

LocoGear

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Technical Bulletin - 11

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Fabricating Instructions for Furnace Bearer - Front - 483-A-5070 Furnace Bearer - Rear - 483-A-5069 Furnace Bearer Plate - 482-A-5216

Engine Frame Reinforcements - 488-A-5072 and 488-A-5073

The following instructions are a step by step description of the process for fabricating the Furnace Bearer - Front (Lima Card Number 483-A-5070), Furnace Bearer - Rear (Lima Card Number 483-A-5069), the Furnace Bearer Plate (Lima Card Number 482-A-5216) and the Engine Frame Reinforcements (Lima Card Numbers 488-A-5072 and 488-A-5073) The Engine Frame Reinforcements were added later. Only one of each are used on the **Western Maryland Railway #6**. You may want to use as a reference the Engine Frame Layout drawing, Lima Card Number 480-A-50000, which also shows the Front and Rear Furnace Bearers in detail.

Prototype Information

The Lima Locomotive Works designed their modern Shays utilizing the fabricated girder side frames, which was used on the **WM #6**. In this design, the Boiler's fire box is supported by two large steel castings. These are the Front and Rear Furnace Bearers which span between the two side frames (See the prototype photos 1 and 2). Both the Front and Rear Furnace Bearers rest on top of the horizontal web of the inside bottom Engine Frame angles. They are also riveted to these angles as well as

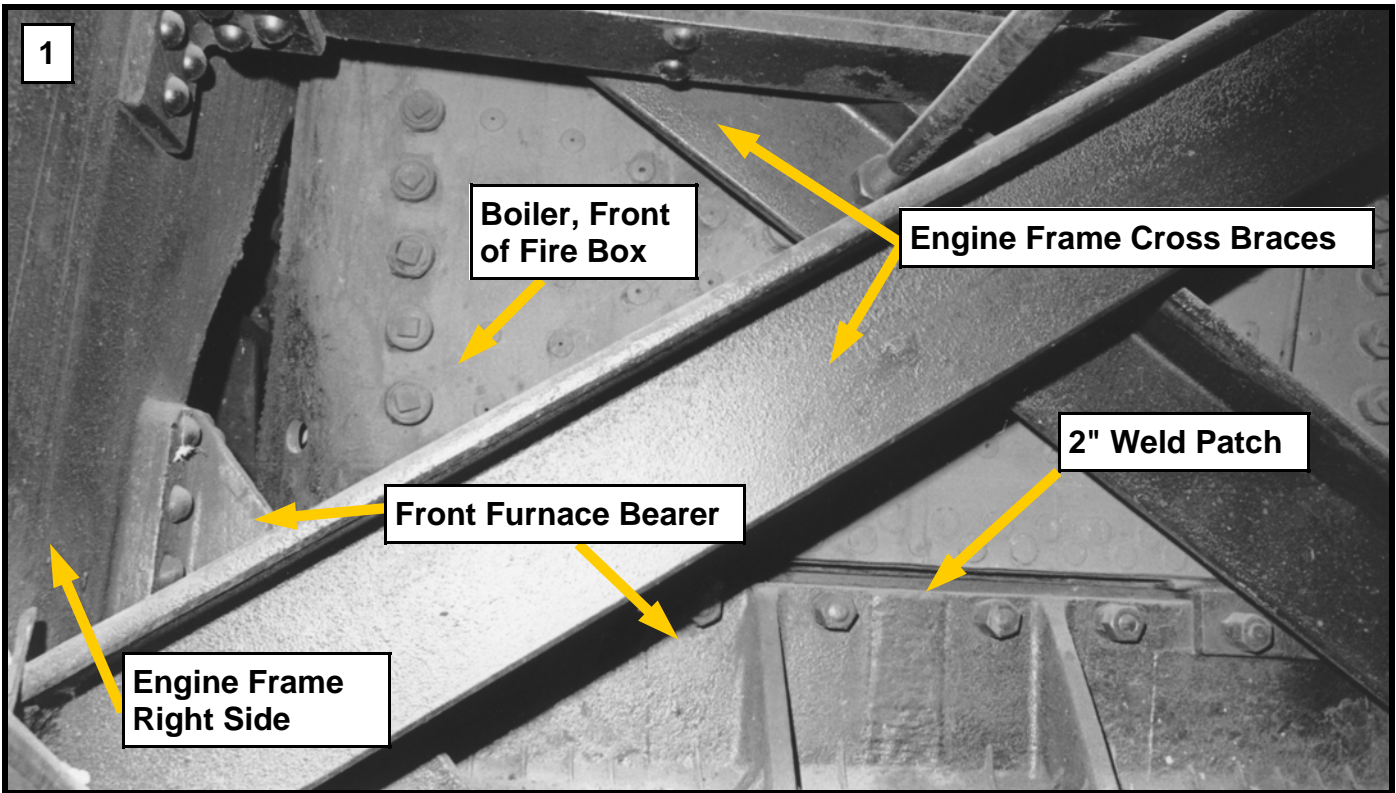
the Engine Side Frames.

The Front Furnace Bearer is positioned directly below the front portion of the Boiler's Mud Ring. It is at this point that the Boiler is immovably bolted to the Front Furnace Bearer through tabs extending downward from the bottom of the Mud Ring (Lima Card Number 144-A-5000). It is from this point that the Boiler is allowed to expand and contract in both directions as the Boiler is heated and cooled.

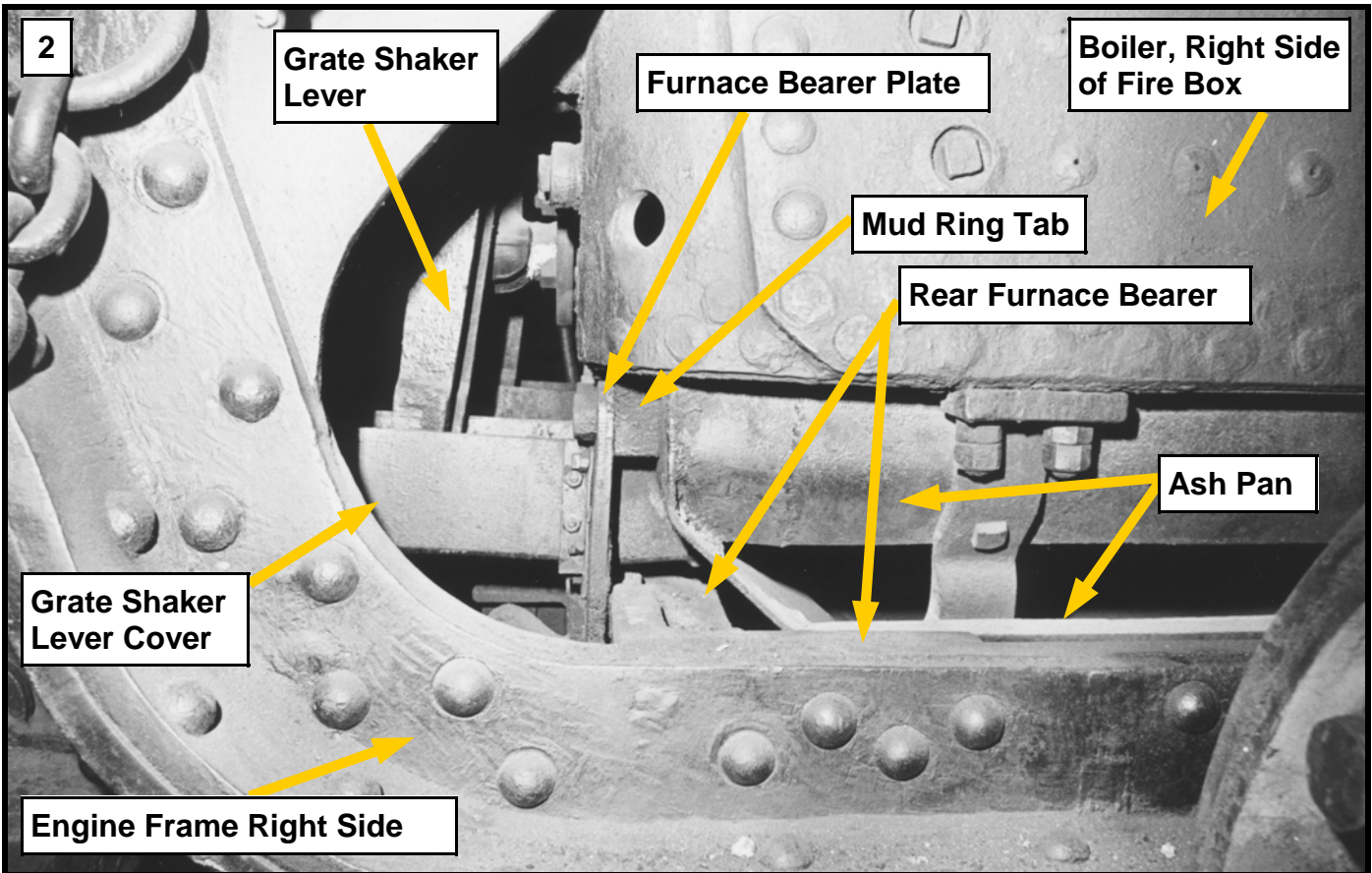
At the rear of the Boiler, the back edge of the fire box is supported by the Rear Furnace Bearer and its flexible Furnace Bearer Plate. The top of the Furnace Bearer Plate is bolted to tabs extending downward from the bottom of the Mud Ring. The Furnace Bearer Plate rests on a narrow ledge near the bottom of the Rear Furnace Bearer and is bolted to it there. The Furnace Bearer Plate flexes forward and backward allowing the Boiler to freely expand and contract while being fully supported.

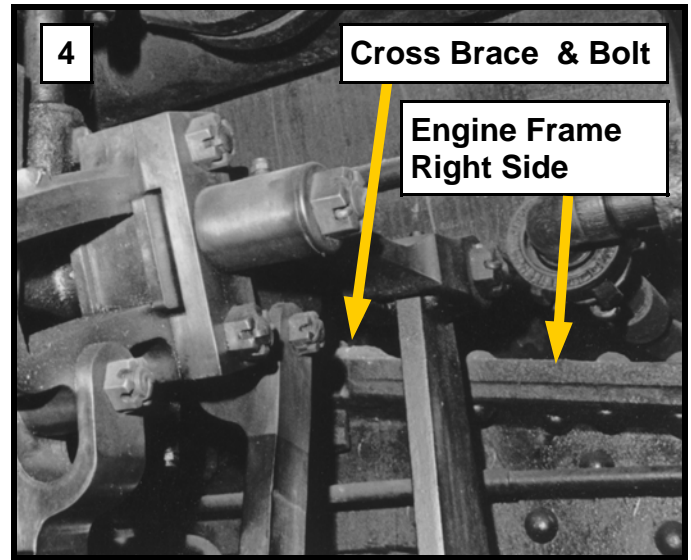
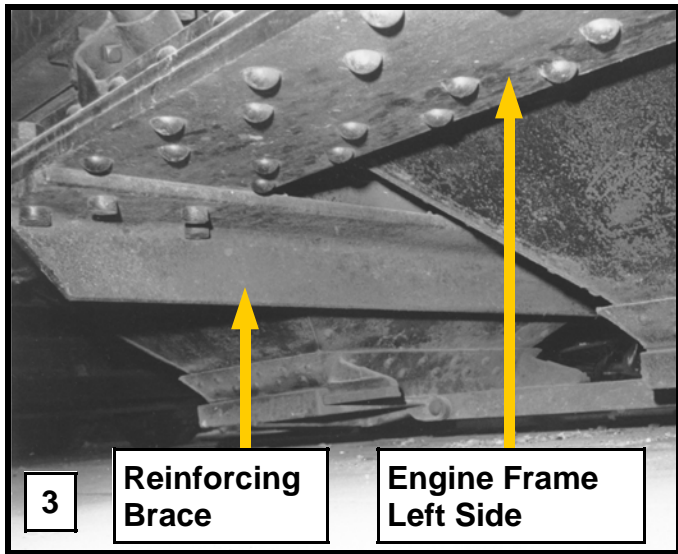
Before we begin discussing the model construction instructions for these parts, there are two interesting stories to be told about the Furnace Bearers on the **WM #6**.

When the **WM #6** was under construction at the Lima Locomotive Works, it seems that an error was made in the original design of the Engine Frame. The original plan showed the right



(Above) This prototype photo shows the Front Furnace Bearer on the **Western Maryland Railway #6**. This view is looking rearward from just behind the front truck. (Below) This prototype view of the Rear Furnace Bearer is from right side of the engine. *Both Photos by Jim Salmons.*





and left side frames to be 73" apart. The frame shop fabricated the Engine Frame according to plan (Lima Card Number 480-A-5000). However, as the story goes, when the erection shop went to lower the Boiler into the Engine Frame, it would not fit. The Engine Frame was too narrow! One can just imagine a communal "Oh, S#@%!" echoing through the Lima shop buildings.

Since they were not about to redesign the Boiler, Lima was faced with the problem of how to now expand the distance between the two side frames. To accomplish this, the major problem to be resolved was that the Engine Frame consists of three large steel castings which spanned between the right and left side frames. They are the Front and Rear Furnace Bearers and the Frame End Casting (Lima Card Number 483-A-5071). Lima was also not about to make new patterns and then new castings to replace the existing ones already riveted in place in the now completed Engine Frame. The other connections between the two side frames were fabricated steel channels and plates. These could be just reworked to a larger size.

What Lima decided to do with the castings was to cut the Front and Rear Furnace Bearers each in half right down the center line of the Engine Frame with a torch, spread everything apart two inches, and then fill in the gap of each casting with weld. This "fix" can be seen in the prototype photo 1. The final distance between the side frames thus became 75", which was wide enough to fit the Boiler inside the Engine Frame.

We will make the Front and Rear Furnace Bearers to the correct size on the live steam model!

Lima also had other modifications that resulted from this design problem, but we will not get into them at this time. A note of caution should be made as you work with the prototype drawings. Most of Lima's drawings have this correction noted on them, but be on the lookout for places where it may effect the model's construction.

There is a second interesting story that involves just the Front Furnace Bearer. The **WM #6** was completed in May of 1945. It was then shipped to the **Western Maryland Railway** and put directly into service. However, once the **WM #6** had operated on the railroad for only a couple of months, they determined that there was a vibration problem on the right side of the Engine Frame in the area of the Bottom Bracket. Lima determined that in order to correct the problem, the Engine Frame needed reinforcing. Lima drew up two drawings to show the "fix" they proposed (Lima Card Numbers 488-A-5072 dated 9/22/1945, and 488-A-5073 dated 10/6/1945).

These drawings show three 6" x 8" x 1" angles which were to be added to the Engine Frame. Two in a cross "X" pattern reaching from the top outside angles of the Engine Frames down diagonally to the opposite side bottom Engine Frame angles. This cross brace would be located just forward of the Boiler's fire box (see prototype photo 1). A third angle was to be welded in place to the rear the Boiler's fire box. There is no indication that this third angle was ever installed. However, there is a 6" x 8" x 1" angle added to the Engine Frame below the Ash Pan. This brace is not indicated on any drawing! It is bolted in place using convenient

rivet holes with their rivets removed (See prototype photo 3).

The repair drawings showed the two cross brace reinforcing angles bolted to the side frame angles at both ends. The top was a rather simple design with the vertical web of each angle cut away leaving the horizontal web to be bent over to lay flat on top of the outside top Engine Frame angles. It was then bolted through convenient rivet holes, which had their rivets removed (see prototype photo 4). The bottom ends of these two cross reinforcing angles was a bit more complicated. The idea was to bend each of the reinforcing angles at the bottom ends so that the horizontal web would lay flat up against the bottom edge of the bottom Engine Frame angles. There they would be bolted using convenient rivet holes with their rivets removed.

You must also bear in mind that this repair was planned to be done with the boiler in place! Also, this repair was not to be done at Lima, but rather “in the field” by the **Western Maryland Railway**. As one might imagine, what the engineers at Lima came up with was not exactly followed by the mechanic who actually had to do the work. The top portions of the angles are positioned and bolted as per the drawings, however, the bottom ends of the reinforcing angles were just cut off with a torch and welded in place to suit the mechanic! The reinforcing angle that connects at the bottom on the left side is welded to the Front Furnace Bearer.

Model Construction Instructions

Lima originally made the Front and Rear Furnace Bearers each as a single steel casting. Lima Pattern Number 48-720 was used to make the Front Furnace Bearer, and Lima Pattern Number 48-719 was used to make the Rear Furnace Bearer. For the live steam model, these parts can be fabricated from several steel pieces. The two major pieces, one each for the Front and Rear Furnace Bearers are cut from a 4" “H” beam with a web thickness of 5/16". The other smaller pieces are made from 1/8" and 3/16" steel plate.

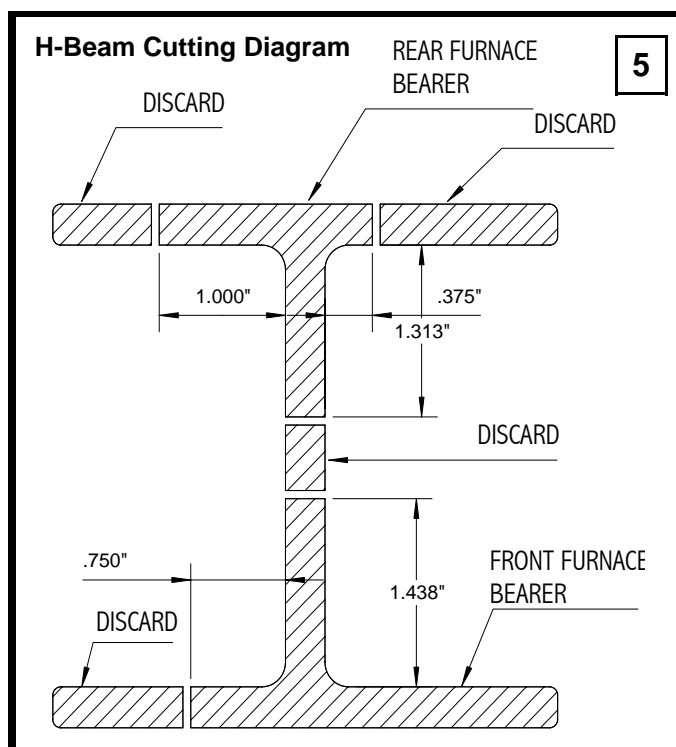
It should be noted that the Front and Rear Furnace Bearers are **not** fabricated as whole units before they are installed in the Engine Frame, but rather the individual pieces are assembled together in place as the Engine Frame is built. Beginning

with step 13, the Engine Frame should be nearly finished. That means that the two side frames should have all of their angles riveted in place, both frame bolsters should also be riveted in place, the Front End Timber plate and channel should be riveted in place, the engine brake cylinder channels should be riveted in place, and the Frame End Casting should also be riveted in place. The installation of the Front and Rear Furnace Bearers and the Reinforcing Braces are the last steps needed to complete the Engine Frame. The instructions to build the Engine Frame are **not** included in this **LocoGear Technical Bulletin**.

The machining instructions for both the Front and Rear Furnace Bearers will be outlined first in steps 1 through 12. The riveting, brazing and welding together of the pieces which make the Front and rear Furnace Bearers and attaching them to the Engine Frame will be discussed in steps 13 through 18. The fabrication of the Furnace Bearer Plate will be discussed in steps 13 through 18. Finally the Engine Frame Reinforcing Braces will be discussed in steps 13 through 18.

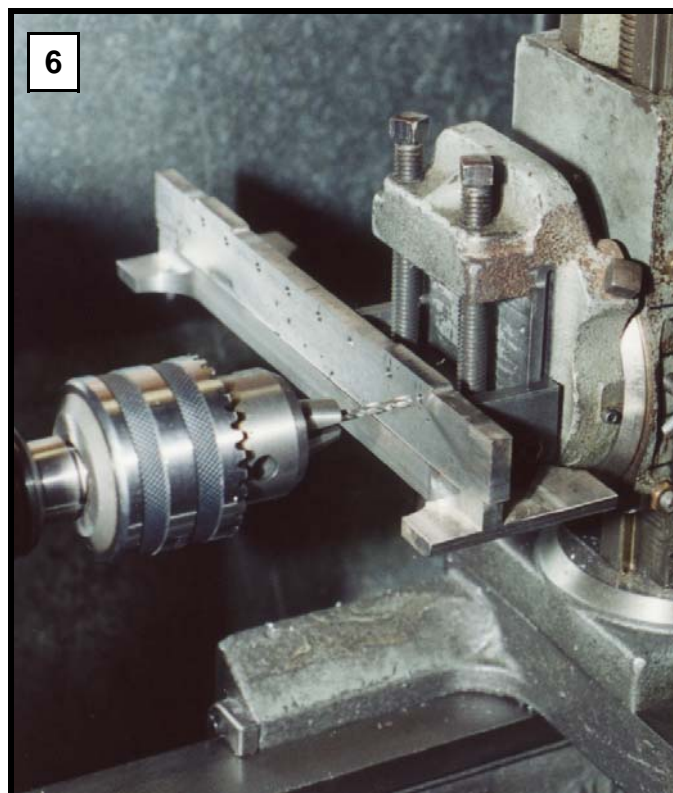
A drawing of the Front Furnace Bearer is shown on pages 8 and 9. A drawing of the Rear Furnace Bearer is shown on page 12. A drawing of the Furnace Bearer Plate is shown on page 13.

1. To begin fabricating the Front and Rear Furnace Bearers, take a 9-1/2" long piece of 4"

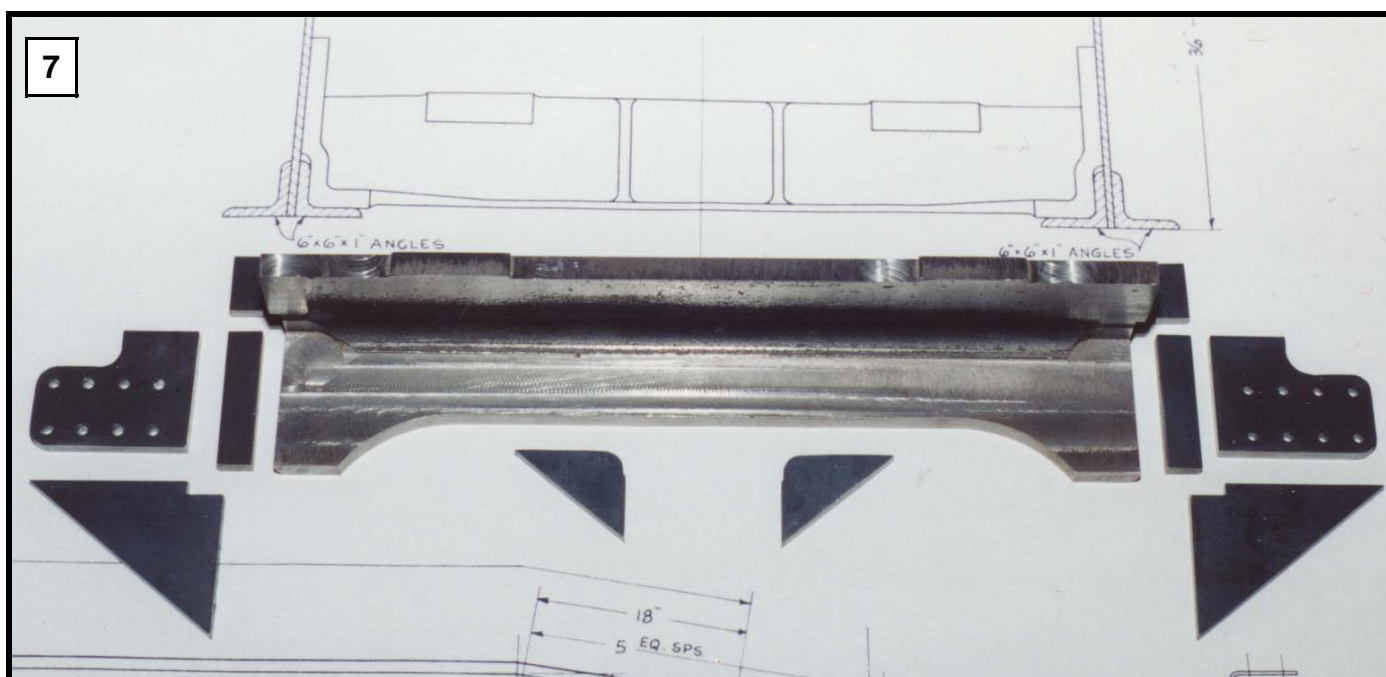


steel "H" Beam and with a band saw rough cut to the dimensions shown in the H-Beam Cutting Diagram (sketch 5). These dimensions will leave approximately 1/16" of material to machine off later. The diagram shows the main pieces for both the Front and Rear Furnace Bearers from the Right Side View. The Rear Furnace Bearer should be rotated 90-degrees in the counter clockwise direction to see the normal up/down orientation.

2. We will first discuss the machining of the Front Furnace Bearer parts. The first step is to take the Front Furnace Bearer "T" section cut from the H-Beam and machine off the bottom surface so that bottom webs are .250" thick. This can be done in a milling machine with either an end mill or a fly-cutter. To do this, turn the "T" section with the bottom side up, and clamp the center web in the milling machine vise. Be careful to place shims as necessary to level the bottom webs and support each edge with shims. If the top surfaces of the bottom webs are smooth, you can mill the bottom surface to the final .250" thickness. However, if the top surface is rough, leave some material on the bottom surface so you can skim off the top surface to smooth it during the operations of the next step. Next finish and square the four edges of the bottom webs to 9.125" x 2.563". Make sure that the wider front bottom web is 1.625" from the front surface of the vertical web.



3. Machining the vertical web of the Front Furnace Bearer is the next step. Clamp the Front Furnace Bearer in the milling machine vise with the vertical web pointing up, and begin milling off the rear surface of the vertical web with the side of an end mill. The front surface of the vertical web can be left un-machined except for removing at least 3/16" of the web fillet at each end of both the front and rear surfaces. This is so the small **A** and **B** plates can

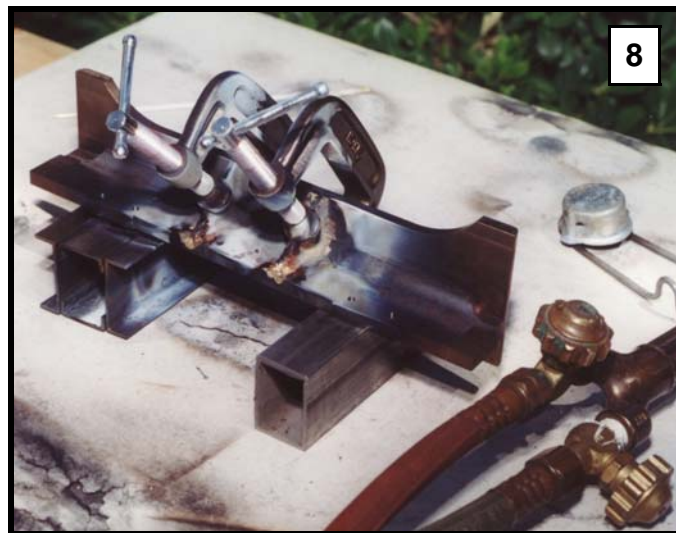


fit in place (see drawing on pages 8 and 9). The top profile and ends of the vertical web can be machined next using the same clamping setup.

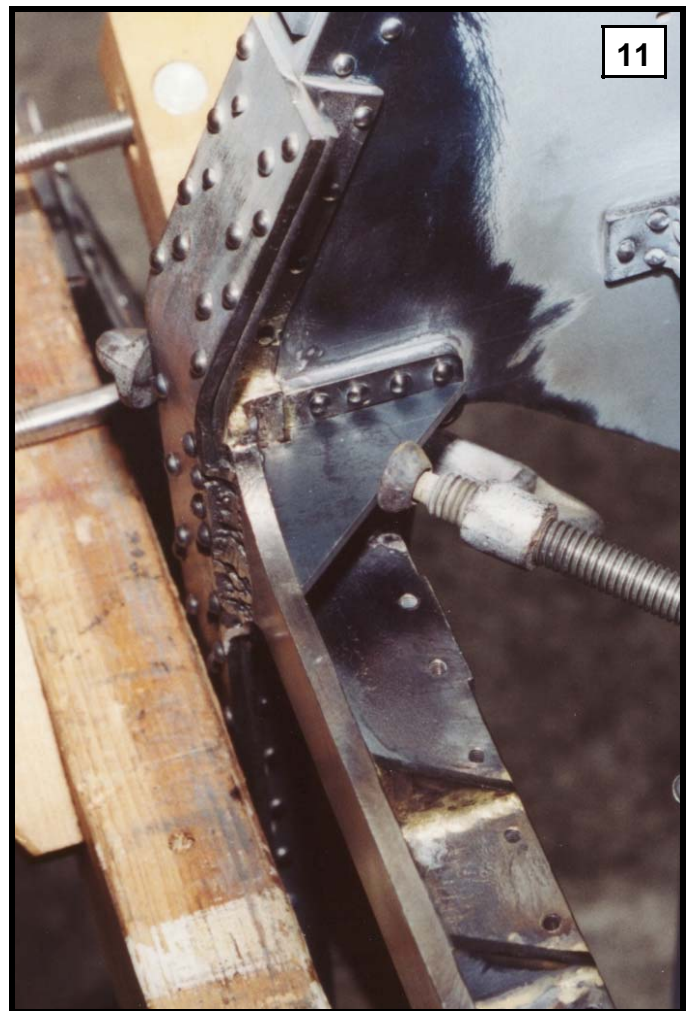
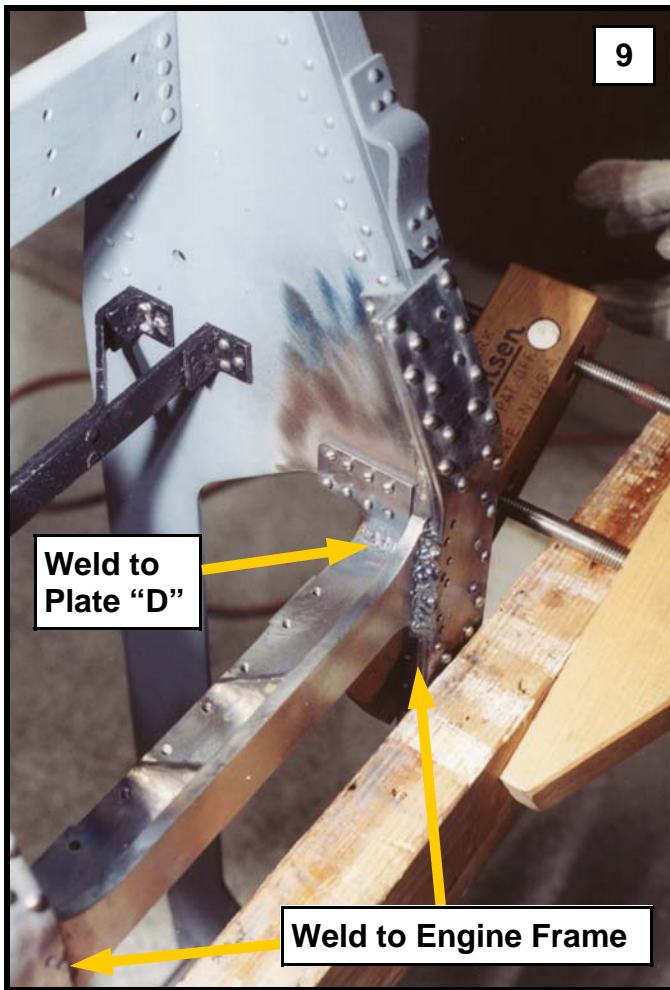
4. The front and rear edges of the bottom webs are cut in with a radius at each end. This is an ideal job for CNC, but if that is not available, remove the Front Furnace Bearer from the milling machine vise and with a band saw, rough cut these areas out leaving as little material as possible to finish with an end mill or a file.
5. The final step in machining the main section of the Front Furnace Bearer is to drill and tap the eight bolt holes for #8-32 threads (see photo 6).
6. Machining two each of plates **A**, **B**, **C**, **D**, and **E** is the next step for the Front Furnace Bearer (see drawing on pages 8 and 9). Except for plate **D**, each is a simple shape. All can be rough cut with a band saw and finished to size by either milling or filing. Plate **D** is a little more complicated, with its rivet holes and radiuses (see photo 7). This completes the machining steps for the Front Furnace Bearer.
7. Before assembling the Front Furnace Bearer, we will machine the parts for the Rear Furnace Bearer. The first step in machining the Rear Furnace Bearer is to take the Rear Furnace Bearer "T" section cut from the H-Beam and clamp the lower vertical web in the milling machine vise and then machine the horizontal web to 1.250" from the front surface of the lower vertical web (see drawing on page 12). The length of the Rear Furnace bearer can also be made to 9.125" long.
8. At each end of the Rear Furnace Bearer is a notch which will be positioned above the 3/4" x 3/4" x 1/8" lower inside frame angles of the Engine Side Frames. These two areas which are .625" wide and run the length of the ends leaving the Rear Furnace Bearer 0.125" thick in this area. In this area there will be rivets that hold the Rear Furnace Bearer to the Engine Frame angles. The drawing on page 12 does not show the position of the rivet holes because these will be drilled later once the Rear Furnace Bearer is welded in place during Step #X. The rivet holes will be located from the corresponding rivet holes first drilled in the Engine Frame angles.
9. The top vertical web of the "T" section can also be machined at this time with the same

clamping setup. This web is nearly all removed down to the top surface of the horizontal web except for 1.625" at each end of the Rear Furnace Bearer which is .313" high. A .500" section of these two webs will later be filed to a slope as indicated in the drawing.

10. The front edges of the horizontal web is cut in with a radius at each end. This is an ideal job for CNC, but if that is not available, remove the Rear Furnace Bearer from the milling machine vise and with a band saw, rough cut this area out leaving as little material as possible to finish with an end mill or a file.
11. The final step in machining the main section of the Rear Furnace Bearer is to drill and tap the eight bolt holes for #8-32 threads which hold on the Furnace Bearer Plate.
12. Machining two each of plates **A**, **B**, and the reinforcing braces are the next step for the Rear Furnace Bearer (see drawing on pages 12). All can be rough cut with a band saw and finished to size by either milling or a filing. This completes the machining steps for the Rear Furnace Bearer.



13. Now we will begin assembling the pieces of the Front and Rear Furnace Bearers and installing them in place in the Engine Frame. Both the Front and Rear Furnace Bearer each have reinforcing plates that can be brazed in place before they are put into the Engine Frame (see photo 8). For the Front Furnace Bearer these are plates **E**. For the Rear Furnace Bearer see brace plates noted in the drawing on page 12.
14. The two plates **D** on the Front Furnace Bearer

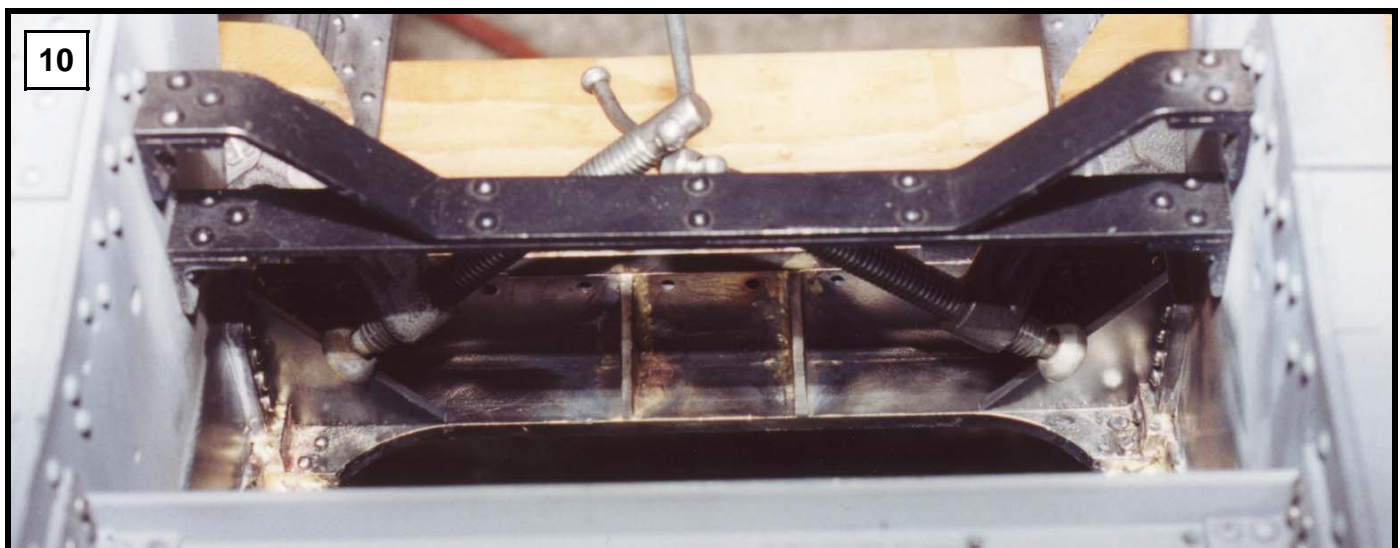


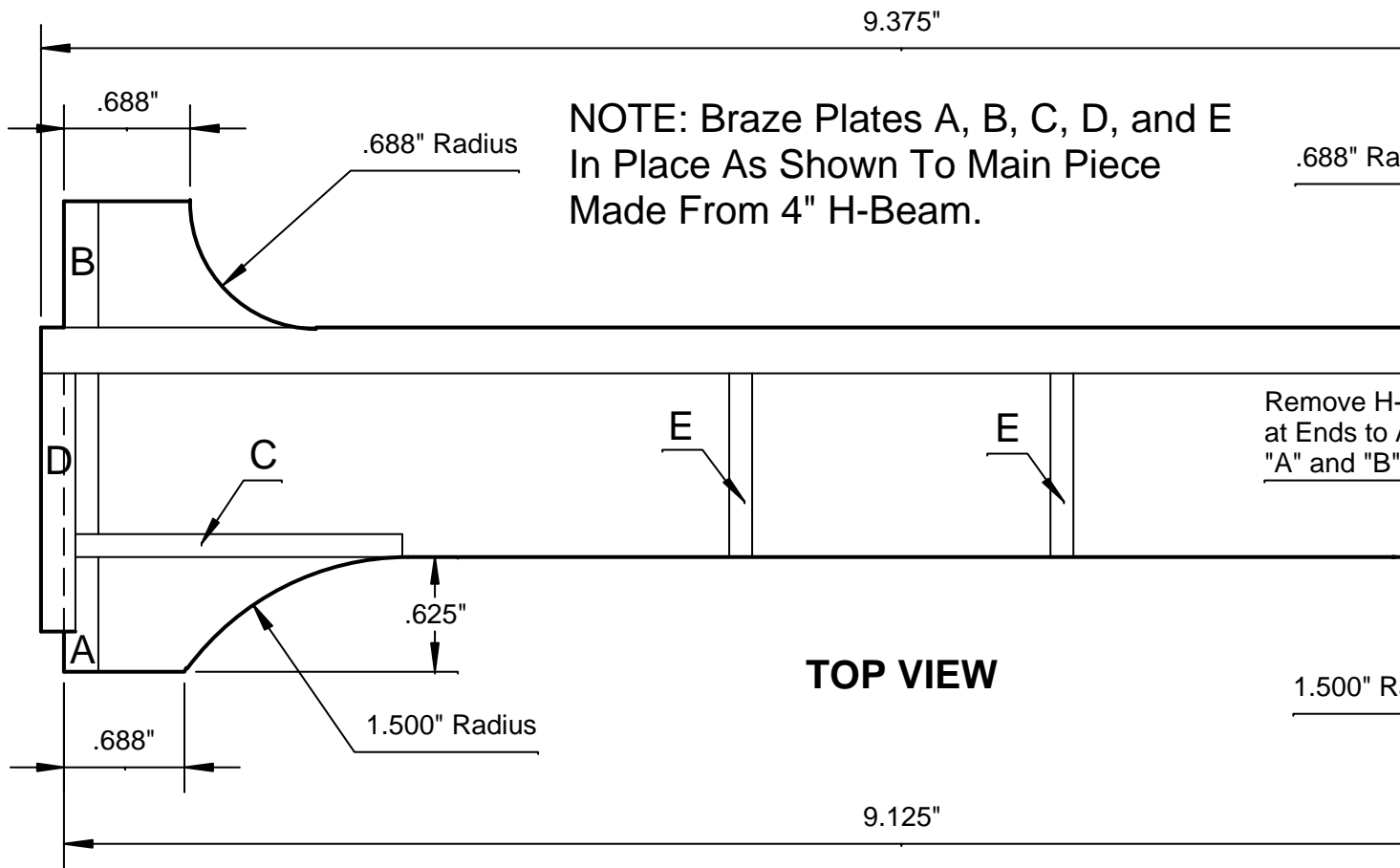
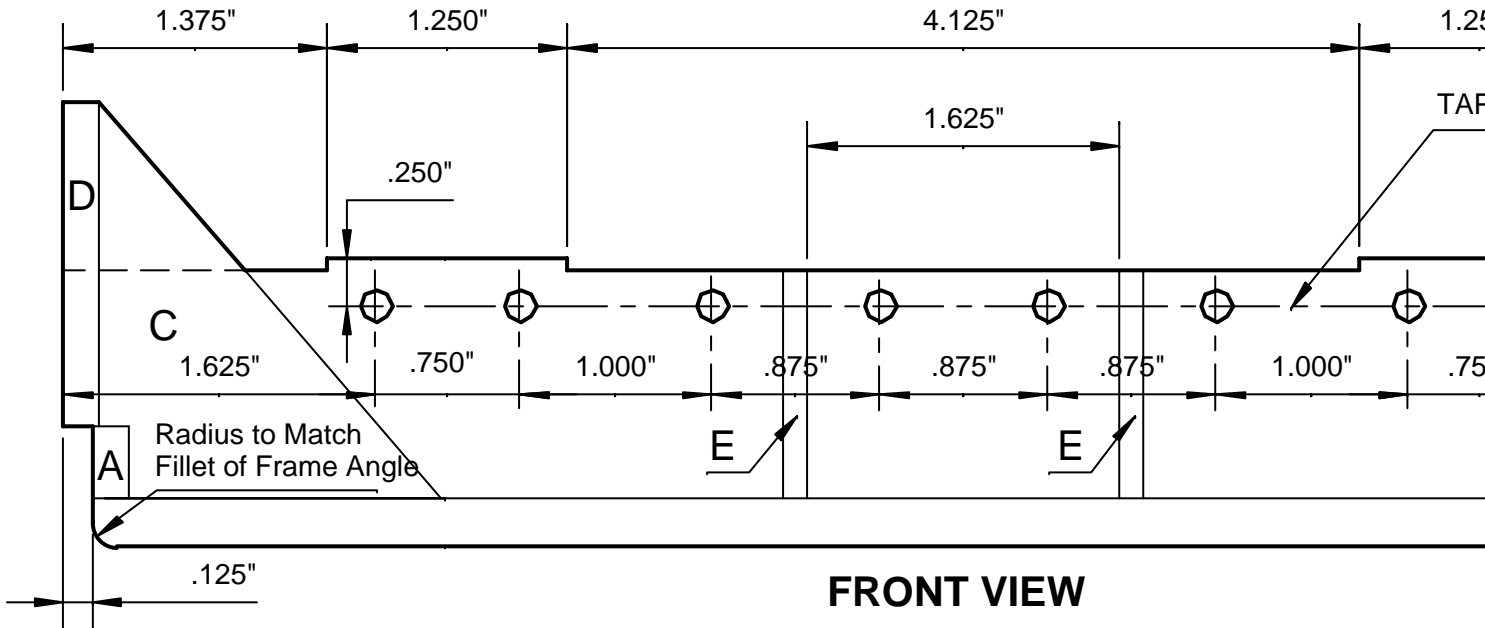
should each be riveted in place to the inside of the Engine Frame see photo 9).

15. The next step is to weld the front and rear furnace bearers to the Engine Frame. Clamp each in position and with the frame laying up side down, weld along the bottom of the Front and Rear Furnace Bearers and the inside edge tip of the bottom inside frame angles. Next tip the

Engine Frame to standing up and weld the Front Furnace Bearer to both of the **D** plates (see photo 9). Chip off any welding slag and wire brush all welds.

16. Once the Front and Rear Furnace Bearers are welded in place, Drill the rivet holes in the Front and Rear Furnace Bearers using the cor-





and Railway Shay #6

earer - Front

umber 483-A-5070

. Johnson 11/25/2001

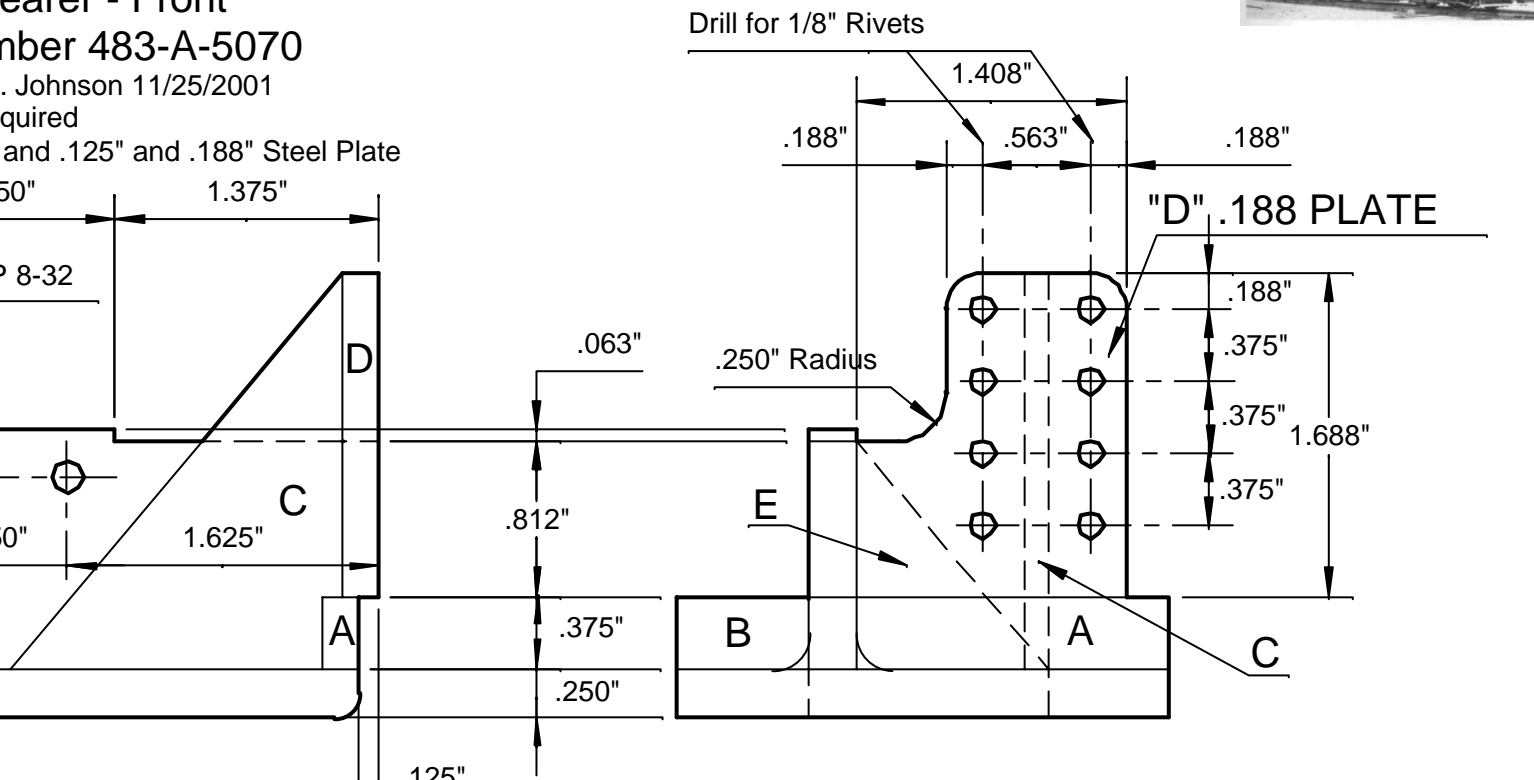
quired

and .125" and .188" Steel Plate

50"

P 8-32

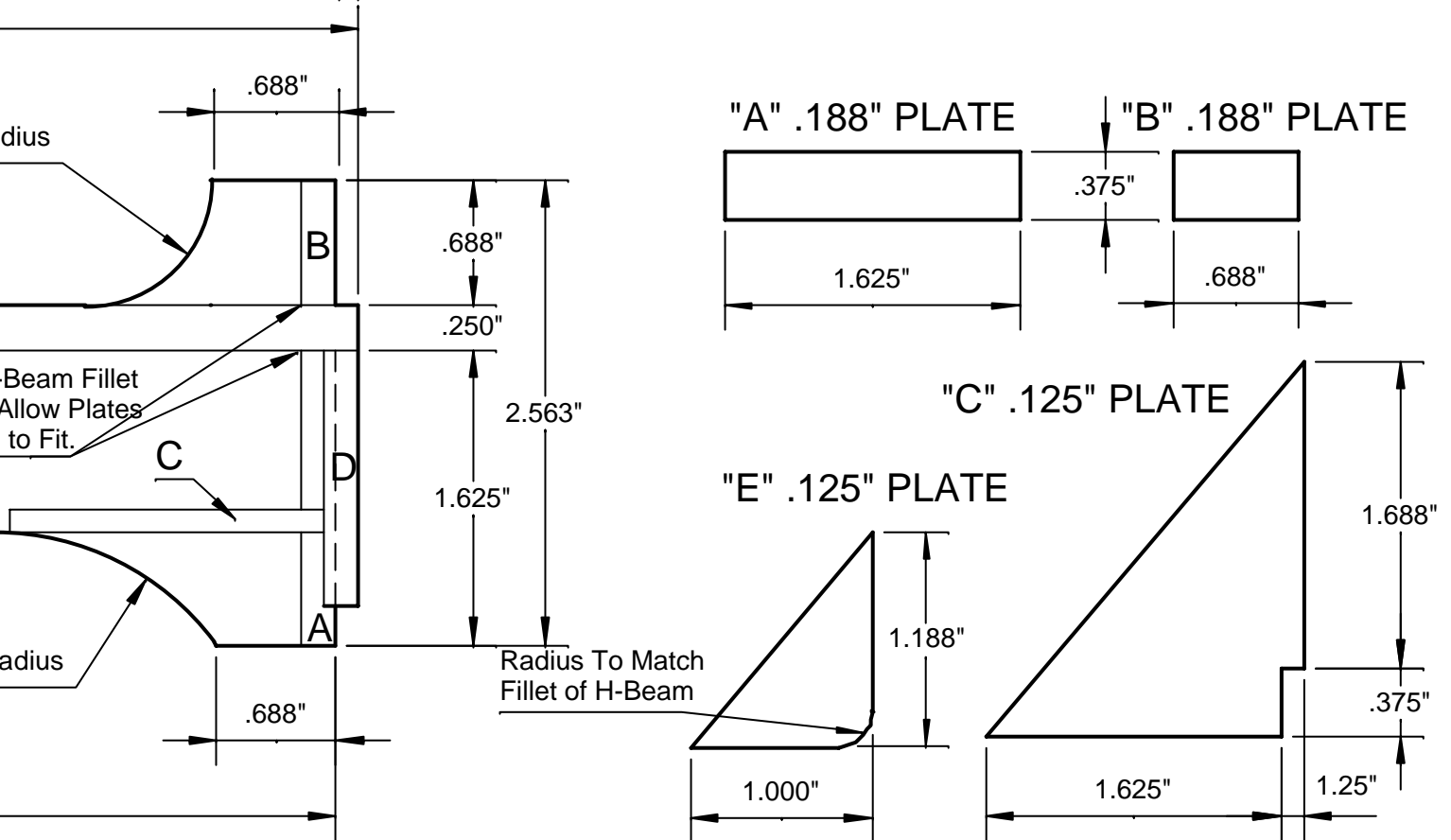
0"



Drill for 1/8" Rivets

"D" .188 PLATE

RIGHT SIDE VIEW

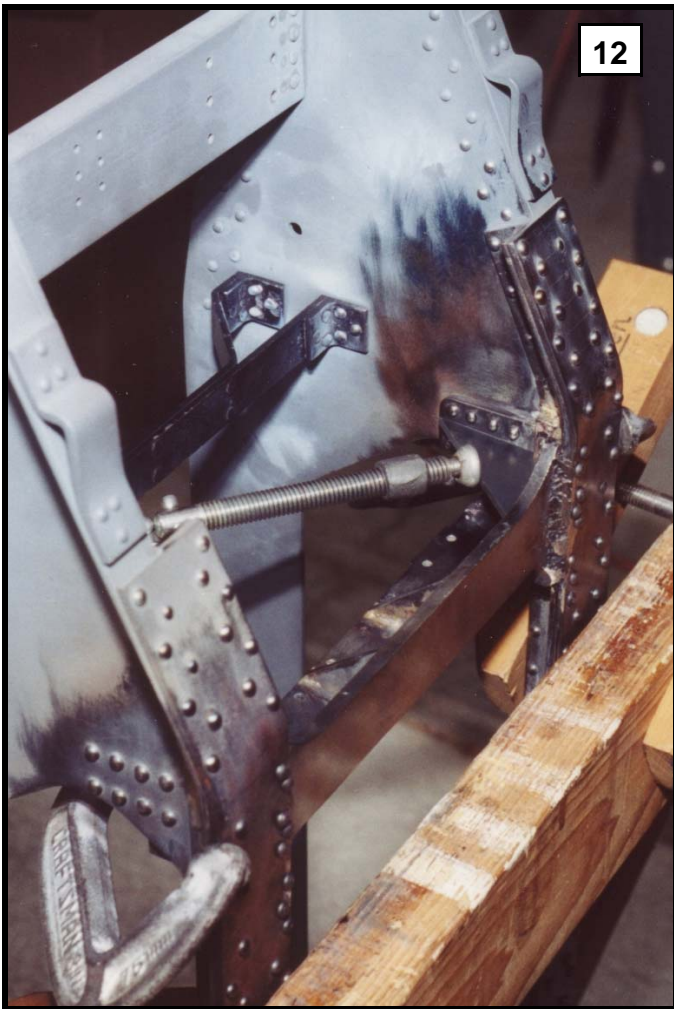


"A" .188" PLATE

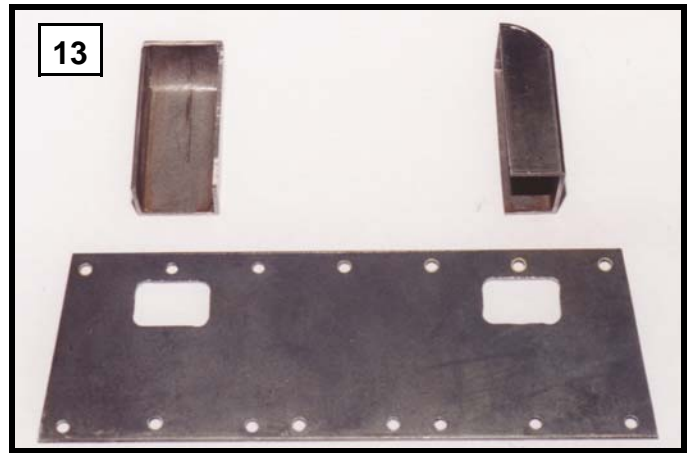
"B" .188" PLATE

"C" .125" PLATE

"E" .125" PLATE



12

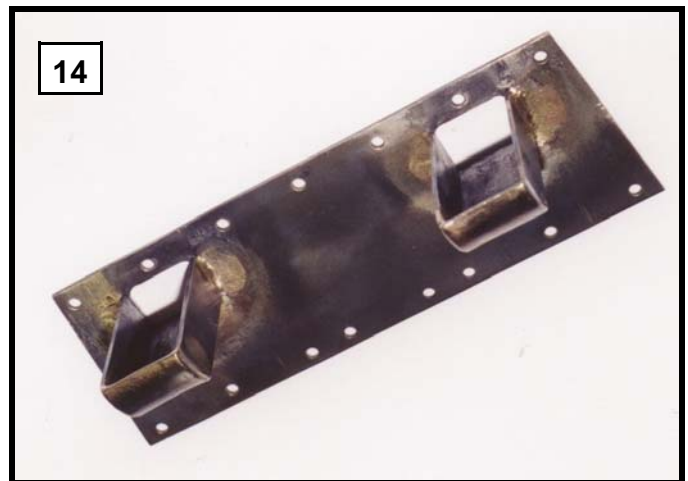


13

drawing on page 13). The flexible Furnace Bearer Plate can be rough cut with a band saw with a metal cutting blade and then filed or milled to the final dimensions. The fifteen bolt holes are all #28 pilot holes for the #6-32 bolts that hold the flexible Furnace Bearer Plate to the Rear Furnace Bearer at the bottom and the Boiler Mud Ring at the top. The two large holes can be rough cut with a 1/4" drill and then filed. Do not file these holes to the final size at this time.

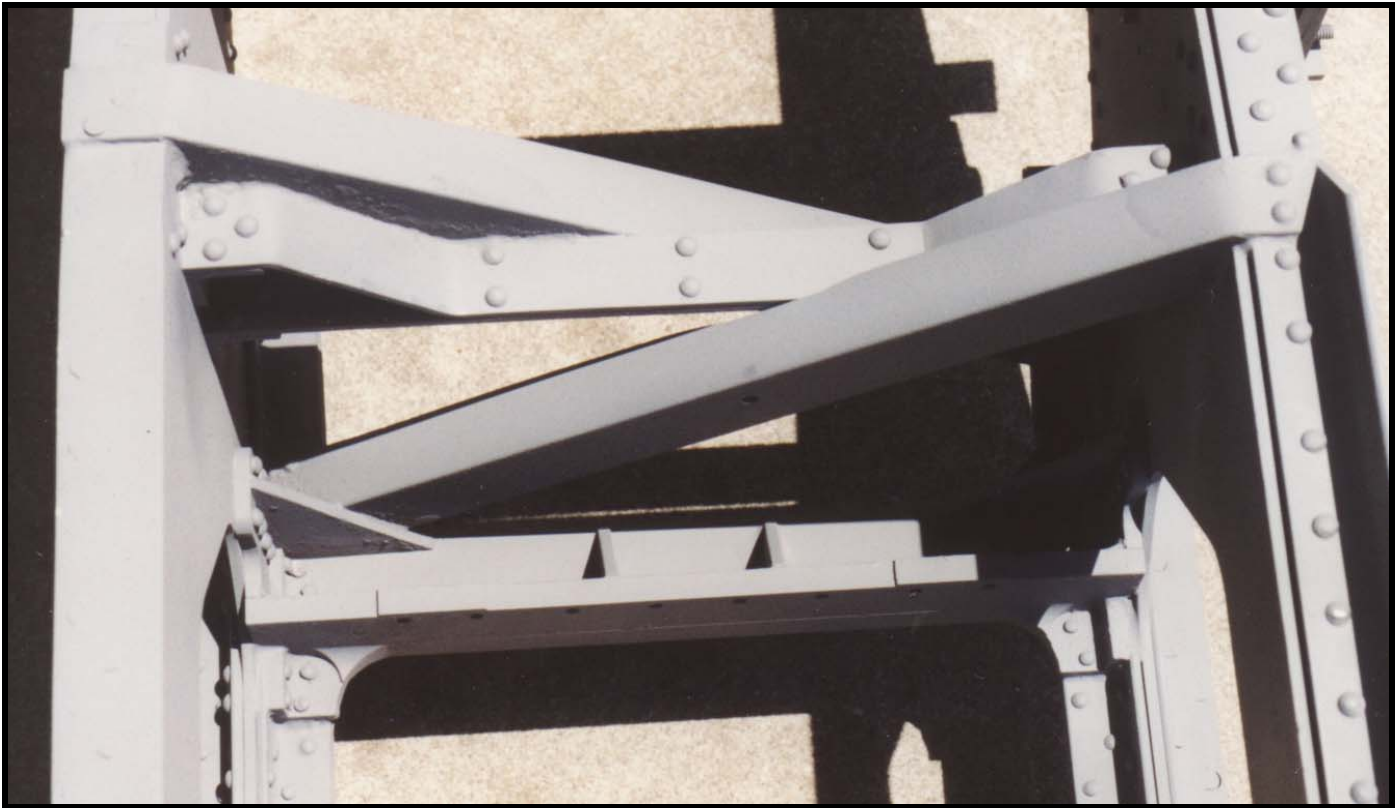
responding holes in the Engine Frame inside bottom angles as drill guides. These rivets can be riveted at this time.

17. Next position and clamp the remaining plates of the Front and Rear Furnace Bearers. These plates are to be brazed in place (see photo 10, 11 and 12). On the Front Furnace Bearer the last plates to be brazed are the C plates. Chip off any flux and wire brush all joints.
18. Finally drill all remaining rivet holes in the Front and Rear Furnace Bearer plates using the corresponding holes in the Engine Frame inside bottom angles as drill guides. These rivets can be riveted at this time. This completes the fabrication and installation instructions for the Front and Rear Furnace Bearers.
19. Next we will fabricate the Furnace Bearer Plate. This assembly consists of three components, the flexible Furnace Bearer Plate and two Grate Shaker Lever Covers (see photo 13). The flexible Furnace Bearer Plate is a piece of 16-gauge steel plate cut to 2.375" x 6.875" (see



14

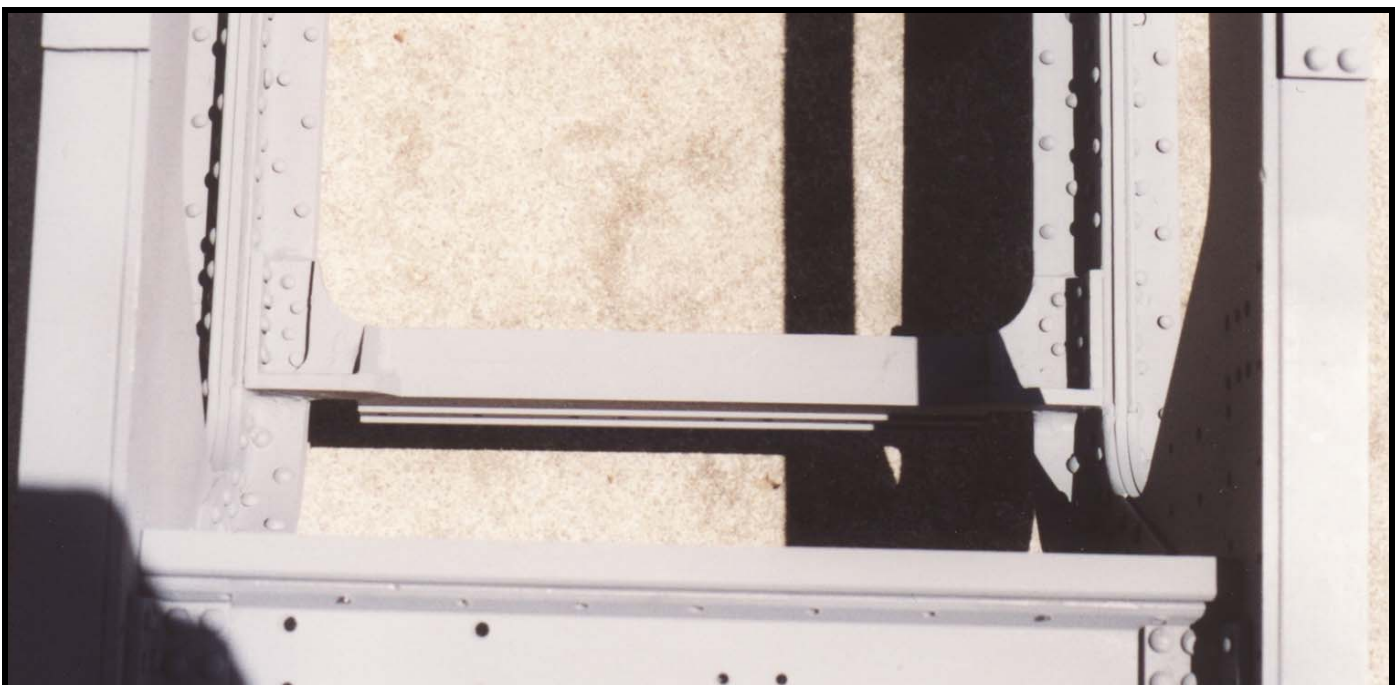
20. The two Grate Shaker Lever Covers are made from 1" x 1" x 0.063" square steel tube stock (see drawing on page 13). Use a band saw with a metal cutting blade to rough cut the tube. Bend the bottom wall around the radius at the end of the side walls and braze together. Use enough bronze to fill the gap and create a fillet on the inside. Trim off any excess of the curved end once brazed. Both Grate Shaker Lever Covers are then brazed to the Furnace Bearer Plate over the two large holes. File the holes to the final size after the Grate Shaker



Lever Covers are brazed in place. Clean off any flux and wire brush all over (see photo 14).

21. Finally we will fabricate the diagonal Reinforcing Braces. As noted on page 3, since the **Western Maryland Railway** did not follow **Lima's** instructions, you can choose to either follow the prototype drawing as **Lima** provided it to the **WM** or diverge from the drawing and

replicate these braces as close to what was actually done. Since you have the opportunity to install them as the Engine Frame is being built, making the braces according to the prototype drawings should work out well. If you want to build your model as close to the current condition of the **WM #6** today, you can follow the remaining instructions. The two diagonal Rein-



Western Maryland Railway Shay #6

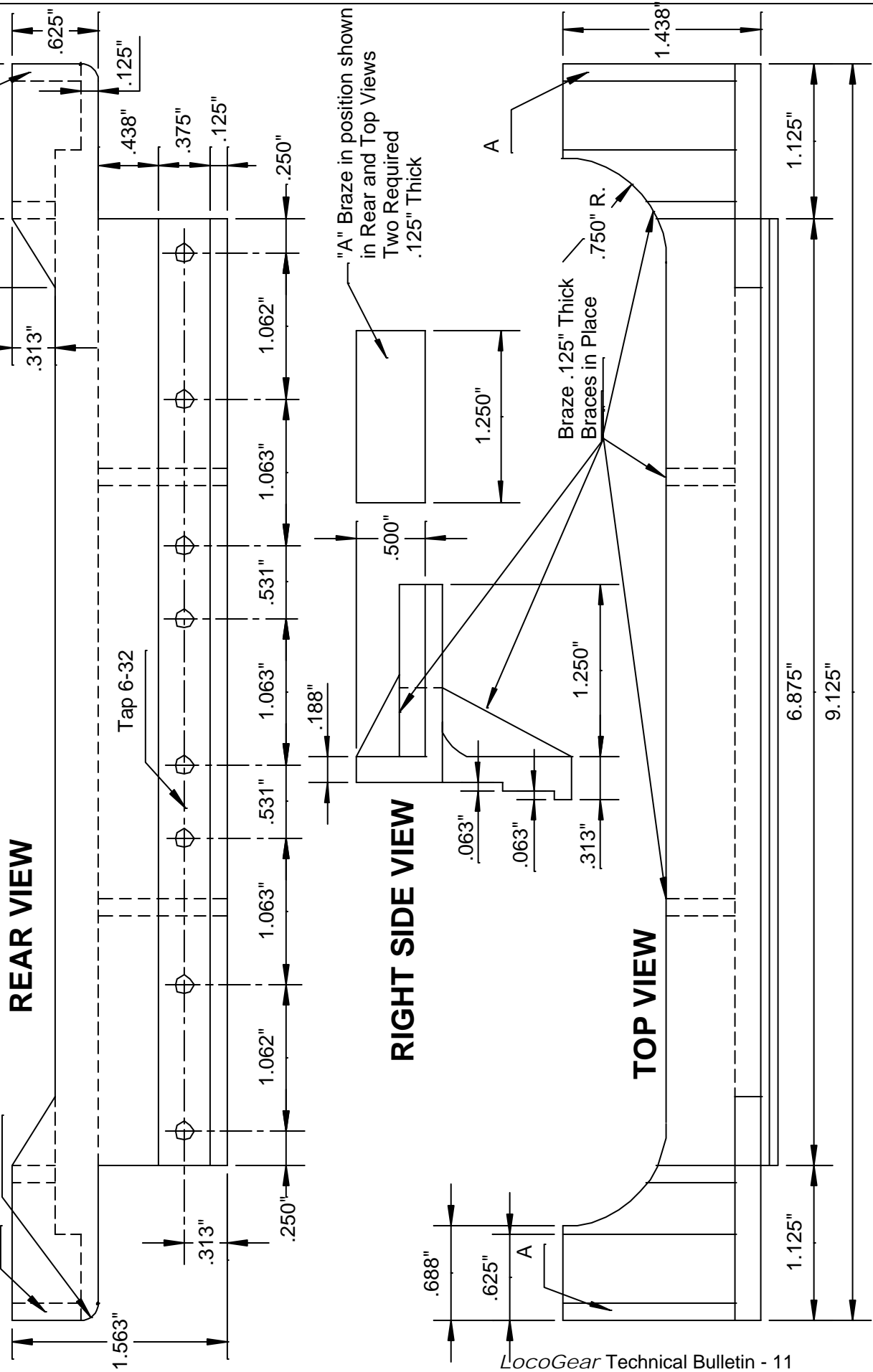
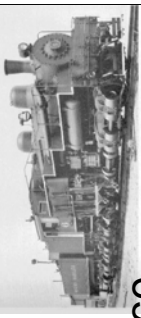
Furnace Bearer - Rear

Lima Card Number 483-A-5069

Drawn by John D.L. Johnson 10/26/2001

1 Required

Made From 4" Steel "H" Beam





forcing Braces are each made from 1" x 1" x 1/8" steel angle with one leg milled down to 3/4" wide. At the top end of each Reinforcing Angle, cut away the vertical angle leaving 1" of the horizontal leg. Also cut away the vertical leg at an angle to match the decent of the Reinforcing Brace so that it can fit against the inside surface of the Engine Frame Plates (see photo 15). Bend the 1 " length of the horizontal legs so they lay flush with the top surfacc of the Engine Frames. Both of these should rest above two conviniently located rivet holes in the Engine Frame. If you have already riveted these rivets when making the Engine Frames, drill them out and also drill through the horizontal leg of the Reinforcing Braces. Do not rivet them in place at this time.

22.

This completes the fabrication of the Front and Rear Furnace Bearers.

