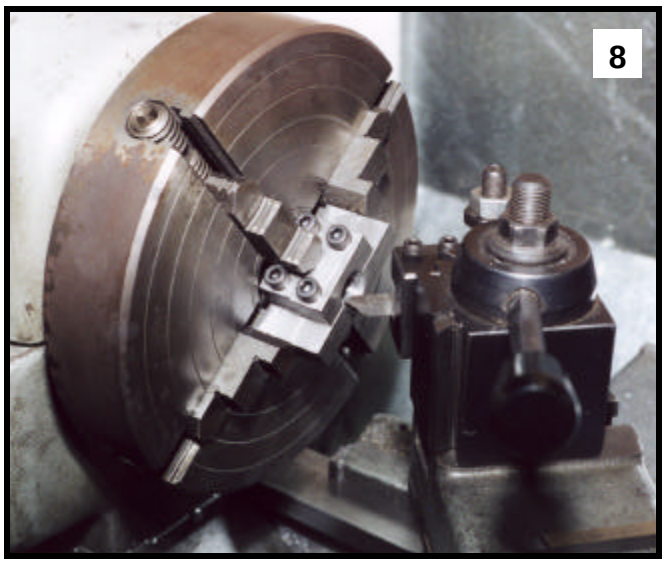
Line and Crank Shaft Coupling Boring Fixture Instructions

To bore the center hole in the Line and Crank Shaft Coupling casting, a fixture is required. This four sided fixture is made to be held in a four-jaw lathe chuck so that the castings can be firmly clamped and aligned for boring. The following steps detail making the Line and Crank Shaft Coupling boring fixture. Refer to the drawing of this fixture on page five.

1. The base of the fixture is a 3"x 2-1/2" x 1/2" piece of steel. Finish and square all sides. Scribe two centerlines across one face of the base. These center lines should extend across the face of the base from the midpoint of each side. Center the base in a four-jaw lathe chuck and drill a center hole with a #2 center drill at the cross-point of the centerlines. This center hole will be used later to position the fixture back in the four-jaw chuck when it is used for boring the center hole in the castings.
2. Two side plates are required to steady the casting. These are cut to 2" x 2-1/2" from 3/16" steel plate. A 1/4"-28 tpi hole is made at the top center of each 3/16" plate. These holes are for two 1" long 1/4"-28 tpi socket head cap screws which are used to align the casting and steady it while boring.
3. The boring fixture horn clamps are made from 1/2" x 5/8" cold rolled steel bar stock. Cut two pieces 2-1/2" long and two pieces 1-1/2" long. Scribe a line around each horn clamp at the center point. These center lines will be used to line up the horn clamps to be drilled and tapped and later when the bottom (long) horn clamps are brazed to the base. Drill and tap the top (short) and bottom horn clamp pieces as noted in the drawing. The bottom horn clamps each have two 1/4"-28 tpi tapped holes. The top horn clamps each have two clearance holes for the horn clamp bolts to pass through. Use 7/8" long 1/4"-28 socket head cap screws.
4. Next take a thin sheet of steel approximately 1/32" thick and cut it to 1-1/2" x 1-1/4". This will become a waste spacer for boring the horn clamp holes. By using a waste spacer when making the horn clamp's holes, the clamps will later firmly hold the coupling horns when boring the center hole of the casting. Drill clearance holes in the waste spacer to allow the four bolts of the horn clamps to pass through so that the two pairs of horn clamps can be held together and next to each other with the waste spacer sandwiched between the top and bottom horn clamps.



5. Bolt the four horn clamps and the spacer together and position the assembly in the four-jaw lathe chuck centered so a 0.500" hole can be bored through at the scribed centerlines and equally into the top and bottom horn clamps. Start with a #2 center drill at the scribed line and waste spacer. Next drill through the horn clamps with a 1/4" drill and then a 7/16" drill



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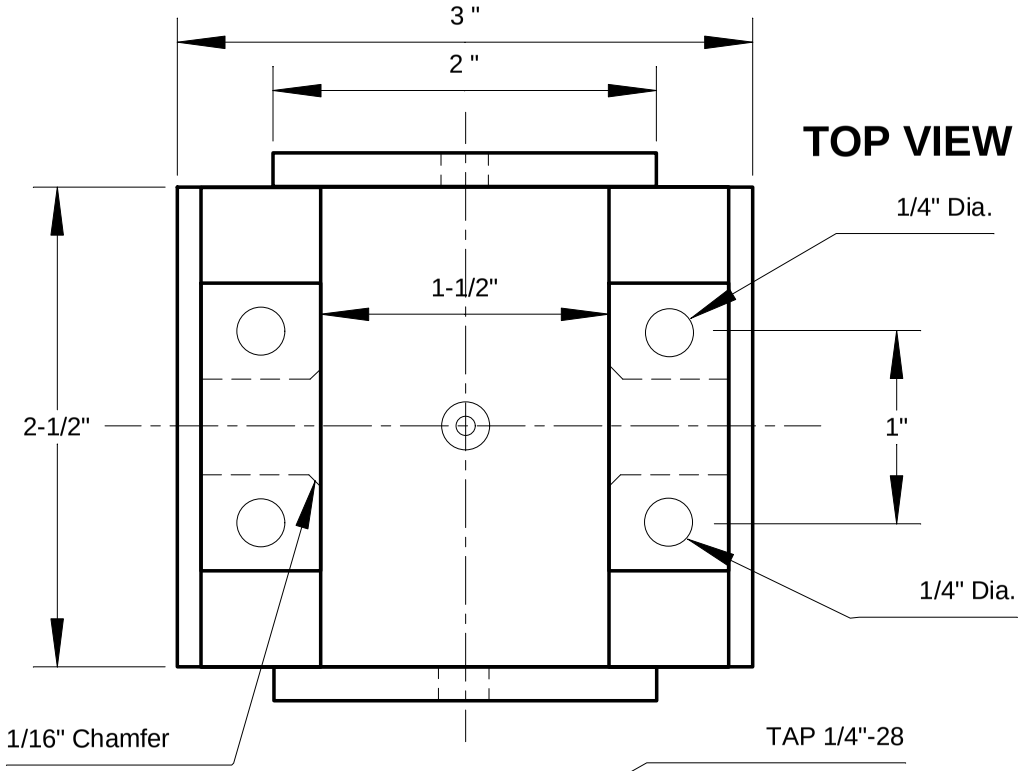
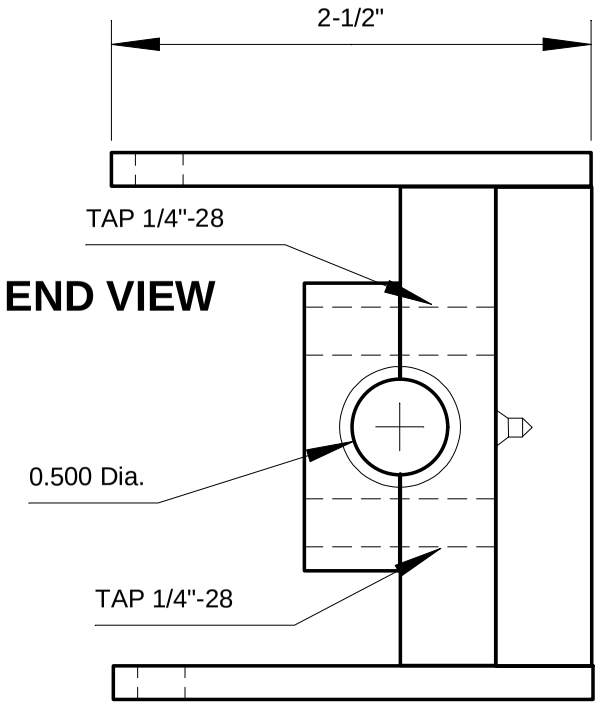
WESTERN MARYLAND RAILWAY SHAY #6 - LINE & CRANK SHAFT COUPLING BORING FIXTURE

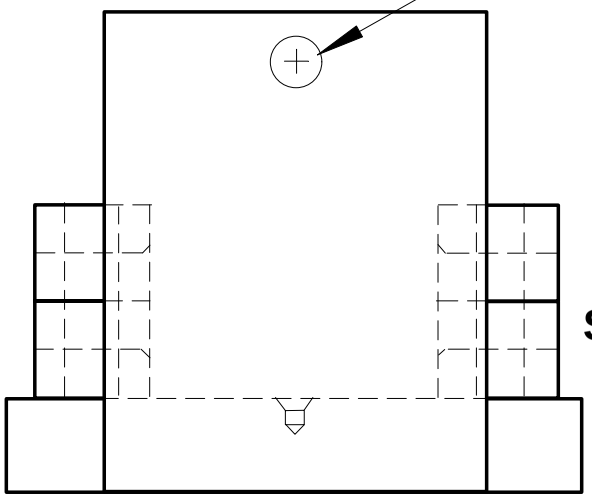
DRAWN By JOHN D.L. JOHNSON - FULL SIZE - 2/2/2001



TOP VIEW

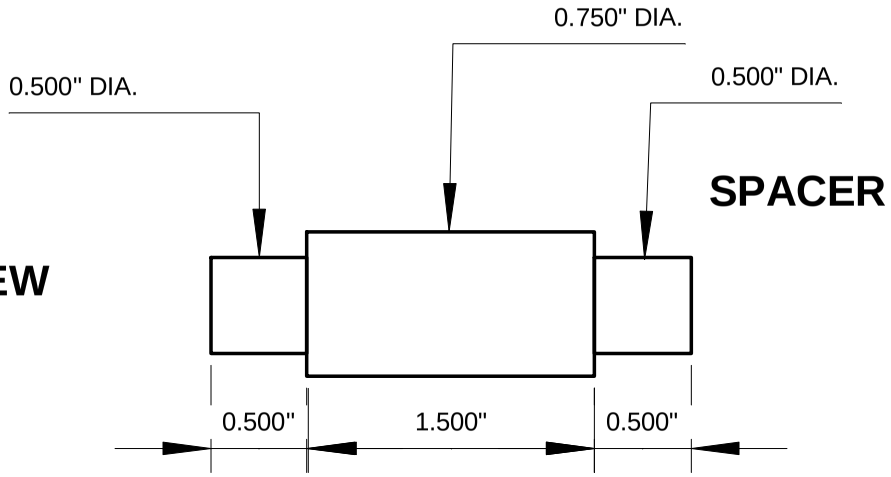


END VIEW



SIDE VIEW

NOTE: BRAZE FIXTURE TOGETHER



SPACER

Boring Fixture Instructions, Continued

(Continued from page 4)

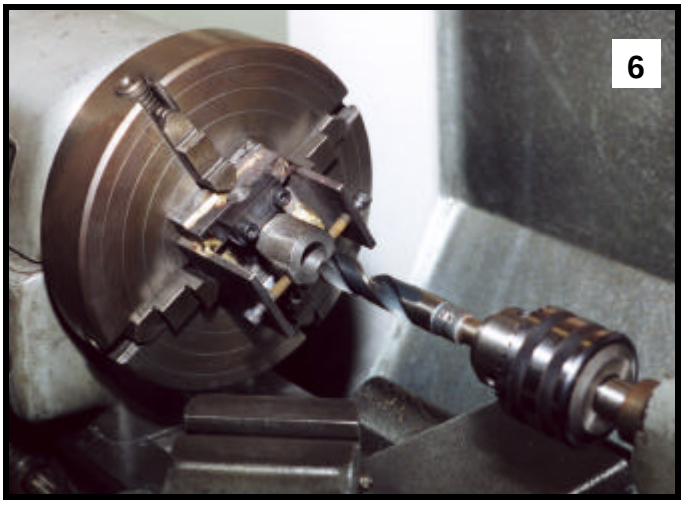
(photo #7). To complete the 0.500" diameter horn clamp hole, use a small boring bar. Finish the hole with a 45° chamfer about 1/16" deep on each side of the assembly (photo #8). This will give each set of horn clamps a chamfer on the inside of the fixture when completed. Before disassembling the horn clamps, mark each pair differently for identification.

6. A temporary horn clamp spacer made from 3/4" round steel bar stock should be turned to the dimensions in the drawing. This will be used to assemble the fixture for brazing.
7. Before brazing the fixture together, clean all parts thoroughly. Place the temporary horn clamp spacer in the horn clamps with the chamfered holes facing the spacer. Bolt the upper and lower horn clamps together making sure the bottom of the bottom clamps are in the same plane. Clamp this assembly to the fixture base lining up the centerlines on the bottom horn clamps with the centerlines on the fixture base. The center drill hole on the fixture base should be facing the temporary horn clamp spacer and half way between the bottom horn clamps. Also clamp the two side plates centered on the sides adjacent sides of the fixture base.
8. Braze together the fixture carefully so that only the bottom horn clamps and the side plates are brazed to the fixture base. Wire brush away any flux and paint the fixture. This completes the steps to make the line and crank shaft coupling boring fixture. If brazing the fixture is not an option, bolts can hold it together.

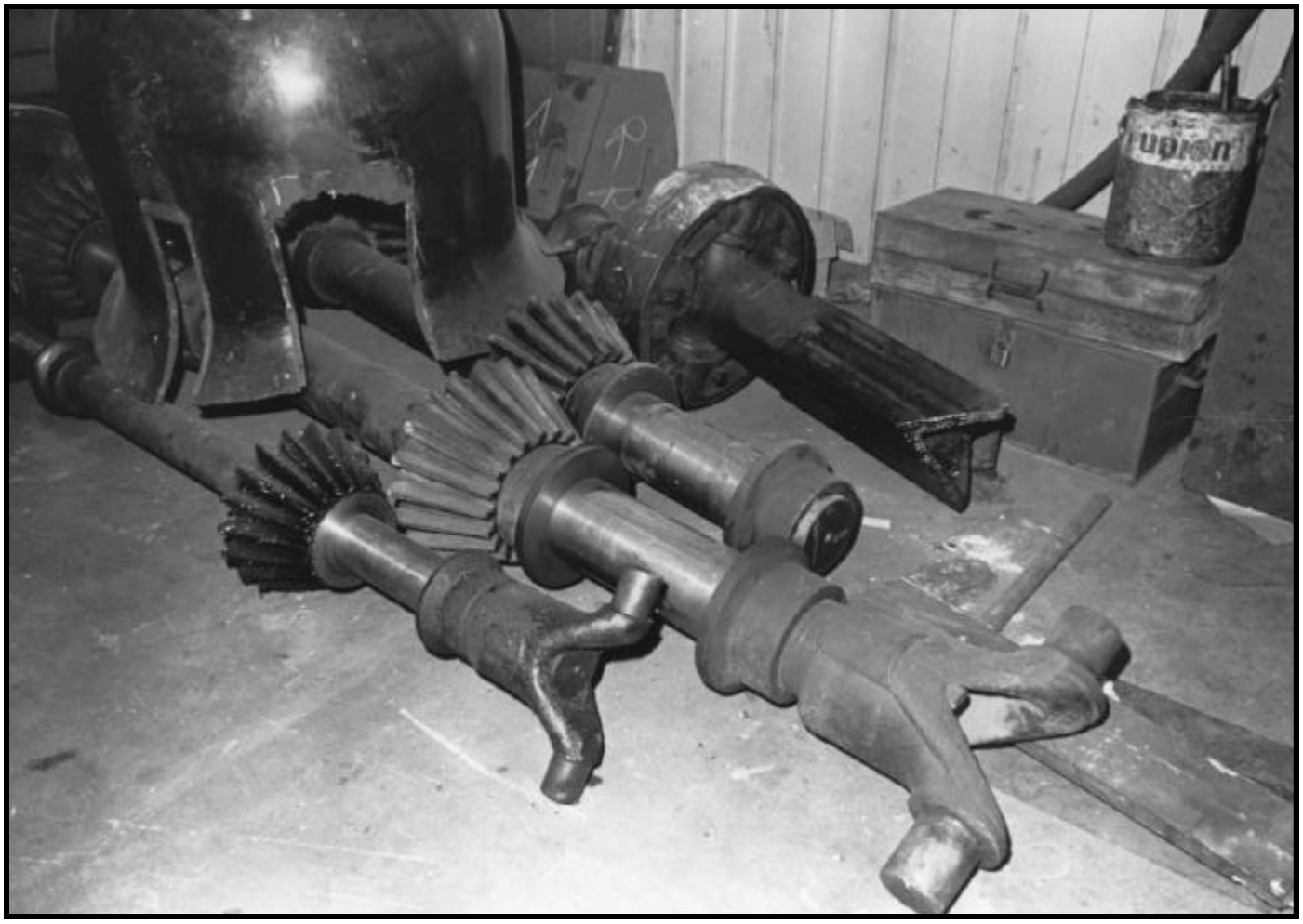
Coupling Machining Instructions, Continued

(Continued from page 3)

lathe chuck, the exact center of the casting and the lathe spindle axis can be aligned. This is achieved when the part line, in a vertical orientation, returns to the same alignment when the casting is turned 180°. Do not over tighten the side alignment bolts as they could later distort the casting when the hole is bored. Finally tighten the horn clamp bolts. Now the casting is ready for boring.



11. Begin the boring process by first facing off the end of the casting so that a uniform surface is made. Do not take off more material than is necessary to get a flat even surface where the hole is to be bored. Center drill the casting and work up in drill size until a 3/4" drill is finally used (photo #6). The finished hole diameter is made with a boring bar. Note that the size of the center hole is different for those couplings used on the ends of the line shafts (0.810") and those on the ends of the crank shaft (0.875"). Each should be made to a press fit with about 0.001" interference.
12. The Line and Crank Shaft Couplings are keyed to their shafts with a 1/8" wide keyway 1/16" deep in the casting. The keyway is located under the portion of the barrel which has been thickened. There are several methods for making keyways. These could include the use of a commercial broach set and a power press, a shaper, or using the lathe as a shaper. For the broach method a custom broach holder would first be made to fit the 0.810" hole. Then it would be a simple process to drive the broach cutter through the holder until the desired depth was attained. The shaper method, either on a shaper or a lathe acting as a shaper, would require a custom ground lathe tool bit mounted in the tool post and moved back and forth to plow



(Above) The Line and Crank Shaft Coupling is clearly shown, at the bottom right, in this prototype photo of **Western Maryland Ry. #6's** line shafts lying on the shop floor of the Cass Scenic Railroad. Note the contrast in size of the 164-ton **Western Maryland Ry. #6's** massive line shafts compared to one of a smaller 70-ton Shay's laying alongside at the left. Photo by Jim Salmons about 1981.

out the keyway. For either shaper method, the boring fixture could be used to hold the casting while the keyway is cut.

This completes the instructions for machining the Line and Crank Shaft Couplings.

Production Notes: