Topic No. 5

(Continued from 1940)

APPLICATION OF IRON, STEEL AND ALLOY RIVETS, WITH RECOMMENDATIONS AS TO THE PROPER METHODS OF HEATING AND DRIVING, INCLUDING THE PREPARATION AND FABRICATION OF SHEETS, RIVET HOLES AND OTHER INVOLVED PARTS, IRON, STEEL AND ALLOY MATERIALS, INCLUDING TOOLS USED WITH THE APPLICATION AND PLATE FABRICATION.

A. G. Trumbull, Chairman
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To the Officers and Members of the Master Boiler Makers' Association:

Development of the locomotive boiler during the early history of the locomotive was gradual but slow and for many years progress in the design and construction of boilers and locomotive parts followed a pattern suited to the type of construction characteristic of those days. Boiler pressures were moderate and did not exceed 180 pounds. With such pressures boiler plates were thinner, joints and laps readily formed, rivets easily driven and no difficult problems encountered. Burden's Best Iron was a sort of universal standard for rivets, they were comparatively easily driven, whether by hand or machine and they continued to be used until higher pressures and larger boilers made them less desirable than the steel rivets generally employed today.

The necessity for improved transportation facilities for the movement of large volumes of freight and the demand for speed in those movements led naturally to locomotives of increasing size, demanded by the requirements for large hauling capacity. Then, following the observations made during the first World War concerning the value of large combustion chamber volumes, the possibilities that depended upon locomotive hauling capacity and the relation that this has to develop horsepower, an entirely new set of conditions resulted. These involved much larger boilers, higher steam pressures, demanding heavier and larger boiler plate connections and rivets which introduced new and different fabricating conditions. The processes required in the fabrication of these boilers were the same as before, but the increased dimensions and weight of the plates introduced difficulties and demanded a different procedure from that which had existed for so many years.

The use of larger boilers and the consequent increase in total evaporation aggravated the troubles occasioned by encrustation which expedited the adoption of means for improving boiler water conditions which, in certain sections of the country, was followed by the difficulty now known as "intercrystalline corrosion," a term descriptive of the condition which develops in steel when subjected to high stresses in the presence of sodium hydroxide. The fact that these stresses are influenced by any factor producing a load on the rivets naturally led to a study of the various means for the reduction of rivet stresses regardless of the manner in which these are produced, that is, whether directly by the normal stresses in the joint resulting from pressure or indirectly by stresses introduced in the rivets by driving at excessively high pressure or otherwise. This, in turn, led to consideration of all of the factors tending to increase the load on rivets beyond that produced by steam pressures and boiler design. It was not until much study had been given to the matter of intercrystalline corrosion that the possibility of introducing conditions favorable to this development through excessive rivet driving pressures became a subject of importance in boiler fabrication.

The studies to which reference is made have led to definite conclusions which may be grouped under the following headings, under which appear corresponding discussions:

Assembling of Plates—Stresses upon rivets in horizontal seams may be greatly minimized through the proper preparation of the seams through which the rivets are finally driven. This requires that the longitudinal courses be so formed that the sections of the plates which are to be joined shall have the same radius as that to which the course itself is to be made. This requires either that the adjoining edges shall be pressed to the proper radius or that the course be rolled and the flat portions of the adjoining plates discarded. Either of these procedures, if properly performed, will produce the desired results, although it is obvious that the use of the pressed edges will involve the least expense. The outside and inside welt straps should likewise be accurately formed in dies having the proper radii.

The subject of boiler fabrication has been very well covered in the report of the Committee on Topic No. 5, made to the Association in 1940. The following revisions and additions, however, are suggested in order to more completely insure accuracy in the preparation of the plates for rivet application to insure that the plates are drawn metal to metal and that the rivets are not over stressed, but are tight enough to avoid seepage through the rivet holes and joints. This is necessary to avoid intercrystalline corrosion of the metal both of rivets and plates. In lieu of the paragraph relative to the application of temporary bolts both in the circumferential and horizontal seams, substitute the following:

> Assemble shell courses by heating one course at the girth seam and then entering the unheated courses into the heated one. It is suggested that the allowable shrinkage be established at a maximum of 3/16" and a minimum of 1/8", measured on the outer circumference of the course which is to be telescoped. Care should be exercised in the assembly to avoid setting up stresses.
>
> Boiler shell courses are required to be bolted together first at quarter, then at eighth and so on in sequence of holes opposite one another, and when riveting the same procedure should be followed. In this procedure the temporary bolts should be placed in every other hole.

It is also suggested that the following requirements be added to the portion of the 1940 report covering fabrication which relates to longitudinal seams:

> Longitudinal shell course seams which are designed with inside and outside welt straps, multiple riveted, shall have the welt straps and rivets caulked inside and outside. Inner welt straps of longitudinal shell course seams shall be scalloped to facilitate caulking.
>
> Flanging of tapered courses on a bull machine to make them fit other courses, or drawing up plates on the bull machine will not be permitted.
>
> Eccentricity of the shell courses should be kept to a minimum and when finally assembled and riveted should not exceed 1/4".

In its report of 1940 on Topic No. 5, the committee illustrated certain tools suggested for caulking operations, these including a fuller caulking tool as well as a combined square and fuller type. Experiments made under the supervision of the Secretary-Treasurer indicate that the fuller type of tool may cause a separation of the plates back of the caulking edges. The original specimen of the plates used in these experiments were 36" long and the rivets were driven at a pressure of 90 tons on a hydraulic bull riveter, the plates originally having been metal to metal which was the

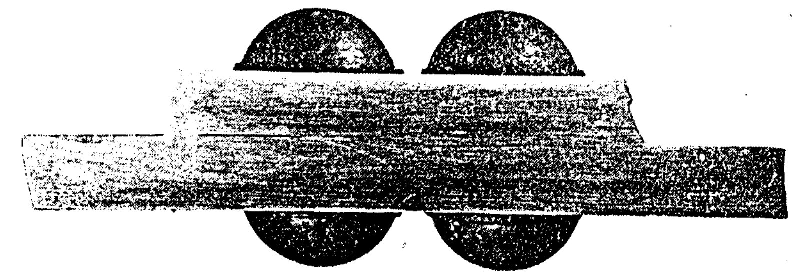


Illustration No. 1 Illustration No. 2

condition after the rivets had been driven and before any caulking had been performed. A fuller caulking tool was used on one side of the plate and a combination square and fuller caulking tool on the other side, both sides being heavily caulked to determine what results would be obtained. The condition resulting from the use of the fuller caulking tool only appears in the following illustration, No. 1, which clearly shows the separation which has occurred between the plates. A similar condition using a combination tool appears in illustration No. 2, which shows no separation between the plates.

Since the avoidance of conditions contributing to intercrystalline corrosion is now an important factor in boiler construction, it is important that the plates remain in contact, which is evidently prevented by the use of a fuller caulking tool, which it appears should be avoided.

Since the preparation and publication of the 1940 reports, the Committee of the Mechanical Division of the Association of American Railroads on Specifications for Materials has submitted recommendations covering specifications for rivet steel and rivets, applicable, however, only to carbon steel. In the interest of standardization, your committee suggests that favorable consideration be given to the adoption of these specifications which cover tolerances for both rivets and rivet heads. A copy of these specifications appears as an appendix to this report. Where it is desired that any modifications in these specifications be proposed, the Secretary of the Master Boiler Makers' Association should be advised, details of the proposed changes being furnished with the reasons therefor.

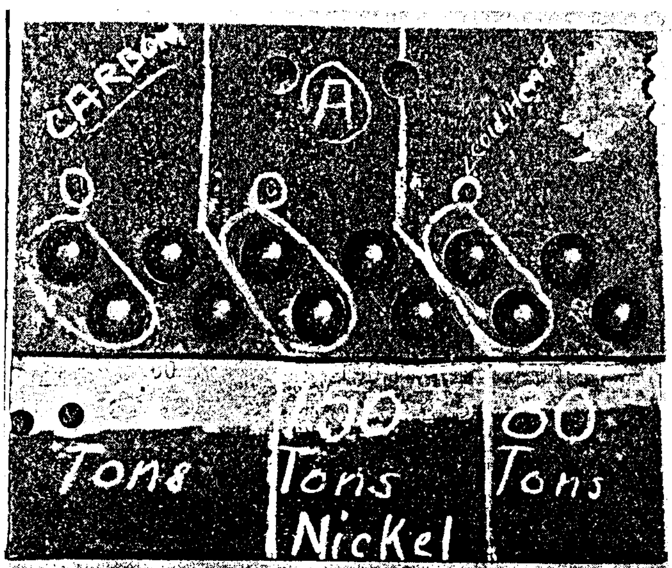
Heating of Rivets—In its report of 1940, the committee gave consideration to rivets and riveting, and remarked that:

"Cold made rivets are well suited to heating in electric rivet heaters." Your committee is of the opinion that this type of heater does not produce the uniformity in heating that can be obtained with those forms of heaters having firebrick lining designed for use with oil burners. Since, with the electric heaters, the ends of the rivets are heated first, it is apparent that there must be considerable variation in the temperature from one end of the rivet to the other. In order to secure proper and uniform filling of the holes, it is desirable that this condition be avoided. Proper expansion of the hot rivet in the hole and satisfactory formation of the heads may be obtained when the rivet temperature is held between 1800 and 1900 degrees F.

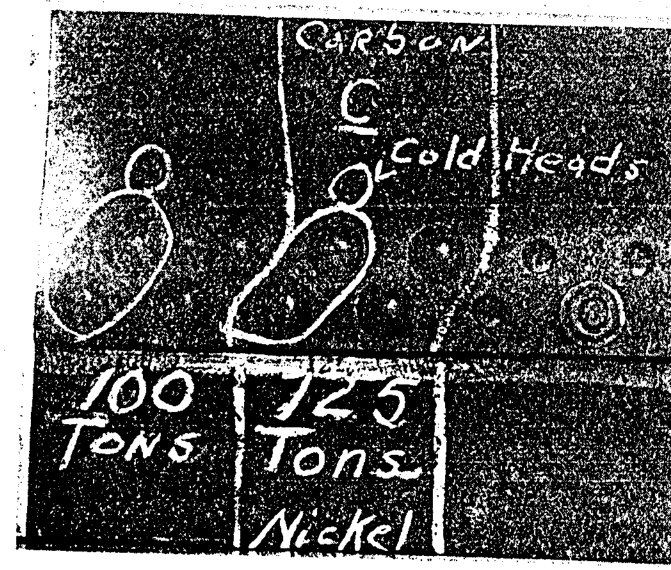
Rivet Pressures—In the consideration of rivet pressures, it is necessary to distinguish between pressures per square inch of the rivet diameter and pressures per square inch of the rivet hole. It is obviously necessary that the holes be increased beyond the normal diameter of the rivet in order to provide for expansion of the rivets under the temperatures to which they are heated and it is likewise necessary that the pressures be expressed in net tons actually applied to the rivet. Pressures at the accumulator may be substantially reduced because of factors introduced by the design of the bull machine itself. The bull machine is generally provided with a release mechanism which exerts a pressure opposite to that required in driving the rivet itself. Other factors also tend to reduce the net pressure of application below what it would be without these factors. These are friction of the parts both of the bull and the piston packing. Variation in these factors requires that their influence be determined so that the pressure actually applied to the rivet may be the net pressure after allowance for these factors. Obviously, it is necessary that this determination be made separately for each bull machine.

Experimental Data—In order to determine the effect upon plates produced by different riveting pressures, sections were made by the American Locomotive Company and tested with carbon steel plates and carbon steel rivets. The following photographs show the conditions which developed on driving carbon steel rivets at the pressures shown.

Photographs 1 and 2 show the conditions which developed on the surface of the plate after the rivets were driven at the several pressures shown on the photographs. Rivets which were driven with the temperature of the rivet on the cold side are encircled in white; whereas, those which are not encircled in white were driven at a more normal heating temperature.

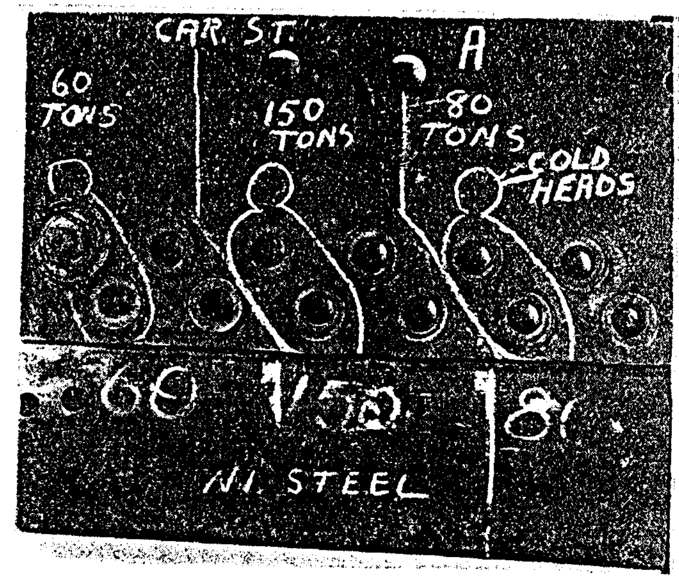


Before removing rivets—Photo No. 1

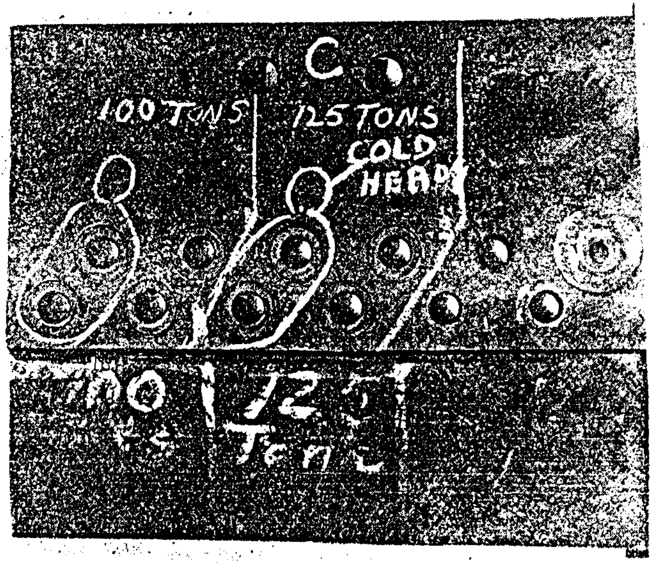


Before removing rivets—Photo No. 2

Photographs 3 and 4 show the condition of the surface of the plate, including that under the head of the rivets, as well as the condition of the rivet holes. These rivets were carefully removed in the laboratory by machining and driving out.



After removing rivets—Photo No. 3



After removing rivets—Photo No. 4

Particular attention is called to the scalloped condition which developed to a minor degree at 100 tons and which appears more pronounced at pressures of 125 and 150 tons.

Sketches A and C correspond with photographs 1, 2, 3 and 4. The Brinell hardness tests of the plate itself are shown, together with Rockwell "B" hardness tests of the plate in the area unaffected by the riveting pressures, as well as results in the area of the plate under the rivet head affected by riveting pressures. The Rockwell hardness tests appear to show variations approximately as follows:

CARBON PLATE "A" and "C"

Unaffected by riveting pressures

Rockwell "B" Hardness 62-73

Under Head Driving Pressure 60 Tons R.H. 79-86

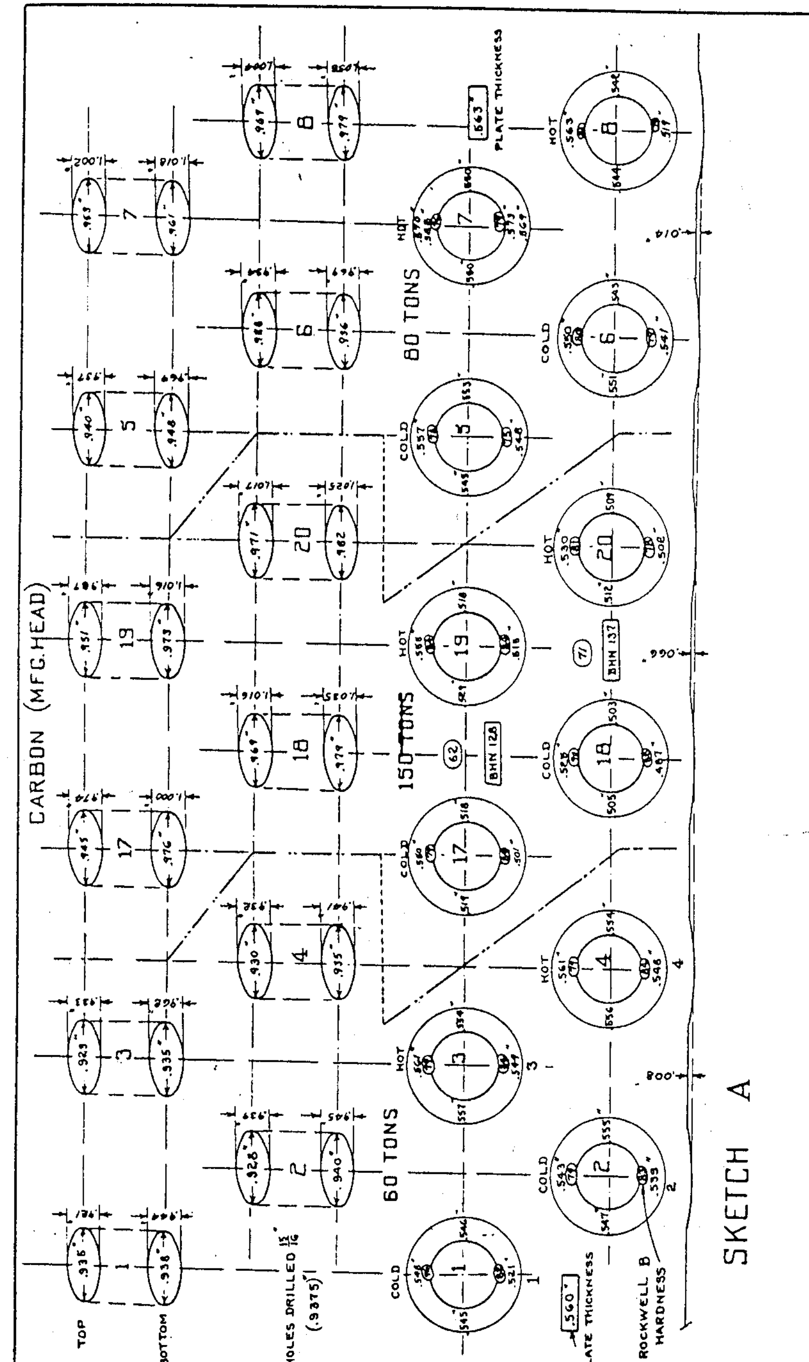
Under Head Driving Pressure 80 Tons R.H. 75-81

Under Head Driving Pressure 100 Tons R.H. 78-89

Under Head Driving Pressure 125 Tons R.H. 76-93

Under Head Driving Pressure 150 Tons R.H. 78-90

Measurements were taken in two directions at the inner and outer side of the plate to show the amount of distortion of the rivet holes after driving rivets at different temperatures and pressures. The findings were as follows:



CARBON (MFG. HEAD)

	60 TONS					80 TONS			
Temp.	*Hole No.*	*Position*	*Transv.*	*Long.*	*Temp.*	*Hole No.*	*Position*	*Transv.*	*Long.*
COLD	1.	Top	.935	.921	COLD	5.	Top	.940	.937
		Bott.	.938	.944			Bott.	.948	.969
	2.	Top	.928	.939		6.	Top	.928	.934
		Bott.	.940	.945			Bott.	.936	.969
HOT	3.	Top	.929	.933	HOT	7.	Top	.953	1.002
		Bott.	.935	.962			Bott.	.961	1.018
	4.	Top	.930	.932		8.	Top	.969	1.004
		Bott.	.935	.941			Bott.	.979	1.058
	100 TONS					125 TONS			
COLD	9.	Top	.966	.937	COLD	13.	Top	.926	.943
		Bott.	.951	.949			Bott.	.945	.969
	10.	Top	.965	.960		14.	Top	.960	.962
		Bott.	.991	.979			Bott.	.977	.996
HOT	11.	Top	.936	.946	HOT	15.	Top	.956	.964
		Bott.	.949	.957			Bott.	.968	1.011
	12.	Top	.946	.957		16.	Top	.957	.976
		Bott.	.956	.966			Bott.	.968	.982

150 TONS

Temp.	*Hole No.*	*Position*	*Transv.*	*Long.*
COLD	17.	Top	.945	.974
		Bott.	.976	1.000
	18.	Top	.969	1.016
		Bott.	.979	1.035
HOT	19.	Top	.951	.987
		Bott.	.973	1.016
	20.	Top	.971	1.017
		Bott.	.982	1.025

Particular attention is invited to the variation in the thickness of the plate under the rivet head after being driven at the various pressures. The discrepancies observed are listed below:

THICKNESS .563
CARBON

		Thickness under rivet	*Difference*
60 TONS	COLD	.521"-.555"	.042"-.008"
	HOT	.548"-.561"	.015"-.002"
80 TONS	COLD	.541"-.557"	.022"-.006"
	HOT	.519"-.588"	.044"-.025"+
100 TONS	COLD	.503"-.554"	.060"-.009"
	HOT	.526"-.560"	.037"-.003"
125 TONS	COLD	.506"-.553"	.057"-.010"
	HOT	.511"-.560"	.052"-.003"
150 TONS	COLD	.487"-.550"	.076"-.013"
	HOT	.502"-.555"	.061"-.008"

The results of this investigation appear to warrant the conclusion that the plate material is considerably affected at pressures of 125 and 150 tons, which obviously makes it desirable that rivet pressures be held below the higher of these two values.

The experience of the builders has indicated that a driving pressure approximating 85 tons per square inch of driving rivet area will provide sufficient pressure and suit the bull riveters now available to the builders. On this basis, your committee proposes the adoption of the following driving pressures, which it will be observed do not exceed a maximum of 125 tons per square inch for the great majority of rivets required in modern boiler construction.

Diameter—In. Rivet	Hole	*Area—Sq. Ins.* Rivet	Hole	*Total Pressure On Rivet Hole at 85 Tons per Sq. In.*	*Recommended Tolerances*
7/8"	15/16"	.6013	.6903	58.675 Tons	55-62
1"	1 1/16"	.7854	.8866	75.361 Tons	60-80
1 1/8"	1 3/16"	.994	1.1075	94.137 Tons	85-100
1 1/4"	1 5/16"	1.227	1.353	115.005 Tons	108-122
1 3/8"	1 7/16"	1.4849	1.623	137.955 Tons	131-148
1 1/2"	1 9/16"	1.7671	1.9175	162.987 Tons	153-164

The original assignment of this subject covered alloy and other materials for both plates and rivets, but nickel is the alloy most generally in use and since the Preparedness Program has been in effect, this has not been available, it has been impossible to make any experiments and verification of existing or development of new practices with respect to materials utilizing this alloy.

Your committee suggests the advisability of a trial of the recommendations that have been made and that a report be rendered in verification or otherwise, of the standard practices which are proposed. This will permit a supplementary report to be made recommending standards of pressure and holding time for adoption by the Mechanical Division of the Association of American Railroads. This will require that the subject be continued and a report rendered to the Master Boiler Makers' Association at its 1942 meeting.

In submitting this report, the committee acknowledges the valuable assistance rendered by the locomotive builders, especially the American Locomotive Company, and by the New York Central Railroad, who consented to the use of data accumulated in connection with tests conducted jointly with the American Locomotive Company.

TABLE I
HOT ROLLED CARBON STEEL BARS

Specified Size Inches	Variation from Size Inches — Over	Variation from Size Inches — Under	Out of Round Inches
7/16 or under	.005	.005	.008
Over 5/16 to 7/16, incl.	.006	.006	.009
Over 7/16 to 5/8, incl.	.007	.007	.010
Over 5/8 to 7/8, incl.	.008	.008	.012
Over 7/8 to 1, incl.	.009	.009	.013
Over 1 to 1 1/8, incl.	.010	.010	.015
Over 1 1/8 to 1 1/4, incl.	.011	.011	.016
Over 1 1/4 to 1 3/8, incl.	.012	.012	.018
Over 1 3/8 to 1 1/2, incl.	.014	.014	.021
Over 1 1/2 to 2 , incl.	1/64	1/64	.023

LARGE RIVETS

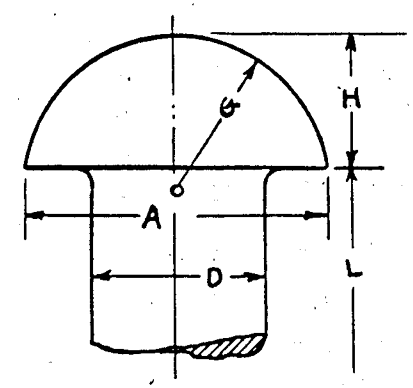


TABLE II. BUTTON HEAD. MANUFACTURED SHAPE

Diameter of Body D — Nominal		Diameter of Body D — Max.	Diameter of Body D — Min.	Diameter of Head A — Basic	Diameter of Head A — Max.	Diameter of Head A — Min.	Height of Head H — Max.	Height of Head H — Min. (Basic)	Radius of Head G
1/2	0.500	0.520	0.478	0.875	0.938	0.844	0.406	0.375	0.443
9/16	0.563	0.593	0.538	0.985	1.048	0.954	0.453	0.422	0.498
5/8	0.625	0.655	0.600	1.094	1.157	1.063	0.500	0.469	0.553
11/16	0.688	0.718	0.663	1.204	1.282	1.173	0.547	0.516	0.609
3/4	0.750	0.780	0.725	1.313	1.391	1.282	0.594	0.563	0.664
13/16	0.813	0.843	0.788	1.422	1.500	1.391	0.641	0.610	0.720
7/8	0.875	0.905	0.850	1.531	1.609	1.500	0.687	0.656	0.775
15/16	0.938	0.968	0.913	1.641	1.719	1.610	0.734	0.703	0.830
1	1.000	1.030	0.975	1.750	1.828	1.719	0.781	0.750	0.885
1 1/16	1.063	1.098	1.036	1.860	1.954	1.829	0.844	0.797	0.941
1 1/8	1.125	1.160	1.098	1.969	2.063	1.938	0.891	0.844	0.996
1 3/16	1.188	1.223	1.161	2.079	2.173	2.048	0.938	0.891	1.051
1 1/4	1.250	1.285	1.223	2.189	2.283	2.158	0.985	0.938	1.107
1 3/8	1.375	1.415	1.345	2.406	2.500	2.375	1.078	1.031	1.217
1 1/2	1.500	1.540	1.470	2.625	2.719	2.594	1.188	1.125	1.328
1 5/8	1.625	1.665	1.588	2.844	2.938	2.813	1.282	1.219	1.439
1 3/4	1.750	1.790	1.713	3.063	3.172	3.032	1.376	1.313	1.549

All dimensions given in inches.

Proportions (Basic): A = 1.75D; H = 0.75D; G = 0.885D.

Tolerance for diameter of body is plus and minus from nominal and for 1/2-inch size equals + 0.020, — 0.022; for sizes 9/16 to 1-inch, inclusive, equals + 0.030, — 0.025; for sizes 1 1/16 to 1 1/4-inch, inclusive, equals + 0.035, — 0.027; for sizes 1 3/8 and 1 1/2-inch equals + 0.040, — 0.030; for sizes 1 5/8 and 1 3/4-inch equals + 0.040, — 0.037.

Tolerance for diameter of head is plus and minus from basic and for sizes 1/2 to 5/8-inch, inclusive, equals + 0.063, — 0.031; for sizes 11/16 to 1-inch, inclusive, equals + 0.078, — 0.031; for sizes 1 1/16 to 1 5/8-inch, inclusive, equals + 0.094, — 0.031; for 1 3/4-inch size equals + 0.109, — 0.031.

Tolerance for height of head is plus from basic and for sizes 1/2 to 1-inch, inclusive, equals + 0.031; for sizes 1 1/16 to 1 3/8-inch, inclusive, equals + 0.047; for sizes 1 1/2 to 1 3/4-inch, inclusive, equals + 0.063.

The length (L) is measured from the largest diameter of the bearing surface of the head to the point in a line parallel with the axis of the rivet.

Rivets with fillets under the head of not more than 1/16-inch in radius are acceptable.

SMALL RIVETS

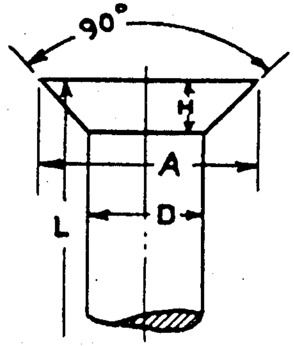


TABLE No. IX. COUNTERSUNK HEAD RIVETS.

Diameter of Body D				Diameter of Head A	Depth of Head H	Included Angle (Deg.)	Length Overall L
Nominal		Maximum	Minimum				
3/32	0.094	0.096	0.090	0.176	0.040	90	Ordered length
1/8	0.125	0.127	0.121	0.231	0.053	90	
5/32	0.156	0.158	0.152	0.289	0.066	90	
3/16	0.188	0.191	0.182	0.346	0.079	90	
7/32	0.219	0.222	0.213	0.407	0.094	90	
1/4	0.250	0.253	0.244	0.463	0.106	90	
9/32	0.281	0.285	0.273	0.520	0.119	90	
5/16	0.313	0.317	0.305	0.577	0.133	90	
11/32	0.344	0.348	0.336	0.635	0.146	90	
3/8	0.375	0.380	0.365	0.694	0.159	90	
7/16	0.438	0.443	0.428	0.808	0.186	90	

All dimensions given in inches.

Approximate Proportions: A = 1.850 x D
H = 0.425 x D

Tolerances. The tolerances on the nominal body diameter shall be those given in the following table:

Body Diameters (Inclusive)	Tolerances	
	Plus	Minus
3/32 — 5/32	0.002	0.004
3/16 — 1/4	0.003	0.006
9/32 — 11/32	0.004	0.008
3/8 — 7/16	0.005	0.010

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

Mr. Trumbull made the following interpolations:

Interpolation No. 1: Before the words, "Mr. Lents, Manager of the Schenectady Works of the American Locomotive Company, writes your Chairman that," Mr. Trumbull said: "Since writing this presentation here, I have had some conversation with Mr. Partington of the American Locomotive Company, who has been asked to make some remarks concerning this report, and he raised with me several questions concerning the rivet specifications. They were not prepared by your Committee on Topic No. 5. They have been adopted as a standard of the American Association of Railroads, who proceeded apparently without consultation with the Boiler Makers' Association, a situation which I hope will not be raised again. We will undertake to see that is not.

"But I have no knowledge myself concerning the details of those specifications, its origin, or what comments were made by the rivet manufacturers. It is apparent however from the form in which it appears that it has appropriate origin and the rivet manufacturers must have had some hand in its preparation. I have no information by which I can give you that assurance."

Interpolation No. 2: Before the words, "However, we as builders must work to specifications, but as a preference I prefer the round-nosed tool for many reasons," Mr. Trumbull said, "By the way our recent experience indicates that a fuller caulking is rather frequently employed." . . .

Mr. Trumbull (Continuing): I think it appropriate that I should ask the Vice Chairman of the Committee to make some comments on the report and such suggestions as he may have in regard to the details. Is Mr. Heidel in the room?

E. H. Heidel (General Boiler Foreman, Chicago, Milwaukee, St. Paul & Pacific R. R., Milwaukee, Wisconsin): This report is a continuation of the 1940 Topic No. 5 on alloy steels and riveting.

What we as boiler makers are after today is to find out how to take care of high pressure alloy steel boilers. With the lower pressure carbon steel boilers, we thought we were sailing along and would have no more trouble, but when we get into the high pressure boilers built of alloy steel we run into entirely different conditions, something we had never anticipated —leaking boilers, leaking shells, cracks in shells and failures of riveted seams.

What is the cause of this trouble? Is it the material? Is it the workmanship? Is it the way we handle the boilers after we get them? Questions of this nature are what started the discussion.

Many roads are having trouble with high pressure boilers. They do crack in the shell. We didn't know what this was with low pressure boilers, but it is definitely here. We have tried to overcome it—you have tried to overcome it. What has been your experience, and what success have you had in correcting the difficulty? Have you patched the boilers? Has the design been changed? Is the same kind of material put back into the boiler? Answers to such questions as these is what we really started out to find.

Under the topic which we have here today, the details have been gone into very thoroughly, and I think that many of the ideas and thoughts which are brought out here should be taken home with us and put up where we can see them, so we can make use of these principles—fundamental principles you might call them—of riveting for high pressure boiler construction.

On page 65 are shown illustrations of caulking tools. You will recall the time when we caulked with hand tools instead of using pneumatic hammers. Everyone had his own tools, and everyone thought that his tools were the best that could be made, and were fixed up and kept in shape. We all had fullers; we all had square tools; we thought that each had a definite place in the caulking of a sheet.

In some of the high pressure boilers of the last fifteen years we have seen the fuller used exclusively on the shell sheets, and the shell sheets remained tight all through the years. We have seen other sheets in low pressure boilers where the square tool was used exclusively and the sheets remained tight all through the years. In late years we have seen that the square tool, or semi-square tool has been used and the sheets are tight.

While we find leaks where both kinds of caulking tools were used, it is my opinion that if either the square tool, semi-square tool or the fuller is used as it should be used, the sheets can be caulked and kept tight. You can use a semi-square tool or a fuller and you can raise the sheet with it by too much caulking. That has been my experience. Thank you.

Mr. Trumbull: I should like to call on Mr. Graulty, if he is in the room, for some comments on the paper.

Mr. James A. Graulty (General Boiler Foreman, American Locomotive Co., Schenectady, N. Y.): Mr. President and Members of the Convention: It has been the practice in our shop to use the round nose caulking tool and my experience has been that it makes a good job. In this room are men who have inspected work in our shop and I know of no criticism from the use of this tool from any of them.

The picture shown in program of the use of square tool makes an ideal job but the opening at the end where Fuller Tool is used extends to center of rivet. I certainly would not believe this was caused by use of Fuller Tool nor would I believe the square tool would entirely close the opening.

Due to uneven gauge of material there is a minute wave-like condition between the plates and when rivets are driven, a slight springing of plates around rivets will cause a separation. This opening sometimes extends from edge of plate to rivet. When sheet is caulked the upper plate is drawn in contact with lower one and if this section were cut through, it would show opening back of caulked section, giving the impression the tool caused the plate to raise up. You would find this condition with use of Fuller or square nose caulking tool.

We have not had much experience with the square tool. It is much harder to use than the Fuller Tool. There are sections, such as outside welt strip seams where the Fuller Tool makes the better job.

I believe that on sheets with proper lap, correct bevel and set up metal to metal and caulked with the bevel, the Fuller Tool makes the better job.

However, as builders we must work to specification but feel this subject is of importance to every member present and would appreciate an expression of their opinion.

Mr. Trumbull: There has been present at the meetings Mr. Mullenhour, who is the Chief Boiler Maker of the Lima Locomotive Works, and a member of the Committee. Is Mr. Mullenhour present this morning? (Not present).

Among the members of the Committee whose contributions were of importance in the preparation of the report is the Secretary-Treasurer, Mr. Stiglmeier, who has had a lot to do with the preparation of the exhibits covered by the report. I will ask him if he will make a few remarks.

Secretary-Treasurer Stiglmeier: Mr. Chairman, Members and Guests of the Master Boiler Makers' Association: I don't know of a subject today that is of more importance than the fabrication of boilers, that, in a way works in conjunction with feed water treatment and the problems of our friends, the Water Engineers. All trying to solve the same problem. You have heard your committee chairman on this topic say, that Mr. Ruber, whom I consider one of the outstanding Master Boiler Makers today, speak in favor of the combination fuller and square tool. I have made personal tests with the combination tool, and the illustrations listed in your meeting program are those furnished by me. And I speak from experience of what I have seen, and seeing is believing, regardless as to what some may say.

You have heard Mr. Heidel a few moments ago speak of the boilers of some time ago that had been fuller caulked, those of years past are not the problems of today. Our problems are the boilers of today. We have got to build boilers today that will in a way overcome conditions that are causing our boilers of today to crack. Some of these conditions have already been corrected. You have heard our good friend Jim Graulty whom I respect very much as one of our outstanding Master Boiler Makers, speak in favor of the fuller caulking tool for several reasons as outlined to you. However, Jim did not say that the combination tool would not do good work, he did say that it was harder to caulk with. And as a representative of the builder he no doubt speaks "cost." And I agree with him that it does cost more to caulk a boiler with the combination caulking tool, but we as Master Boiler Makers on the railroads must speak service, and like the doctor, we have to treat and take care of the boilers when they get sick, have to get them in the best possible condition, have to keep the boiler in a condition where they will not fall apart under present day conditions. And as I had told those in attendance at our 1940 meeting, that if we do not build boilers that are going to stay intact, it will not be long before the steam locomotive boiler will be a thing of the past.

Today I again stand before you and repeat the same words. And for these reasons I am in favor of the combination caulking tool, for reasons that you will not get a condition as the specimens I hold before you, these specimens were cut from one of those sick boilers we have on our hands today, these specimens were caulked with the fuller caulking tool and you will note are raised $\frac{1}{16}$". What caused this condition, improper fit, if it was, the builder was wrong in putting the boiler together under those conditions. If it was the fuller caulking tool, why do we continue to use the same, under such conditions we hear the Water Engineers say, that is the cause of our boilers getting sick with this so-called caustic embrittlement, this due to foreign substances entering the openings between the sheets. And I am quite confident that the combination caulking tool will do much to overcome the opening of the sheet during caulking. And I again repeat, the better we build a boiler regardless as to its cost, it will be the cheaper boiler at the end, and while the combination caulking tool might be harder to use, we get a condition that will keep the metal to metal, regardless if the caulking is excessively heavy.

Introducing the combination caulking tool is similar to introducing Nickel Steel for locomotive boiler shell sheets, as many of you remember, we were told at that time that it would be impossible to get nickel steel plates without excessive pitting, however, today with the cooperation of the steel plate manufacturer we are getting nickel steel plates of all sizes that are a credit to the manufacturer at a reasonable cost, that is all I have to say regarding to the combination caulking tool.

However, I do want to speak on the tolerance of rivets. You will note in your meeting program that the A. A. R., in selecting their committee members on this subject had selected mostly Engineers of Tests, not a Mechanical Engineer or Master Boiler Maker, and while we have the highest of respect for these gentlemen in their respective line of work, particularly in setting up standards dealing with the physical properties of material, it would seem to me giving these gentlemen the work dealing with the fabrication of boilers, is like assigning the work to the clerk in the office, for reasons that they are not familiar with the work of fabricating boilers.

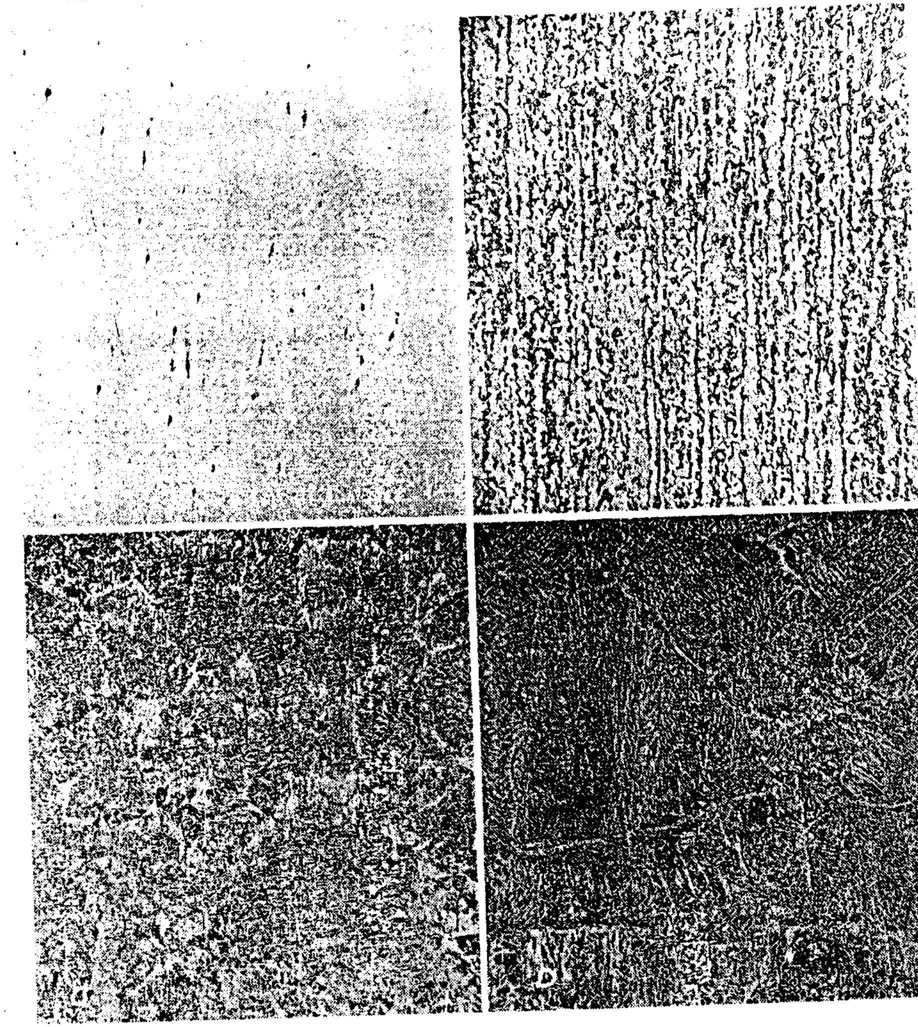
You no doubt remember that in the year of 1940, your committee on this subject recommended a tolerance not to exceed .010" minus and .020" plus over basic diameters 1" to 1⅜" and that rivets be free from scale.

In your meeting program today you will note that the A. A. R. committee recommends rivets of the 1" to 1⅜" diameters with tolerance of .035" plus and .020" minus over basic size, this no doubt the recommendations of the Rivet Manufacturers. Surely your committee for 1940 were practical Master Boiler Makers who were familiar with the fabrication of boilers of today and had given this subject much study.

As an example, let's take a rivet hole prepared for a 1" diameter rivet, the general practice is to ream the hole 1/16 inch larger than the basic rivet diameter, we then would have a rivet hole 1.0625" taking a rivet with .020" minus, we then would have a difference of .0825" between rivet shank and wall of the hole, on the other hand, if we take the rivet with .035" plus over basic size, we only have a difference of .0275" between the rivet shank and wall of hole, this under cold condition. With conditions of this kind, it is no wonder that we have scalloped sheets at the caulking edge and large and small heads at the time of driving rivets, a seam of this kind surely must set up cold stresses out of the rivet holes that are not visible to the eye, don't you believe that such conditions have much to do with the present day checking of sheets out of rivet holes, we might get metal to metal fit, correct tonnage for driving rivets, unless we give the same consideration to the rivet tolerances, we still are going to have trouble if the Mechanical Engineer or the Builders don't give these tolerances some attention. It would be my suggestion that the Association go on record, recommending to the Mechanical Division of the A. A. R., that in the future when they are setting up standards dealing with the fabrication of boilers, that they give consideration to having representatives of the Master Boiler Makers' Association on their general or sub committee. That, gentlemen, is all I have to say, and sincerely hope that my remarks will be taken in the same spirit as given, and that the same will be of some benefit to you. (Applause).

Mr. Trumbull: Mr. H. H. Service of the Santa Fe, will you favor us with some comments on the report?

Mr. H. H. Service: Members of the Association: I didn't expect to be called upon this morning, but I do have a few things I brought with me. I want to dwell on some of our experiences in which we have rivets failing and no indications of leaks around these rivets, which kind of breaks into this caustic embrittlement or crystallizing-cracking theory which has been advanced.



No. 1 "A" Transverse section of Ni-Rivet as received, 100 dia., unetched, showing dirt inclusions. "B" Longitudinal section of Ni-Rivet as received 100 dia., 2% Nital etch showing original structure. "C" Oil heated Ni-Rivet from service and no failure, 100 dia., 2% Nital etch showing fine grains of sorbite. "D" Electrically heated Ni-Rivet from service and no failure, 100 dia., 2% Nital etch showing a coarse ferrite network free from numerous inclusions.

I have a few of these rivets. You can examine them if you wish, afterwards. We found them defective in the boiler, and they probably were broken before we found them. However, when we removed them we discovered that some of the shanks were broken either at end under head or in near the center. Now you can readily see that these rivets have been hammer tested several times on the side of heads by the hammer marks. These tests being made monthly to see if any are broken or loose and we run into these conditions.

You can see there is no alkali scale on them whatever, indicating there were no leaks. Therefore, we thought it may be the material (nickel steel), so our metallurgist secured a new rivet from stock and he prepared it for micrographic examination, and this photograph No. 1A shows there are many small inclusions throughout its structure.

I don't believe you will find this condition in an ordinary steel rivet, if so, not to the extent as in the nickel steel rivet. Therefore, it is my opinion to start at the beginning and I think it is something that the manufacturers should try to overcome, as it is the very thing we don't want in a weld and we complain and try to overcome it.

I might add that this photomicrograph was taken at one hundred diameters.

The next thing is how are these rivets being heated. I believe I mentioned this before at the last meeting and that a better control of heating nickel steel rivets should be given consideration in order to secure the best results.

I made a little experiment myself with the same type of rivet and I found by heating the rivet in an electric heater, and heating the rivet fast, I could blow a hole through the shank of rivet before the head of rivet would become very hot. Now when you can blow a hole in the side of rivet shank in that manner it tells me that the grain structure is being expanded too rapidly by heat concentration resulting in a severely burned rivet. Therefore, if you apply that type of rivet into hole and that rivet is not in a uniform plastic condition how are you going to tell after such a rivet is driven if it is of a normal structure.

I say this because the photomicrographs show that the nickel steel rivets that have failed, and they were heated by the builder in an electric heater, some of these rivets have had as many as three or four cracks in shank and heads. Also these photomicrographs show cracks develop at these inclusions in rivet material, and the enclosed photomicrographs Nos. 1, 2 and 3 show some of the findings.

Based on these findings it occurs to me that this type of rivet (nickel steel) should be heated slowly or with more of a soaking heat.

The next thing I want to talk about is, recently we had a peculiar failure on a nickel steel boiler which was discovered in one of our main shops during the hydrostatic test. Now mind you, we had inspected this boiler inside and outside after it had been sand blasted, before flues were applied and there were no indications of cracks. I have with me a sketch (see Fig. No. 1), showing the locations of these cracks which did penetrate through the plate, and they are located under boiler check flange on each side of front boiler course.

Regardless of what caulking tool had been used, the inspector noticed a slight leak about the size of a pin head about $\frac{3}{16}$" away from caulking edge and it was a very slow leak and called it to the Boiler Foreman's attention, he having no desire to caulk this, but said let's get that flange off and see what's under there. After removing the boiler check plate, it was found there were four cracks in boiler shell extending from rivet holes that were not visible before removal of outside plate.

The opposite side plate was removed and two cracks were found; one however, did not extend from rivet hole but was in the solid plate.

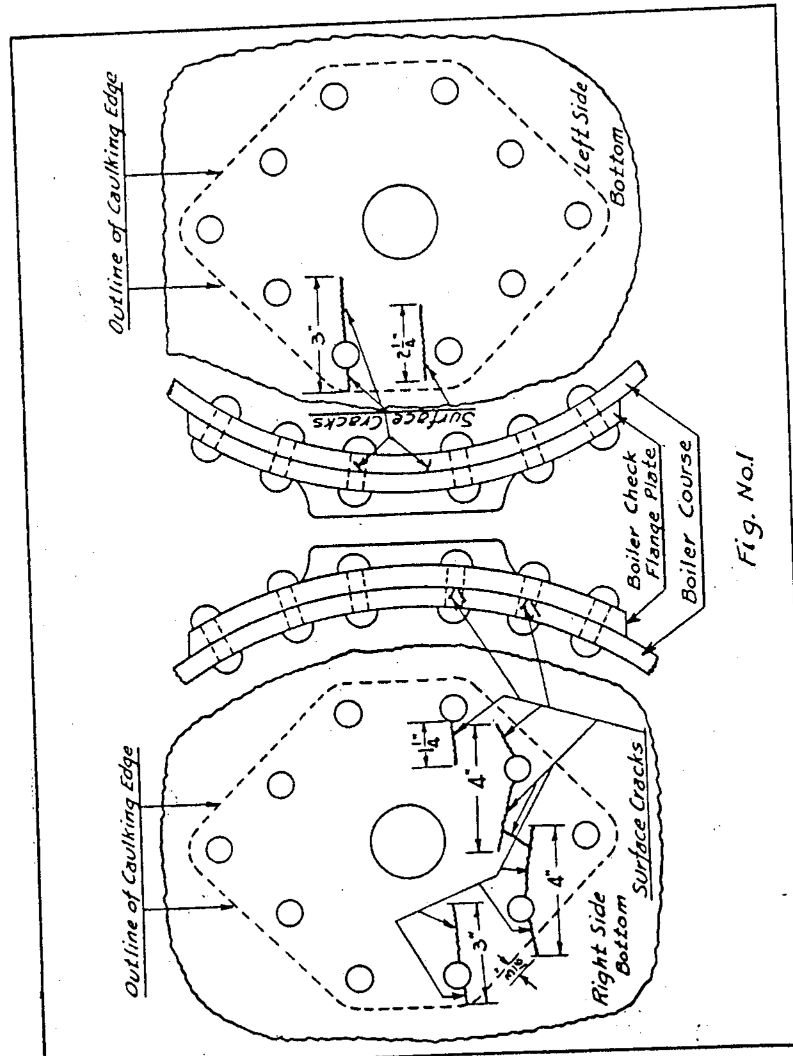


Fig. No. 1

This, I consider a good find, gentlemen, but what is causing the cracking? The cracks did not penetrate into the water side of plate and only extended about half way through as I have outlined in this sketch and any one who wishes to see it can do so.

This is something we are getting into on this nickel boiler steel and rivet topic, and in the latter case there were no broken or defective rivets. We have found, however, where we found broken rivets we also have found cracked plates, and I consider this serious, and I have come here to learn all I can in regard to this matter and the proper methods of heating this type of rivet; and would like to learn from somebody present if anything has been done to control the temperatures of electrically heated rivets.

Mr. Trumbull: I will be glad to call on someone who has had experience with nickel steel rivets.

Among the honored members of your Association is a man who has had long years of experience in boiler maintenance and construction. What he might say on the subject, I am sure, will have the full weight of experience and of the presidency of the Association. I should like to call on Mr. Buffington for a few remarks on the paper.

Mr. Buffington: I wanted this opportunity to talk to you fellows about this, because while I haven't got a speech made up on it, I have a few notes on it.

So that you all know what we are up against, in August, 1941, *Railway Mechanical Engineer* listed locomotive orders: steam, 48; diesel, 47.

I believe Mr. Stiglmeier made the remark here last year that it was up to the people now to get busy because the steam locomotive would be a thing of the past, and I think the manufacturers should take note of these things, because if they don't they aren't going to make them any more. The manufacturer's idea seems to be that all he has to do is to make them and we will maintain them, and that is a thing of the past.

I thoroughly agree with Mr. Stiglmeier about the fuller. I have been telling you people that for the last fifteen or twenty years, but nobody would believe me. We have used a common, ordinary finishing tool. I prefer to use the flatter and hold the same angle that the sheet is made, and in place of prying your sheets apart as you do with your fuller, you don't leave a mark on it. It is folly to talk about having to be an expert man, and so on. That used to be the case when they did all these things by hand. Today they are all machine men. They can hold up an air hammer and if you use the flatter and grind them off a little bit and hold them to the angle that the sheet is planed, you set your sheets together.

I am going to draw that on the board. I am not an expert draftsman, but at least you can understand what I have in my mind, and I want you to get it.

(Drawing on board). Now you see that the fuller goes in there, and no matter who grinds that fuller, he makes a groove there by the sheet. Ninety-nine men out of 100 get grooving, and there is only one thing to do with that, and that is to take enough caulking up there, and you create

a ragged edge, and I have run up against a ragged edge that long (indicating), and brought it back to the shop and asked how I could keep it tight. Where a leak has developed you have to go along the whole seam to get it stopped.

If you take a flatter, you can hold it at that angle and put the sheets right together. The edge is ground off a little bit, and there is no trouble. Anybody can hold that. To convince you that I am right, fifty years ago we used flatters and the sheet never leaked. It would crack half way up in the rivets and it didn't leak, did it? That is all you need for an argument. Those sheets are put right together with the flatter.

Go back to England, when they made the boilers out of iron. They didn't dare to use the fuller because it would pry the sheets apart. They used the flatter and they set it right down together and all you have to do is go along with that little combination tool that Mr. Stiglmeier recommended, just to trim the edge. If there is a pinhole when the pressure is on, all you have to do is touch it, and it stops.

Is that sufficient? It should be convincing to all of you, and it won't cost any more to get that done that way than it will the other. Why not do it? You get that. Why not do it? Boilers are cracking now. I bet you a dollar to a dime—and I will give you back the dime if you win—that every boiler that we have cracked in the last fifteen years has been caulked with a fuller. Do you want to take me up on that? You are not going to. I know I am right.

Now with regard to the driving of those rivets, I have a statement over here which says that the A. M. E. Mechanical Committee makes their recommendations, and we will forget about the half-inch rivets and take the ⅛, 100 over. We might take 10/1000, as one man said, but a boiler maker maybe doesn't know much about thousandths. And the A. A. R. is 8/1000. And I could look all the way down this list, clear down to the bottom, ⅝ and ¾ inclusive, and 22/1000 under and 22/1000 over as against the A. A. R. 16/1000 under and 16/1000 over. *Over* doesn't mean a great deal to me, see. But it is the *under* that counts.

You see, there is a variation here of approximately 3/100 or 32/1000 and between the two schedules as given so far as the rivets are made out of nickel steel, I would prefer the A. A. R. to the A. M. E. It seems to be a fact that we have to give the manufacturer tolerance on rivets.

That was taken up way back in 1906, and there was a question at the time about making the rivets to basic size, and there was experimental driving of the rivets cold. This isn't anything new except that we are up against new propositions that we didn't have before.

Then about fifteen or eighteen years ago they got the notion into their heads that they ought to make their boilers flexible. I may be talking out of turn, but I want to tell you that unfortunately that flexibility went the wrong way. They have them too flexible now. Whenever you give that much tolerance, you have 100 plus 065, that makes you approximately .0725 clearance in the hole on the bottom.

Now we come down to the large size. You have .016 plus 0625 equals .785 clearance in the hole, approximately 5/64, and you have no way to fill that up.

You know, forty or fifty years ago when the holes were 1/16 clearance on the big boiler rivet, those were the days when we didn't have any reamers and didn't have any air hammers, and we drilled the holes and put them together, and if we were unfortunate enough to be out, the rivet wouldn't be in. We would ream them with a half round tool, and some were this way and some were that way, and some the other way, just so we got the rivet in.

But with the clearance that you have in there today, there isn't anybody that can drive that rivet and upset it at this point (indicating on board) either in two sheets or four. I don't care how much pressure you put on it, ito upsets from this end up (indicating). You have already got a head made there, and it doesn't upset. But if you will take that, you can let your manufacturer have this tolerance. But if you don't do that, why quit the sixteenth, and go to a smaller hole?

Now, we have talked about a thirty-second on those rivets ten or fifteen years ago, but there has never been anything done. Personally, I think it is time something was done, besides talk. You can give your tolerance there to suit either one of those people. The manufacturer says he can't make it. He can't? All right, all he has to do is to ream the die out. He says it will cost more money. Why should it cost any more? He says, "Well, you would have to make one head at a time." That might be so, and it might cost a little more to the railroads possibly. But you know I am the kind of fellow—well, you couldn't expect a homely man as I am to be anything but plain—and I have said, "You are paying for it, and you tell the manufacturer that you want something and he has to get it, and that is all there to it."

I believe that we could get that if we would ask for it. That would overcome your tolerance. Otherwise, I don't see what you are going to do but take the least of the tolerance. You can take what suits you the best and cut the tolerance down on the hole, give us a thirty-second, and that would help some.

I went to a shipyard one day and I was rooting around, and I found some rivets in there, upset under the head. I asked why they got that, and they said that they got that when they punched the holes. I said, "Why?"

"Well," they said, "when you punch the hole you leave the hole a little larger on that side, and it is not perfectly true, and that upsets it."

Of course the answer is something to fill up the hole. If you do that, you take the movement out of it. I will grant you that treated water has aggravated the condition, has made the problem worse. It has aggravated the condition that we have always had in some respects, but I think that this is the solution that will help, and we need help.

I don't blame the manufacturer for feeling as he does, but he must be reasonable, or we are going to loose out on the whole business, not that it matters much to some of us older fellows, but there won't be any boiler makers after a while unless they are in the shipyards. I believe I have said pretty nearly enough on this topic. You all know that I mean exactly what I am telling you. We are getting things now from manufacturers that you couldn't ten or fifteen years ago.

We all have to get closer together on these things. We are getting conditions from those people we couldn't touch. Let's lay aside all those funny ideas of ours, and get together to stop this trouble, and if we fill up the holes in those seams and lay the seams and get the material up before we rivet it and put pressure enough on the rivet to drive a good type of rivet, we will be all right.

We have enlarged the rivet hole on the inside from a sixty-fourth to a sixteenth, and then wonder why it cracks. (Applause).

Mr. Trumbull: Well, as usual, we know right where Mr. Buffington stands on this subject. We are fortunate that he has expressed himself so forcefully. A man who can do so speaks from long experience and certainly from knowledge.

Another member of the Association present that I am sure you will be glad to hear from in this connection is Mr. Harper of the Big Four. Is Mr. Harper in the room?

Mr. Carl A. Harper (General Boiler Inspector, New York Central, Indianapolis, Ind.): Mr. President and Members: After hearing the reading of the Committee's report on rivets, there is nothing I would have to add to the subject as we are using carbon steel in our boilers. As I recall, the trouble being experienced with rivets has come into prominence since the use of alloy steel. However, according to the report the proper material for both sheets and rivets, and tools have been determined. Science, however, cannot compensate for the human element, particularly in piece work shops, therefore, the closest of supervision and inspection must be maintained in the construction of modern boilers. (Applause).

Mr. Trumbull: Are there other members of the Association who would like to discuss this topic? Is Mr. Miller of Milwaukee in the room?

Mr. Harry G. Miller (Engineer of Tests, Chicago, Milwaukee & St. Paul R. R., Milwaukee, Wis.): Gentlemen, the only thing that I want to talk about this morning is the alleged incompetence of the A. A. R. Committee on Specifications for materials. I don't think I have to make any apologies for the Committee. The basic specifications is the American Society of Testing Materials, A-31. The dimensions given are an exact copy of those set up by the American Standards Association. The men who did that work represented the producers, the American Society of Mechanical Engineers, Boiler Code Committee and several other authoritative groups. So I doubt that the specification can be improved as to tolerances unless you want to go to the Manufacturers' Association and ask them for prices and costs on introducing more accuracy than they are able to supply on a commercial basis at the present time.

Mr. Trumbull: The last member of the Committee on this topic is Mr. Yochem of the Missouri Pacific, who has some comments on the papers that have been read.

Mr. F. Yochem: Gentlemen: It seems we have turned the clock back talking about chipping and caulking to avoid seepage between shell sheets and the separation of plates by the use of a fuller caulking tool.

The photo in our programs shows plates separated by the use of a fuller. A job of this kind can be done with a good air hammer and a light fuller in the hands of an inexperienced caulker. If our shell sheets are properly fit up, iron to iron and a good job of riveting is done, there is no need of heavy caulking, and a fuller with not less than a 3/8" nose should be used. We have also talked about the so-called caustic embrittlement; some of us are of the opinion it is a water condition that causes the cracks around rivet holes; what about cracks at rivet holes in the top of our boilers? This is in the steam space, no water at all; will the steam from this same water cause cracks at rivet holes? If it does; perhaps it is also responsible for cracked cylinders. My opinion is the same as it was when we first had this condition in shell sheets on boilers that were four years old. I said it was a poor job of fitting up by builders, excessive hydraulic pressure used on rivets that were improperly heated. For example, take your outside throat sheet, the flange extends up to approximately the side center line of boiler; you have cracks develop extending from these rivet holes to the caulking edge of throat sheet. You remove these rivets and throat sheet flange springs away from shell course as much as 1/4". Do you think that throat sheet flange had been properly layed up iron to iron before rivets were applied, and after you have removed throat sheet you find shell sheet rivet holes in the same location cracked; don't you think there was a heavy stress at seams rivet holes before there ever was any pressure on the boiler? Now take a condition of this kind and aggravate it with an operating condition; what will you get? Cracks! It was necessary to renew these throat sheets and shell courses after four years from builders. We had to do the job with sledges and air hammers; they have been in service more than eight years now and no cracks; working in the same territory, using the same water. What is it, good boiler work and bad water, or vice versa? I tell you, gentlemen, you have got to get the job fit up iron to iron, good reamed holes and proper heated rivets, driven up tight. Forget about this 150 ton pressure on hydraulic riveter to do the job.

We are rebuilding twenty-five engines in our Sedalia Shop that were purchased new in 1930; original design was a straight flue sheet in firebox, no combustion chamber; in rebuilding them we are applying a 60" combustion chamber. Therefore, it was necessary to change the shell courses, making them longer to maintain same length of flues. We are renewing the second and third courses. In dismantling the sheets we found the rivet holes elongated as much as 1/8" toward caulking edge. The size of rivets was 1 5/16"; thickness of shell plates 1 3/16". The caulking edge of shell sheets in place of being straight was like a saw out at each rivet hole. I say excessive bull pressure on rivets when they were applied is responsible for the condition and we wonder why we have cracks at rivet holes. Some one said something about five thousandths thick feelers used on fit up work. The best feeler is zero. If your plates are iron to iron you can't and don't need a feeler.

Some of you may say high pressure and high speed is a contributing factor; what about switch engine 190 pound pressure, working in yards, no speed there. Take our Mechanical Engineers, they make prints showing radius for knuckles and we ruin the plate trying to comply with prints; what results, cracks.

Let us consider 1" to 1½" shell sheets, rolled to a circle cold. Imagine the stress that is put in the plates to get required circle. Why not after sheets are rolled bolt in outside and inside butt straps securely in place and normalize or stress relieve the entire sheet. Gentlemen, there is a lot we all have to do to try to eliminate boiler sheet cracking before we can say to our water chemist, "She's your baby." If we do not make a big improvement, including the builders, the Diesel engine is going to put us in the same organization with the horse shoers and the initiation fee is going to be expensive. I thank you.

Mr. Trumbull: There is a lot of meat in what Mr. Yochem has said. He is absolutely right about the necessity for closer fitting up, and as someone else said in the discussion this morning, for the use of adequate bolts to hold the plates before they are riveted.

Since the discussion began Mr. Mullenhour has appeared. I wonder if he would like to make some comments on the topic?

Mr. C. G. Mullenhour (Superintendent of Boiler Department, Lima Locomotive Works, Lima, Ohio): President of the Association and Chairman of the Committee on Topic No. 5, Gentlemen: I am a little late this morning. I did not hear what was being said but I did get in on the last part about fitting up sheets, rivets, caulking and things like that, as the builder does it, and the discussion about hydraulic rivet pressures. Of course, we build locomotives. We build the boilers, but we do try to build them to the satisfaction of the purchaser. Our shop has inspectors from the purchaser and those inspectors are skilled men, men who know their business. They know how to build a boiler possibly better than we know how to build a boiler, and we try to go along with them in building them. It is up to the service those boilers give whether American, Baldwin or Lima locomotives gets some orders from that company. I tell you, we go along with those men. The men put there by the railroad company go along with this job and see that they get what they want.

I heard Mr. Yochem say that the sheets spring. That is all right, but there is a way of laying them up, a bolt in every other hole, putting it up within .005 to .006. It might look iron to iron, but you have to get a feeler in there, a five-to-six-thousandths feeler, and if the job doesn't come up within that, we put it there before any rivets are put in that job..

On our hydraulic riveters we have regulators, a valve that regulates the pressures, and on the heavier materials, which are all 1¼" to 1 7/32" material, we put it up on the bull and use what we call a setting-up process and regulate the pressure on the hydraulic riveters so that it doesn't damage or set-up any undue stresses or throw any pressure on one spot. That can be done properly with skilled labor, and it isn't going to hurt the boiler plate.

We have jobs going through the shop that have been looked at by the R. R. representatives that come along. They inspect them and we have no trouble with them whatsoever. So far as the rivet pressure is concerned, we have no trouble. There used to be excessive pressure put on rivets by hydraulic riveting, but that doesn't happen any more because of the regulators. It used to be that everybody wanted too much pressure, as much pressure as they could possibly get, on a rivet. You couldn't give them enough. They figured that you had to get 150 tons there or you were going to have a loose rivet. We don't do that any more. The amount of pressure that you should put on the rivet is just enough that there is no squeezing of the sheet or corrugating.

So far as caulking is concerned, some like the square tool and some like the fuller. We use what we call a combination fuller which I think is very good. It is not what we would call a round-nose, and not a square tool. It is about half way between. It doesn't throw the little burr around the caulking edge that you have to trim off with a tool. It makes a nice job, sets the sheet where it belongs—that is, if your sheet is up within five-to-six-thousandths. Other people say iron to iron. You can look at a job and say it is iron to iron, and then you put a five-to-six-thousandths feeler in there and you find it isn't iron to iron.

With that process and with this combination caulking tool, we get a very good job. It isn't prying your sheets apart or throwing any stresses on your plate.

Also I notice that he discussed caulking rivets, with fingernail tool. That is not right. We use what we call a little cup. It is a half-round tool, but we don't use it for caulking rivets.

Now there are people who might come into the shop and see that tool being used, but it isn't used for caulking rivets. It is used for cutting off the collar. After the collar is removed the rivet is caulked and it is caulked with the round tool. But unless you stay there and see the full operation, see how the job goes along, you might figure that it is caulked with the sharp tool.

All the way along the line I think this topic has been taken care of very well, but there are some things that should come up, but the time is getting short. I would like to bring out those few things I heard Mr. Yochem talk about. I believe if Mr. Yochem would come around the shop and look it over, some of the things he used to get he will find that he doesn't get any more. Skilled labor in a boiler shop is a lot different from what it used to be. Your workmanship is better than what it used to be. Anything used to go, but it doesn't go any more. You do the job and you do it right, and it it is done properly with the right tool. That is all I have to say, because we are building to satisfy the railroad companies. Thank you. (Applause).

Mr. Trumbull: Among those who have had a real interest in boilers for many years is a man who has had a great responsibility in his life for the development of the American Society of Mechanical Engineers Boiler Code, which most builders now are observing. He is Mr. Partington of the American Locomotive Company. Mr. Partington, do you wish to make some remarks on this topic?

Mr. James Partington (Manager, Engineering Department, American Locomotive Company, New York): Mr. Chairman, Members and Guests: I am glad to have this opportunity to say a few words on this subject which is a very timely topic, largely because locomotive boilers today are built for high pressures and they are operated for maximum horsepower output which means that they have to be right.

I will make my remarks very brief, but I want to spotlight a few points in the Committee's report. Mr. Trumbull and his Committee are to be congratulated for the very comprehensive review they have made of this subject, which is really not simply a question of driving rivets, but the wider topic of fabrication of riveted boilers. The subject, I think, is properly one that should be dealt with very fully by the Master Boiler Makers' Association, because today the railroads are by far the major industry that uses riveted boilers. In the stationary field riveted boilers have practically disappeared, for two reasons: The substitution of welding; and in large power plant installations, of course, the change to water tube installations.

One of the points, therefore, that I wish to talk on is the material specifications for rivets. Mr. Miller has very properly defended the action of his Committee in adopting specifications and tolerances which have been issued by the American Society of Testing Materials and the American Standards Association, and accepted by the A. S. M. E.

No industry other than the railroads today has the major interest in rivets that you have, and I think it would be quite proper to bring up some points for consideration. Those specifications of the A. S. T. M. and the A. S. M. E., which are identical, make no mention of carbon content of carbon steel rivets. The A. A. R. says, I believe, Max., .18 carbon. That leaves steel for rivets open to any downward trend in carbon and I know that checking on rivet material has in some cases shown a very low carbon content. The only requirement is that tensile strength of rivets shall be from 45 to 55 thousand pounds. That will permit a very low carbon content, and if you get down toward the 45 thousand tensile range, you are getting a very soft rivet, softer than you ought to have from the standpoint of allowable shear stress.

Before leaving that point, I want to say that the A. S. T. M. and the A. S. M. E. have recently adopted a specification for carbon steel rivets which I think goes to .25 carbon and a tensile strength of 70 thousand pounds. I offer the thought that these rivets may provide a satisfactory substitute for alloy steel rivets in connection with alloy steel construction.

On that point, I think the Committee has done the proper thing in avoiding at this time recommendations for alloy steel plate and alloy rivets on account of the general material situation.

The fitting up which has been pretty thorougly discussed and the heating of rivets are two items which, today, are particularly well supervised and largely on this account the practice of builders of locomotive boilers shows generally superior workmanship as compared with any other riveted boiler construction in other industrial lines. This has made it possible to reduce the driving pressures, and your committee's recommendation of a maximum of 85 tons is certainly sufficient for getting good riveted joints with carbon steel rivets and carbon steel plates. In fact, I believe that a range from 75 to 85 tons today is perfectly workable and probably a good place to fix the range for these driving pressures.

You have heard a considerable amount about caulking. I am not qualified to talk on the caulking subject, as it has been put forth. I do wish to say a word or two about the Committee's recommendation that the inside weld strap of boilers be made of scalloped edge construction so that the inside caulking can be equal to the outside caulking. That recommendation is certainly in line with good boiler shop practice and will insure tight joints on the water side. The only question, I think, that might be considered is whether the recommendation should be broadly made without any downward pressure limit at which it need not be made obligatory. Boilers for locomotives are still built to the lower pressures, say 180 to 200 pounds, and it may be questionable whether the scalloped-edge inside weld strap should be insisted upon for the lower-pressures which permit the use of thinner sheets and much easier construction to obtain a good job.

In connection with caulking, I might mention that there has lately been brought before the Boiler Code Committee of the A. S. M. E. a suggestion that the caulking edge of boiler sheets and pressure vessel sheets of riveted construction be flame cut, and that the caulking be made on that flame cut edge.

It is a well-known fact shown by careful investigation that flame cutting does, even in carbon steel, cause a change in the hardness of the steel for a slight depth, a sixteenth or a thirty-second of an inch, and I think it is doubtful whether a recommendation of this sort will be approved. I mention this point, though, simply as a matter of technical information for your Committee.

I think the Committee has covered its subject well, and that they have made a definite contribution in pointing the way toward better boiler construction. (Applause).

Mr. Trumbull: I am reminded by Brother Buffington that we are losing time on our schedule, and it is desirable that this discussion be limited. So if there are no objections, I will close the paper. I think that it will be found by the different railroads that as we use nickel steel bars and high pressure carbon steel bars, there will still be trouble from cracks due to what has here been termed caustic embrittlement. In other words, it is not so much a matter of material as it is of conditions in connection with the service of the boilers.

It is true, however, that nickel steel seems to have a tendency to crack; whereas that condition does not prevail to the same extent with carbon steel. And to that fact is due the higher stresses which are present in the nickel steel boilers and boiler rivets.

That raises another question which I think should be considered by the Committee who may handle this subject next year, and that is whether or not nickel steel rivets are desirable even though the boiler shells may be nickel. It is entirely possible to produce a joint in the nickel steel shell which is adequate for the purpose where carbon steel rivets are used. Mr. Partington touched on that somewhat in his remarks.

I think that the discussion which has developed in connection with boiler riveting and caulking tools points to the necessity for further consideration of that subject also.

I think the committee appointed next year on this subject, if the recommendations of the Committee on Topic No. 5 this year are followed, should also give further consideration to the caulking tool subject.

Now, there is one thing about the discussion concerning the rivet specification that I think ought to be explained in order that the procedure of the Association of American Railroads in the adoption of specifications may be understood by the Master Boiler Makers' Association. Subjects such as these are considered by different committees of the Association of American Railroads and are submitted to the Association for formal approval. If the individual railroads voted in favor of adoption of this specification for rivets without referring it to their own boiler supervision, that is certainly something for which the Association is not responsible, but the situation does point to the desirability of taking some action to insure that subjects of this character receive the approval of the Boiler Makers and that in the case of rivet recommendations, for example, that official action should be taken by the Master Boiler Makers' Association.

I will undertake to see that measures are taken so that this will be done in the future. In this case, however, the chief criticism appears to be in the tolerances. It is well to bear in mind that close tolerances, if forced upon a manufacturer, are likely to effect upon the cost. It is true not only of rivets, but of almost everything else, where tolerances are incorporated in

the specifications. So the boiler makers ought not to insist upon tolerances, certainly close tolerances, unless we are absolutely certain that we are justified in so doing.

There is another situation which has developed. I presume most of you are familiar with it. That is that in the present emergency we are unable to accomplish some purchases that we might under other conditions, and unless the other interests who are concerned with rivet steel join with the master boiler makers in securing closer tolerance specifications, we are going to have extreme difficulty in getting it because we are not going to be able to buy rivet steel or anything else with closer tolerances than are demanded by other interests. It will be just impossible to get it.

I think that is all I have to say in closing the topic, except this, that with the aid of the Secretary-Treasurer I will undertake to bring this matter of tolerances or other features in connection with rivet specifications to the attention of those committees of other associations where this specification originated. (Applause).

President Buffington: As we are now further behind with the program, we will not have further discussion of this topic at this meeting, and I will entertain a motion that we thank the committee for their beneficial work in the interests of all concerned. Do I hear a motion?

Mr. Moseley: I move that the report of the Committee be accepted and that the Committee be thanked for the excellent report and the discussion that has been brought out.

Mr. Yochem: I second the motion.

The motion was voted upon and carried.

President Buffington: We will have discussion on Topic No. 3, Mr. Harper, Chairman.

Mr. Harper: You will note by your Programs that our Committee is composed of members from three nations.

Mr. Harper read the report of the Committee on Topic No. 3.