AN INVESTIGATION OF VARIOUS TYPES OF ARC WELDED JOINTS

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In the last few years there has been much discussion as to the relative merits of arc welded joints as compared to riveted joints. There is an old precedent which mush be removed before arc welding will come into its own. The purpose of this paper is to help establish confidence in this process of fabrication with special regard to strength and reliability.

Electric arc welding is the transformation of electrical energy into heat through the medium of an arc for the purpose of melting and fusing together two metals, allowing them to melt, unite, and then cool. The fusion is accomplished entirely without pressure. The heat is produced by the passage of an electric current from one conductor to another through air, which is a poor conductor of electricity and offers a high resistance to its passage. The heat of the arc is the hottest flame that is obtainable, having a temperature estimated to be between 3,500 and 4,000 deg. C.

The metal to be welded is made one terminal of the circuit, the other terminal being the electrode. By bringing the electrode into contact with the metal and instantly withdrawing it a short distance, an arc is established between the two . Through the medium of the heat produced metal can be entirely melted awsy or cut, added to or built up, or fused to another piece of metal as desired. A particularly advantageous feature of the electric arc weld is afforded through the concentration of this intense heat in a small area, enabling it to be applied just where it is needed.

When using direct current, which is now more generally used for arc welding than is alternating current, the metal to be welded is made the positive terminal of the circuit, while the electrode is made the negative terminal.

When the arc is drawn the metal rod melts at the end and is automatically deposited in a molten state in the hottest portion of the weld surface. If the proper length of arc is uniformly maintained on clean work the voltage across the arc will never greatly exceed 22 volts for bare electrodes and 35 volts for coated electrodes.

It is very essential that the surfaces be absolutely clean and free from oxides and dirt, since any foreign matter present will materially affect the success of the weld.

The object of Test Pieces Nos. 1 and 2 was to determine which was the stronger, a single- or a double-V butt weld. The double-V specimens gave the better results, the average load being 21,100 lbs. per linear inch of bead. The strength of these welds was approximately that of the material itself, one specimen necking down and failing in the piece, the weld staying intact. The single-V welds gave poorer results. The average load was 16,300 lbs. per linear inch of bead and the results were not so uniform as in the case of the double-V. The double-V welds had a strength 29.5 % greater than the single-V welds. This increase in strength should more than pay for the extra work entailed in the making of the double-V welds.

Test Pieces Nos. 3 and 4 are a study of lap welds. The object was to determine whether a single-lap weld or a lap weld made by two welds , one on top of the other, would be stronger. The single-weld pieces, No. 3, gave an average load of 13,950 lbs. per linear inch of bead. In Test Pieces No. 4 a small weld, about 1/8 in. bead, was first made and then this bead was built up to the same size as No. 3 (3/8 in. bead). The average of No. 4 welds was 13,780 lbs. per linear inch of bead, or slightly less than No. 3 Test. The results therefore showed no advantage gained by a double welding.

The lap welds in general gave much poorer results than the butt welds, but this disadvantage might be offset in many cases by the relative ease of making the lap welds.

Test No. 8 is a study of welds developing only shearing stresses. The average load was only 9,630 lbs. per lineal in. of bead, much less than that of types 3 and 4. Type 8 has no advantage over types 3 or 4, but could possibly be combined with them to give added strength for the same length of contact of the pieces.

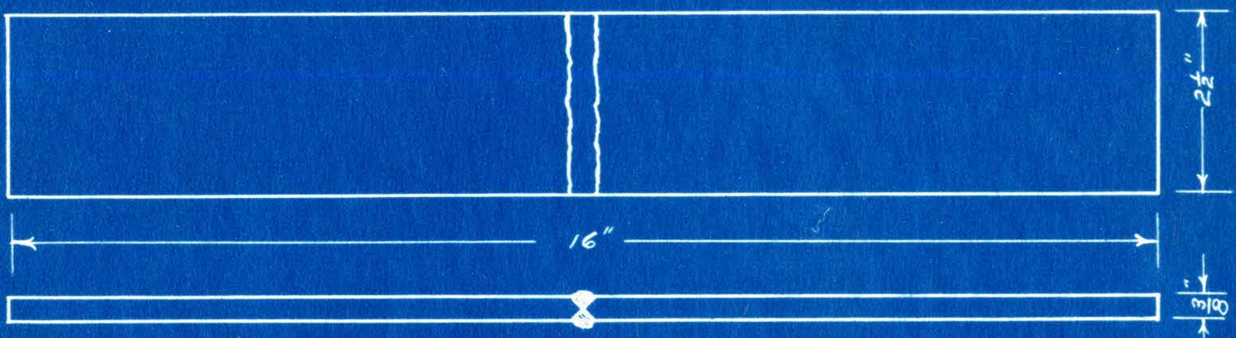
Test No. 9 is a combination shear and tension double-V butt weld. The average load was 10,650 lbs. per linear in. of bead. One specimen failed in both the piece and the weld, the other two failed in the piece. In these tests it was impossible to develop the full strength of the welds due to the eccentricity of the stresses set up in the pieces under test. This eccentricity of forces caused the specimens to tear under a much smaller load than they should have. Fig. 1 shows how the pieces failed.

In Tests Nos. 5, 6 and 7 it was the object to show that a lintel plate could be welded instead of riveted to an I-beam to support a wall over a door or window. The specimens consisted of 14-in. sections of 30-lb. I-beam, to which were welded 12-in. plates. The welds were 1½ in. long and there were three on each side of the I-beam. The manner of testing is shown in Figs. 2 and 3. The specimens were inverted and supported in a fixture built up from plates and channels. Timbers were clamped on either side of the web of the I-beam and the load was applied through blocks to these timbers. In this way the loading was similar to what it would have been if the beam and lintel plate had been supporting a wall. Test Pieces No. 5 (with a ¼ in. plate) sustained an average load of 11,450 lbs. The plates were bent down about 45 deg., but the welds did not fail. In one specimen the plate tore .

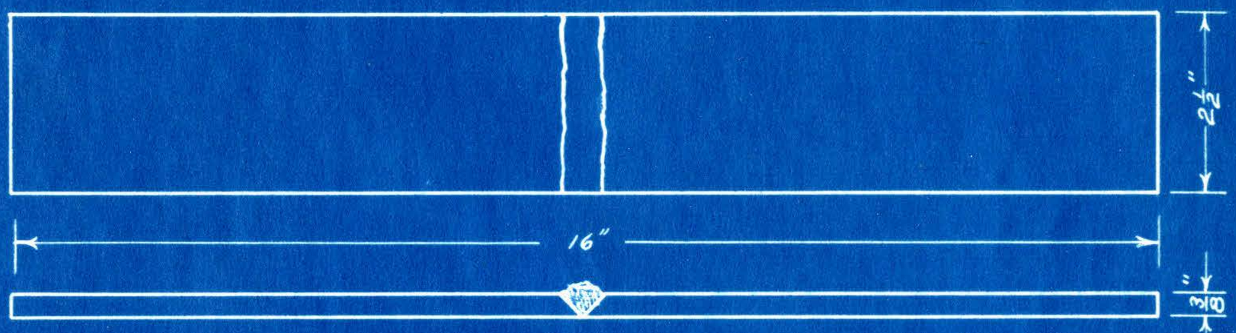
In Test No. 6 (with a 3/8 in. plate) the average load sustained was 28,270 lbs. The welds did not fail, the plates being distorted and torn in all three specimens. Figs. 4 and 5 show the bending and tearing of the plates, the welds staying intact.

In Test No. 7 (with a ½ in. plate) the average load sustained was 38,380 lbs. In all three specimens the plates were bent xx down and the welds failed, as shown in Fig. 6.

Based upon the load sustained it was calculated that type No. 5 would support a 13-in. brick wall 75.5 ft. high, type No. 6 a wall 186.5 ft. high, and type No. 7 a wall 253 ft. high. This was based upon the assumption that all of the weight was supported by the plates, a mush more severe loading than would actually take place. These tests, we believe, show that arc welding is entirely suitable for fastening lintel plates to I-beams, as in all cases the plates were bent before the welds failed. The arc welded lintel plate is superior to the riveted one in that it can be fabricated more cheaply. No counter-sinking of the rivet heads on the bottom of theplate is necessary with the arc welded plate.

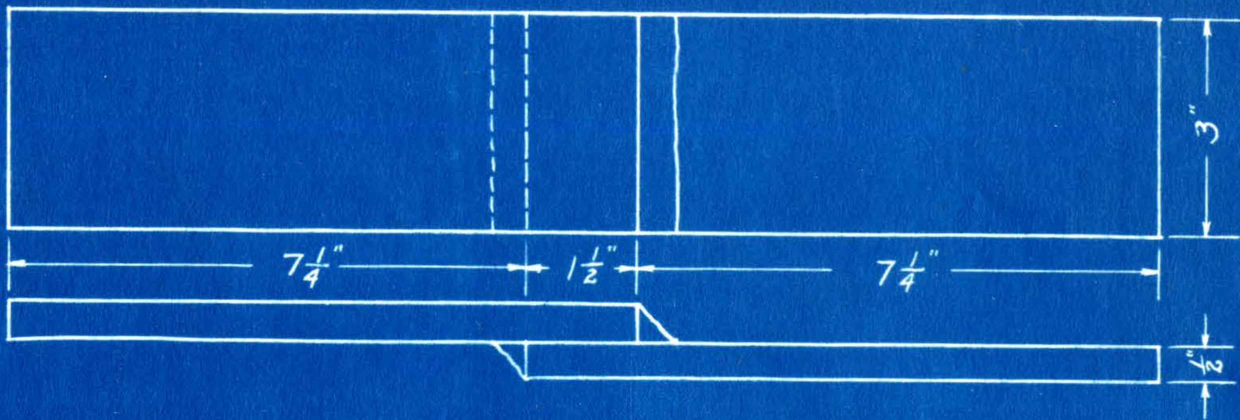


BUTT-WELD DOUBLE V T.P. 1

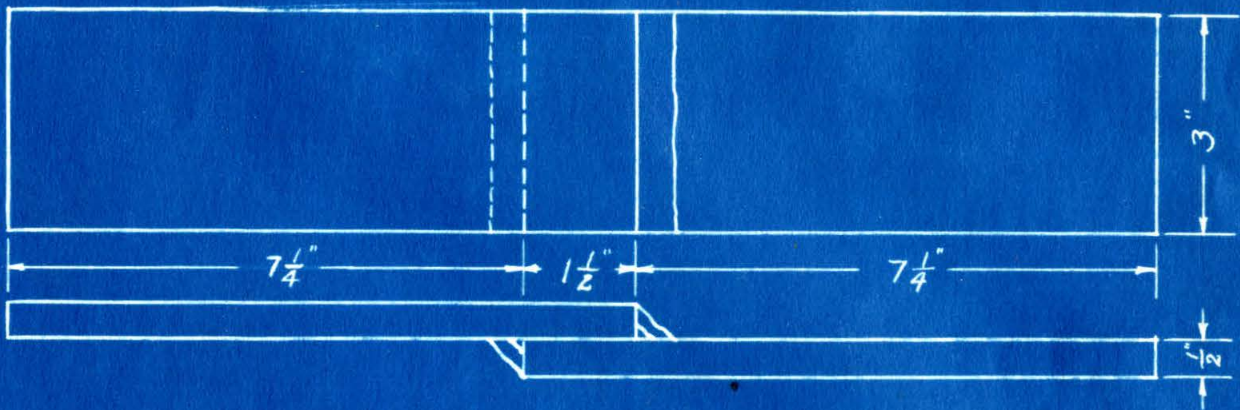


BUTT-WELD SINGLE V T.P. 2

Mark of piece	Breaking Load	Lin. in of bead to = one ¾ in. rivet 50,000#/in"	Breaking strength per. lin in of bead	Remarks
T.P.1A	53,200	1.04	21,300	Failed in the piece
B	52,900	1.04	21,200	" " " weld
C	52,200	1.06	20,900	" " " "
Ave.	52,770	1.05	21,100	
T.P.2A	46,650	1.18	18,700	Failed in the weld
B	37,150	1.48	14,900	" " " "
C	38,200	1.44	15,300	" " " "
Ave.	40,670	1.36	16,300	

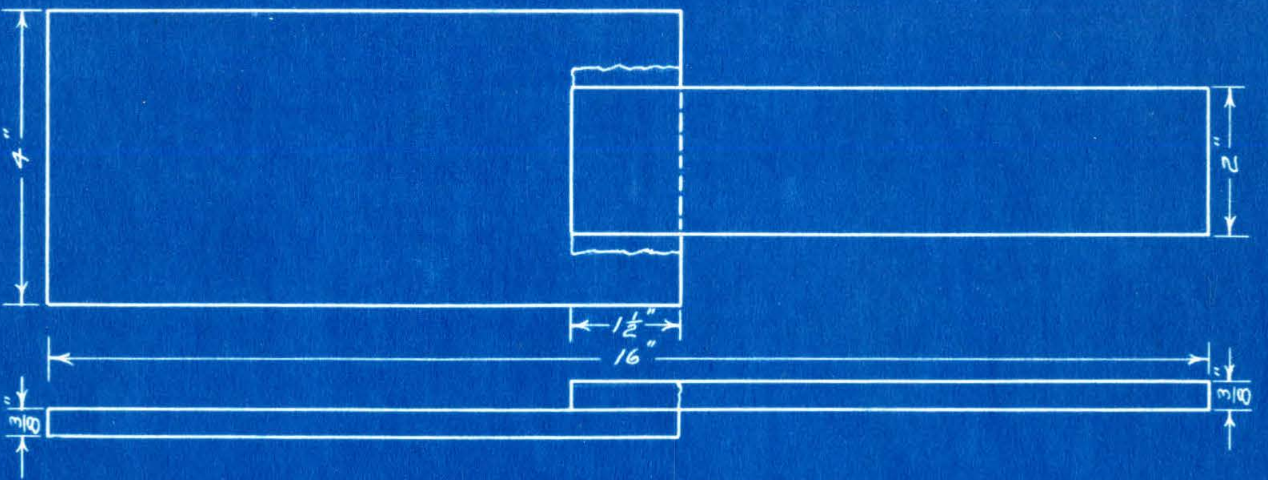


LAP WELD - SINGLE BEAD T.P. 3

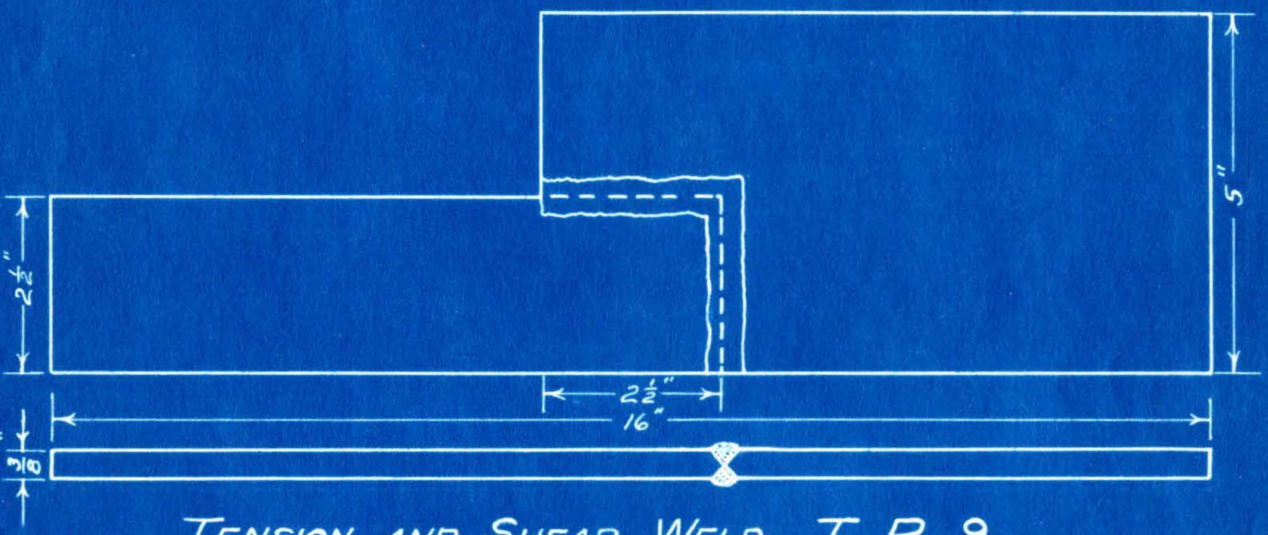


LAP WELD - DOUBLE BEAD T.P. 4

Mark of Piece	Breaking Load	Lin. In. of bead to = one $\frac{3}{4}$ in. rivet 50,000#/□"	Breaking strength per lin. in. of bead	Remarks
T.P. 3A	86,200	1.53	14,400	Failed in the weld
B	80,550	1.65	13,400	" " " "
C	84,010	1.58	14,000	" " " "
Ave.	83,850	1.59	13,950	
T.P. 4A	81,850	1.62	13,650	Failed in the weld
B	85,400	1.55	14,230	" " " "
C	80,675	1.64	13,450	" " " "
Ave.	82,640	1.60	13,780	

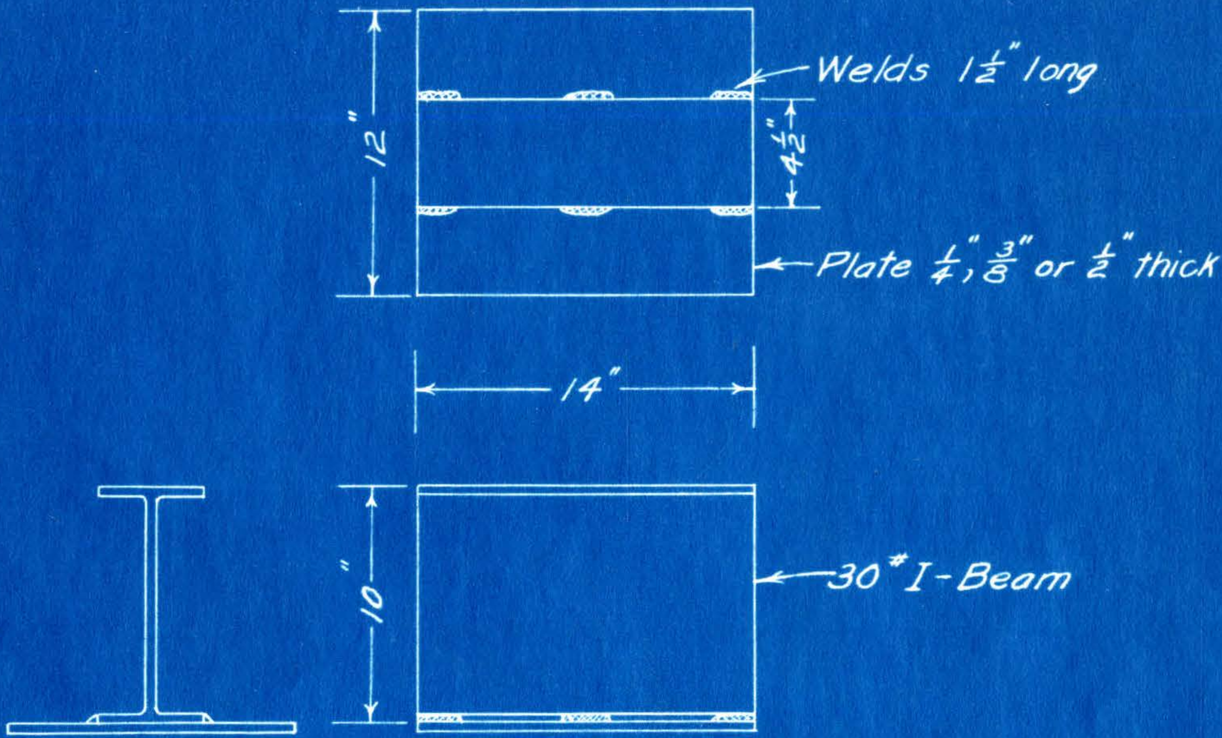


LAP WELD T. P. 8



TENSION AND SHEAR WELD T. P. 9

Mark of piece	Breaking load	Lin. in. of bead to = one ¾" rivet 50,000#/in.²	Breaking strength per. lin. in. of bead	Remarks
T.P. 8A	28,950	2.29	9650	Failed in the weld
B	28,100	2.36	9360	" " " "
C	29,675	2.24	9900	" " " "
Ave.	28910	2.28	9630	
T.P. 9A	55,800	1.98	11,180	Failed in the piece & in the weld
B	54,150	2.04	10,850	Failed in the piece
C	50,100	2.20	10,050	" " " "
Ave.	53,350	2.08	10,650	



Mark of piece	Thickness of plate	Ultimate load	Heighth of equiv. 13" wall	Remarks
T.P. 5A	¼"	11,500		Bent Plate
B	"	11,250		Tore "
C	"	11,600		Bent "
Ave.	"	11,450	75.5'	
T.P. 6A	⅜"	29,600		Tore Plate
B	"	28,100		" "
C	"	27,100		" "
Ave.	"	28,270	186.5'	
T.P. 7A	½"	36,450		Weld Failed
B	"	39,800		" "
C	"	38,900		" "
Ave.	"	38,380	253.0'	

Fig. 1

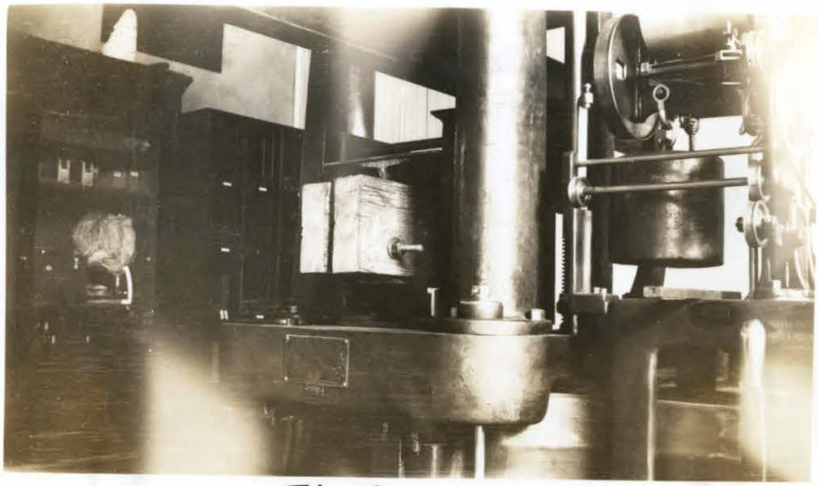


Fig. 2

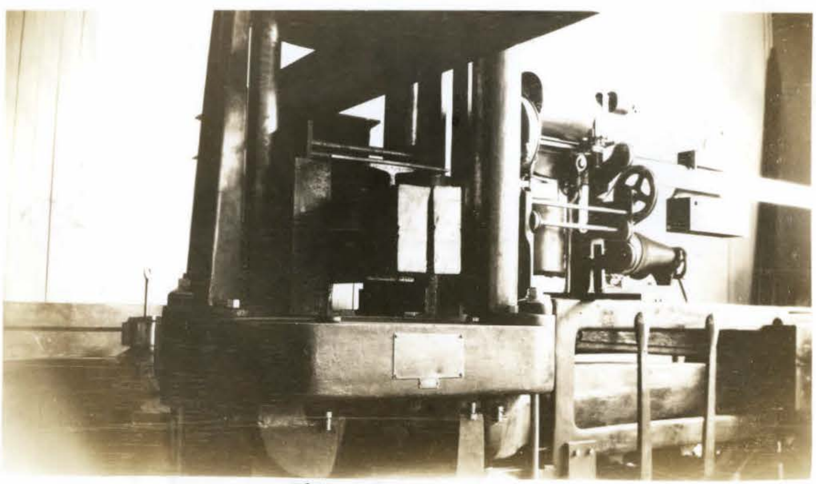
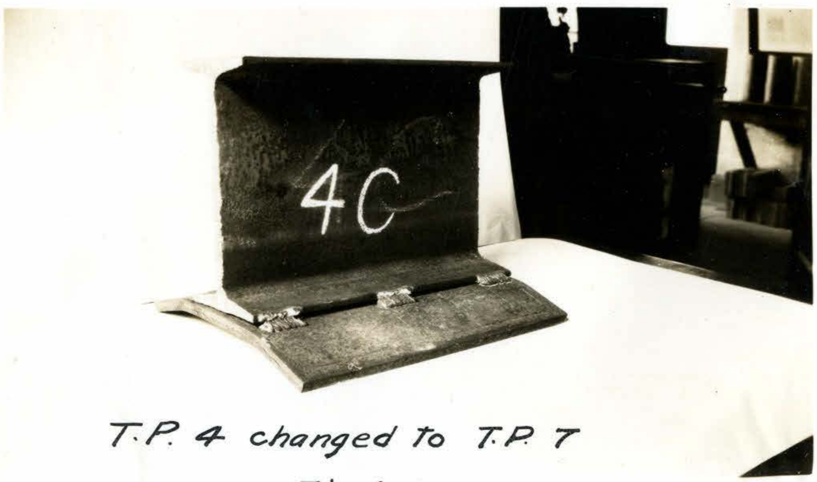


Fig. 3

Fig. 4

Fig. 5



T.P. 4 changed to T.P. 7

Fig. 6