ARC WELDING OF CAR

WHEEL FLANGES AND AXLES

GENERAL ELECTRIC COMPANY

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ARC WELDING OF CAR WHEEL FLANGES AND AXLES

General Information

One of the most difficult problems confronting the mechanic of a street railway car shop is that of building up worn flanges and axles. This class of work has been done with various degrees of success by the electric arc welding process, but no standard method of procedure has as yet been adopted.

Internal Stresses

It has always been recognized that internal stresses exist in car wheels and axles as a result of the manufacturing process, but their location has never been accurately determined. Welding by the electric arc process will in itself tend to produce additional stresses which will cause failure, if proper welding conditions are not obtained. The local heating to fusion of only a small portion of metal produces a tremendous straining in adjacent portions of the parts being welded which in turn influence the solidifying of the deposited metal and cause heavy straining in it by rapidly conducting away the heat.

Methods Sometimes Employed with Flanges

One method of building up car wheel flanges is to interrupt the continuity of the metal deposition and let a small section of the deposited metal cool while more metal is being added on a portion of the wheel at a considerable distance from the first deposit. The greatest drawback with this practice is that the results are uncertain and there is the danger that the wheel welded in this manner may stand up all right during the welding operation and break down when additional stresses are set up due to loading, moving over uneven tracks, or sudden application of brakes. Failures in such cases occur usually by chunks cracking out of the flange. Flaws and blowholes are very apt to be found in the deposited metal due to starting and stopping the arc at various points thus increasing the possibility of failure.

Another less popular method for reducing the amount of accumulated stresses is that of keeping the wheel cool during the welding operation by immersing it in water except for a small portion which is left exposed to the action of the arc.

A method which is claimed to secure good results and which has been used with a fair degree of success on locomotive tires is to deposit the metal on the flange in a single layer using an electrode about 1/4" in. diameter. With this method the arc must be hot enough to cause the molten metal to flow rapidly so that the amount of heat communicated to the wheel is minimized. The metal is put on the flange at an angle of approximately 30 degrees to the direction of wear on the wheel. See. Fig. 1.

A method for rebuilding flanges on locomotive tires which was recommended at a recent convention of the International Railways General Foreman's Association is somewhat different than any heretofore described. A 3/16" coated carbon steel wire with a carbon content as high as 60 or 75 points is employed in order to obtain a degree of hardness as near that of the original tire as possible consistent with safety from failure. When applying the metal, the start is made on one side of the wheel at a point corresponding to the horizontal center line and welding in an upward direction to the center line at the top. This process is then repeated by starting on the opposite side and welding upward to the top finishing half of the wheel. The engine is then moved a sufficient amount to allow of finishing the opposite half in the same manner. With this method the wheels need not be removed from the locomotive. See Fig. 2.

Methods Sometimes Employed with Axles

The practice of welding car axles has not been regarded with much favor due to liability of failure in service before sufficient mileage is obtained. Some railway companies are building up the bearing surface of worn axles and are getting a fair mileage.

Fig. 3 shows how the metal is sometimes put on the axle. By depositing the metal parallel to the axis of the axle in this manner it is claimed that contraction stresses are minimized resulting in a more lasting weld. On the average about 150 amperes with a 5/32" electrode are used. Practices vary in different cases, however.

Comparative Costs of Rebuilding Flanges

The cost of building up a 63" locomotive tire under shop conditions is approximately as follows:

18 lbs. welding wire 3/16" x 14"	@ $0.15 lb.	$2.70
45 kw-hr. power	@ 0.02 per kw-hr.	
6 Hours labor	@ 0.75 per hr.	4.50
TOTAL	-	$8.10

This figure will vary slightly depending upon the size of the tire, skill of the operator, amount of material, etc., but it represents average conditions. The cost of acetylene welding these tires is about $8.00 more per tire due to the price of the gas. It is good practice (although not always followed) to remove the wheels and machine the tire after welding, thereby making a good smooth job.@ 0.70 per hour1.40

The cost of turning down a 63" locomotive tire with a worm flange necessitating removing 5/8" of service metal from the tread is shown as follows:-

210 lbs. of metal	@ $0.05¾ lb.	$12.07
Removing 2 hours	@ 1.20 per hour	2.40
Oil for heating, 3 Gals.	@ 0.08 per gal.	.24
Portage		.55
Turning 2 hours	@ 0.70 per hour	1.40
Applying 2 hours	@ 1.20 per hour.	2.40
Oil for heating, as before		.24
	TOTAL-	$19.30

These figures show a considerable saving for arc welded flanges. It is estimated that the life of the tire will be increased from one third to one half by the use of arc welding.

Some idea of the value of the automatic arc welding process as applied to the rebuilding of worn flanges in street railway car shops may be obtained from the following approximate figures which have been taken from data on installations of General Electric automatic arc welding equipment. The figures given are for a pair of forged steel wheels.

INSTALLATION "A"

Welding labor, 5 hours	@ 0.55 per hour	$ 2.75
Turning, 4 hours	@ 0.75 per hr.	3.00
Material, 10½ lbs.	@ 0.10 per lb.	1.05
Power, 4½ kw. for 5 hours	@ 0.02 per kw-hr.	.45
	TOTAL-	$ 7.25

INSTALLATION "B"

Welding labor, 6 hours	@ $0.56½ per hour		$3.40
Turning	4 hours	@ 0.65½ per hour	2.60
Material	15 lbs.	@ 0.10 per lb.	1.50
Power 5.1 kw.	for 6 hours	@ 0.02 per kw.-hr.	.60

TOTAL--$7.10

INSTALLATION "C"

Welding labor, 7 hours	@ 0.56½ per hour		$4.00
Turning	7 hours	@ 0.55½ per hour	4.00
Material	15 lbs.	@ 0.10 per lb.	1.50
Power 5.1 kw.	for 7 hours	@ 0.02 per kw.-hr.	.71

TOTAL--$9.21

The cost of a new pair of wheels is about $70 and ordinarily after being worn sufficiently to require repair will not allow of further service after a new flange is turned unless the flange is built up by welding before turning.

Comparative Cost of Reclaiming Axles

The cost of rebuilding the bearings of car axles may be illustrated by the following figures:-

Labor, 15 hours	@ 0.75 per hour	$11.25
Material, 30 lbs.	@ 0.10 per lb.	3.00
Machining, 2 hours	@ 0.75 per hour	1.50
Power, 3 kw. for 15 hrs.	@ 0.02 per kw.-hr.	.90

TOTAL--$16.65

The cost of a new axle is about $30.00 so that the repair by arc welding represents a saving of about 45%. These figures will undoubtedly vary with different practices and types of axle but these average figures given will serve to show how considerable savings may be secured.

Economies Effected by the Arc Welding Process

On the average a new forged steel car wheel will run about

60,000 miles before it is necessary to repair the flange. However, this figure varies somewhat depending on the location and layout of the system, upon which that wheel is operating. It is generally considered that 5,000 miles of service will wear the tread of a car wheel about 1/16 of an inch so that about 3/4 of an inch of service metal has been worn off when the flange necessitates repair. Ordinarily, the tread of a new forged steel wheel is about 1½ inches thick, so that after the wheel has seen 60,000 miles of service, the tread thickness is only 3/4" thick. Now, if the wheel is machined in the lathe in order to secure a proper flange contour at least 1/4 of an inch of service metal must be removed from the tread of the wheel. This procedure leaves a final tread thickness of 1/2" or under which is below the safe operating limit and the wheel must therefore be scrapped after giving 60,000 miles of service. Even if the original tread thickness should be such as to allow of some service after the worn flange has been turned up, the removal of 1/4 of an inch of service metal from the tread removes approximately 20,000 miles from the useful life of the wheel. This represents a total loss.

Now, if the worn flange is rebuilt by arc welding and then turned to the proper contour without touching the tread at all, approximately 35,000 miles of additional service may be secured before the wheel must be scrapped. With the General Electric automatic welder this saving is possible and is actually being accomplished at the present time in several instances. See Fig.4.

RECOMMENDED PRACTICE FOR REPAIRING FLANGES

Welding Technique

The practice of welding car wheel flanges is far from standard but data already obtained from successful application of the process indicates a fairly definite procedure. An electrode wire of the ordinary commercial grade 5/32 of an inch in diameter with about 170 amperes may be used. The speed of travel at the arc should be about 5 or 6 inches per minute. Instances are known where a current of 225 amperes on 1/8 inch diameter electrode have been used but the speed of travel at the arc was about 7 inches per minute. This gives a more rapid metal deposition than the lower current value but the heating effect in the latter case is undoubtedly considerably greater and this heating effect should be minimized in order to avoid the harmful results of expansion and contraction.

Preheating and Annealing

Preheating and annealing has been advocated as a panacea for correcting the harmful effects of expansion and contraction. Machineability of the deposited metal is not the determining factor as in many shops grinders are used for removing flat spots and rounding out flanges. Heat treatment of welded wheels cannot be recommended from the cost standpoint as it has been found that a wheel treated in this manner costs about as much as a new one. Hence, no saving is effected. Also it may be safely said that there is no preheating apparatus at present which satisfactorily accomplishes the desired results.

Failures of Flanges and Their Causes

There are instances where several hundreds of flanges have been rebuilt without any failure of the wheels occurring in service or during the welding operation. Usually when failure occurs either the wheel cracks through the tread or the flange breaks out in chunks due to improper welding procedure or failure to observe certain precautions.

One prominent cause for failures of car wheel flanges is the tendency to allow the wheels to remain in service until the flange has worn so thin that it cannot be built up without cracking off. It is very important that car wheels be removed and welded before the flange has worn too thin to permit of successful welding. Just what this limit is is not definitely known but on one railway which is using General Electric automatic epuipment the flanges are not allowed to wear thinner than 3/4 of an inch. When the flange has worn to this thickness the wheels are removed and the flanges welded. No breakages have occurred with this practice.

RECOMMENDED PRACTICE FOR REPAIRING AXLES.

Welding Technique

The welding of car axles has been regarded with distrust in some instances because of conservatism and in others because of a few failures. Where this class of work has and is being done successfully the same welding technique is used to deposit metal as is used when welding flanges. The metal should be put on spirally instead of in the manner shown in Fig. 3. Preferably these spirals should run in the direction of the torque which is applied to the axle.

No standard method of procedure can be recommended due to lack of information but it may be truthfully stated that in some instances car axles are being welded successfully by the automatic process. See Fig. 5.

Preheating and Annealing

The cost of preheating and annealing a welded axle bring the cost of repairs approximately up to the cost of a new axle and besides this consumes much valuable time. Most railway car shops are not equipped for this class of work and usually the amount of work necessary would not compensate for the installation of such facilities.

Failures of Axles and Their Causes.

Failures of car axles usually occur at the inside bearing shoulder where the bearing stress is concentrated. Usually the bearing surface is built up and machined to size without any attention being given to the junction at the bearing shoulder. The result is that a crack developes in the junction between the deposited metal and the shoulder surface which ultimately causes failure under the repeated stresses imposed by the pounding of the wheels on the rails.

It is known that axles crystallize after a certain period of service as a result of repeated stresses caused by pounding of the wheels, uneven wheels, etc. Arc welding will not improve this condition hence fractures are sometimes caused by excessive crystallization. In order to avoid this condition axles should not be allowed to run beyond a certain limit, which is yet to be determined, in order to get good results from the welding process. The usual thought is to get as much wear as possible before welding the axle but this attitude must be changed if the savings possible by using the welding process are to be secured.

In order to avoid the concentration of stress which undoubtedly occurs at the bearing shoulder of a welded axle it has been suggested tha. the bearing should be turned off in a lather so that the axle will be conical in shape where the shoulder is located normally. The bearing surface should also be turned slightly to remove the oil bearing layer and then the weld metal should be laid on the clean new metal surface. One great object of this procedure is to remove the abrupt junction of bearing shoulder and weld so that a concentration of stress is avoided. It is suggested that the conical surface in question have a slope of approximately 30 degrees to the axis of the axle.

K. A. PAULY, ENGINEER
INDUSTRIAL ENGINEERING DEPT.

Prepared by: W. L. Warner

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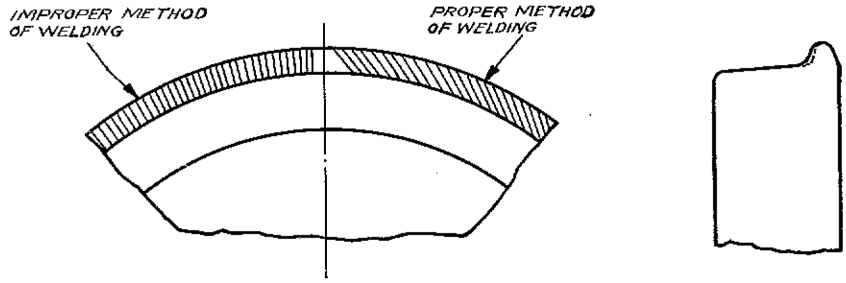

FIG-1. SHOWING A METHOD OF BUILDING UP A TIRE FLANGE WITH HAND WELDING PROCESS.

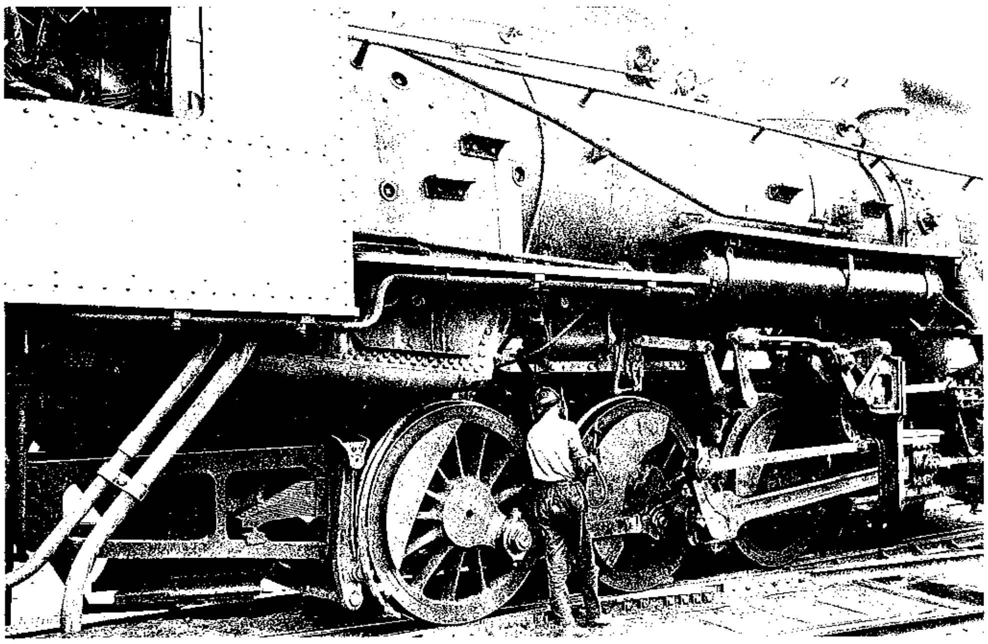

FIG.2. SHOWING HOW FLANGES AND FLAT SPOTS ARE BUILT UP WITHOUT REMOVING THE WHEELS FROM THE LOCOMOTIVE.

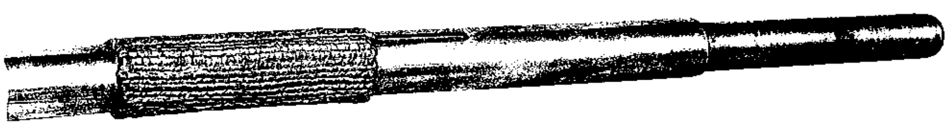

FIG-3. A METHOD OF PUTTING METAL ON A WORN AXLE BY THE HAND WELDING PROCESS.

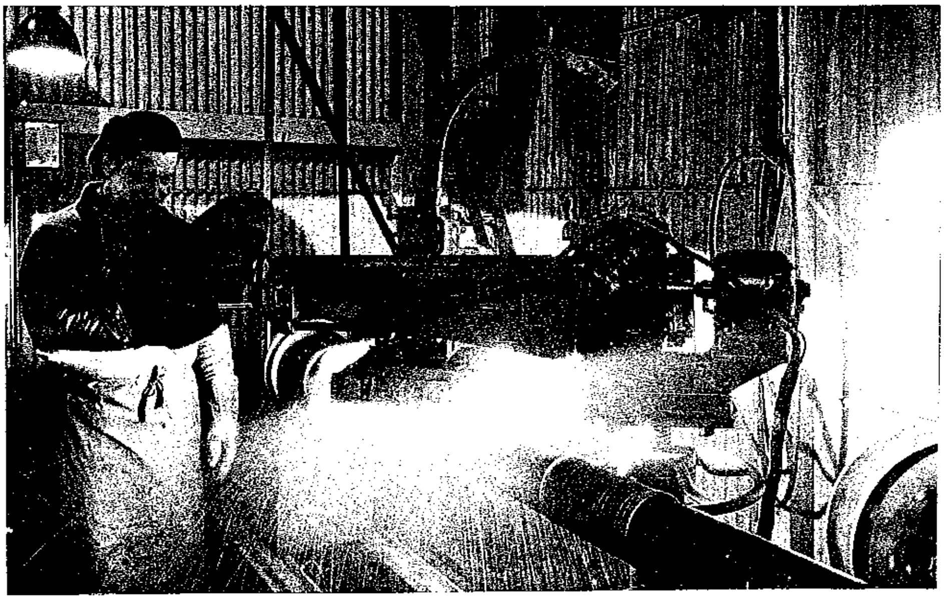

FIG. 4. GENERAL ELECTRIC AUTOMATIC ARC WELDING MACHINE IN OPERATION BUILDING UP A CAR AXLE IN THE SHOPS OF THE WORCESTER CONSOLIDATED STREET RAILWAY CO. 200 AMPERES AND 5/32" BARE ELECTRODE USED.

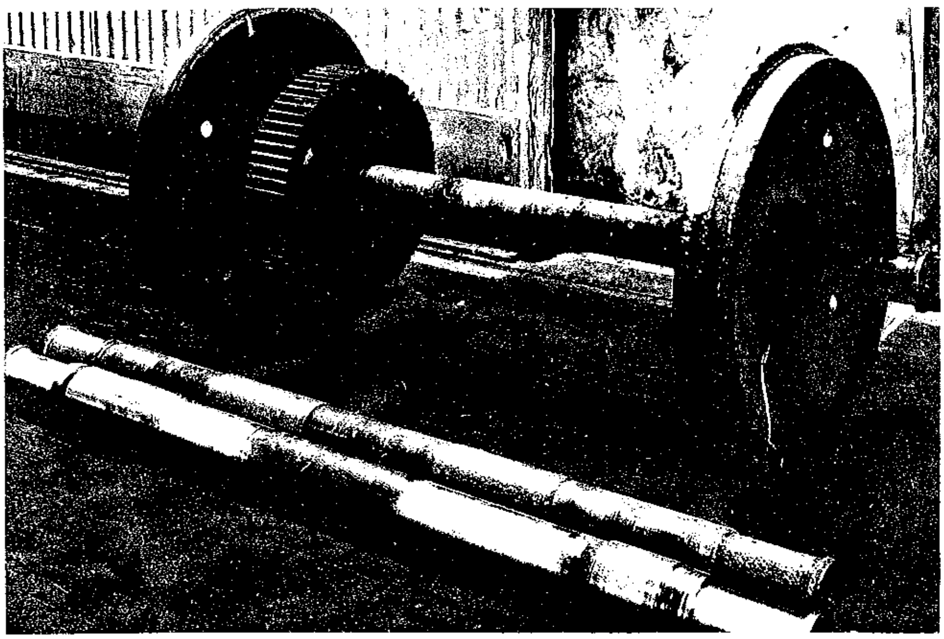

FIG. 5. ARC WELDED CAR WHEEL FLANGES AND AXLES IN THE SHOPS OF THE WORCESTER CONSOLIDATED STREET RAILWAY. THE AXLE TOWARD THE CAMERA HAS BEEN WELDED AND MACHINED.