Myron C. France (Past President, General Boiler Foreman, Chi., Min., St. Paul & Omaha R. R.): I move that the report of the Committee on Law be approved as read.

. . . The motion was seconded by Edward H. Heidel, Gen. Boiler Inspector, Chi., Mill., St. Paul & Pacific R. R., and upon vote was declared carried . . .

President Gilley: We will now have the report on Topic No. 5, "Advantages of Steam Space Spray Boiler Check versus Side Boiler Check." Mr. F. E. Godwin, Chairman, Mechanical Inspector, Canadian National Railways. Mr. Godwin.

. . . Report on Topic No. 5 was read jointly by Chairman Godwin and Mr. C. A. Leet, Superheater Co.

Topic No. 5

ADVANTAGES OF STEAM SPACE SPRAY BOILER CHECK OR TOP BOILER CHECKS. Versus, SIDE BOILER CHECK.

MR. F. E. GODWIN, *Chairman*
Mechanical Inspector
Canadian National Railways
MR. W. F. WOLLARD, *Vice-Chairman*
System Boiler and Welding Foreman
Chicago, North Western R. R.

MR. W. H. KEILER
I.C.C. Loco Inspector
Bureau of Locomotive Inspection

MR. C. R. KIRKWOOD
Supervisor of Boilers
New York Central R. R.

MR. J. J. DESMOND
Round House Foreman
Washington Terminal R. R.

MR. C. L. LEET
Service Engineer
Combustion Engineering Co.
Superheater Division

The suggestion put forward by our Secretary, A. F. Stiglmeier to the effect that individual papers on this topic be incorporated into a comprehensive report embodying the highlights of the papers has been accepted by this Committee.

In preparing this paper we are at a disadvantage due to the fact that very few railroads keep accurate records of firebox repairs, however, fact finding from operating conditions is often more accurate than the statistical records compiled.

The application of the "Top Boiler Check" apparatus is not new to the boiler making industry; years before the introduction of the feed-water heaters using exhaust steam as a medium for preheating the feed-water, many devices had been tried out with a view to increasing the feed-water temperatures entering the boiler and reducing to a minimum the passage of cold water travel inside the boiler eliminating the stresses that were set up in the shell and firebox plates. These devices consisted of various perforated pipe arrangements, chutes and trays fastened to front end boiler braces; some of the European roads had applied an additional dome on top of the first course with delivery feed pipes connected direct to the top of this dome where water contacted steam at boiler pressure and with the aid of baffles the water was raised to near boiler temperature before coming in contact with the heating surfaces within the boiler thereby reducing stresses that were previously set up by the induction of cold water. All reports compiled at that time read as follows:—

"The 'Top Feed' apparatus has been proven by lengthy and carefully conducted trials to not only considerably reduce the wear and tear of the boiler but also found to be economical from a coal consumption point of view."

We in this country are all familiar with the results obtained by preheating the feed-water with waste heat in the exhaust steam and its effect on boiler maintenance but ever since the advent of these exhaust steam devices, little if any consideration has been given to the advantages that can be derived from Top Boiler Check apparatus, however, some railroads did not lose sight of this. Mr. E. H. Heidel's report published in Railway Mechanical Engineer dated November 1942, indicating six years' service

had been obtained from new side sheets, after application of "Top Boiler Checks." This was further substantiated by results obtained on the New York Central Railway and incorporated in the paper on "The Advantages of Steam Space Spray Nozzles" read before this association last year by Mr. K. D. Relyea of the New York Central System. In his report he states that the New York Central reapplied Top Checks after having abandoned them many years ago but on reapplication they have incorporated an additional feature, namely the spray nozzle attachment to the delivery end of the top check, for the purpose of diffusing the feed-water which will more readily pick up a higher B.T.U. value from the steam than we can expect to accomplish by the delivery of a solid bore of feed-water supplied at Side or Top Check.

On Boilers with limited steam space it has been said that the Top Boiler Check has a tendency to create a carry-over condition when the engine is working at maximum capacity; this problem confronts many railroads involving high maintenance in super-heater units, valve bushes, and high lubrication cost.

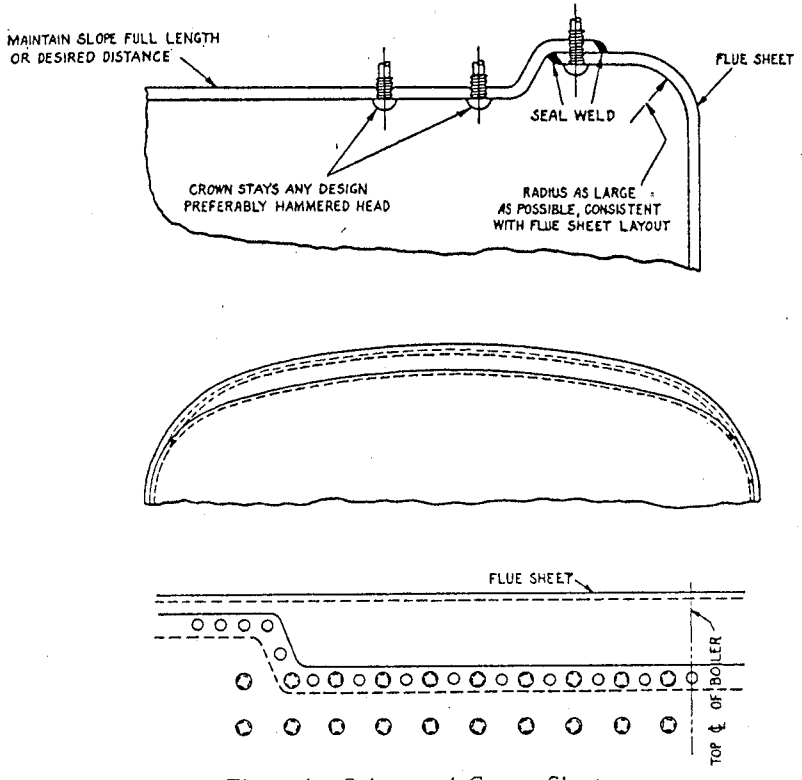


Figure 1. Submerged Crown Sheet

Since the present trend is toward dieselization and fewer steam boilers will be built we have what can be termed a permanent problem unless some

railroads advance the proposal as recommended in our proceedings for 1944, pages 68-69, and referred to this Committee by Mr. C. A. Harper.

"It is recommended that the crown sheet on locomotive boilers be lowered to provide more steam space in the boiler. In that connection we suggest that the crown sheet on the boiler of one or more locomotives, on several railroads be lowered in like manner or similar to that shown on sketch, Fig. No. 1, and a study made to determine the beneficial results obtained, if any, in the control of carry-over and foaming.

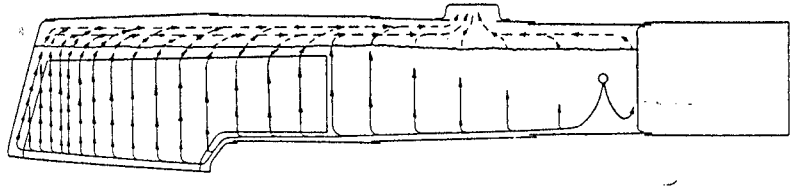
Since the water in most locomotive boilers is now carried higher than the 3" above the highest point of the crown sheet as prescribed by Federal Law, the lowering of the crown sheet as shown on Sketch, Fig. No. 1 and at the same time change the lowest water reading to 3" above the highest point of the crown sheet, will result in an increase of steam space in the boiler equal to the reduction made in the minimum height of water to be carried over the highest point on crown sheet.

With this method of lowering the crown sheet employed, it will not be necessary to change the flue lay-out or superheater unit assembly, and the reduction in direct heating surface will be practically negligible."

Joint Report by MESSRS. C. R. KIRKWOOD, New York Central, and C. A. LEET, Superheater Co.

In the past few years, the New York Central System has taken an active interest in the problem of reducing side sheet maintenance in locomotive fireboxes. Side sheets had long been an expensive and troublesome item in boiler maintenance but became even more serious as steam demands tended to go higher and higher without proportionate increases in boiler and firebox sizes.

The problem became particularly acute in the period from 1940 to 1943 when the L-3 and L-4 class locomotives were delivered to the railroad. These as were all other road locomotives on the New York Central, were equipped with side boiler check valves. There were 115 locomotives involved in the two classes and, after delivery to the railroad, the average mileage accumu-



SKETCH Nº 1

——— WATER FLOW
------- STEAM FLOW

Sketch 1. Assumed Circulation with Side Boiler Check

lated before patches were necessary on the original side sheets was only 100,000 miles. In one extreme case, only 28,000 miles of service were accumulated before it became necessary to patch the side sheets. These locomotives were taken into the shops for classified repairs at approximately 140,000 miles. In all cases, it was necessary to apply ½ side sheets on both right and left sides and, in some cases, ¾ side sheets were necessary. Then, after dispatchment from the shops, it was found necessary in many cases to patch both right and left side sheets in less than one year.

Certain factors which might affect the life of the side sheets were investigated in order to determine corrective measures. All but 15 of the L-3 and L-4 class locomotives are equipped with open type feed-water heaters. To minimize the effect of oil in the boiler on side sheet life, careful attention was given to the setting of mechanical lubricator feeds and the lubricators were sealed to avoid tampering. Trial applications of alloy steel firebox side sheets were made but these too failed between 83,000 and 155,000 miles.

Although it is common practice to issue instructions to engine crews against the use of a feed-water pump with the throttle closed, it is also common practice for crews to open the feed-water pump steam valve wide when the throttle is closed and pump cold water into the boiler to absorb the high temperature around the firebox to prevent the safety pops from opening. Where open type heaters are used with no live steam heating valve, the cold water entering the boiler through a side boiler check will flow to the bottom of the barrel of the boiler and then back and down along the lower side sheets and up. This flow will result in a temperature drop along the lower side sheets of as much as 150 deg. at a time when firebox temperatures are very high.

This flow will continue until the high firebox temperatures are absorbed. The circulation in a boiler is primarily due to the high evaporation rates around the firebox. If the feed-water pump is used to chill the boiler to prevent popping, after the fire cools there will be very little circulation in the boiler and cold water will lie on the bottom of the boiler. When the throttle is again opened and circulation begins, this cold water must be heated to evaporation temperature and for a short time interval, even though the pump is not used, the temperatures along the lower sheets will remain low at a time during acceleration when firebox temperatures are very high.

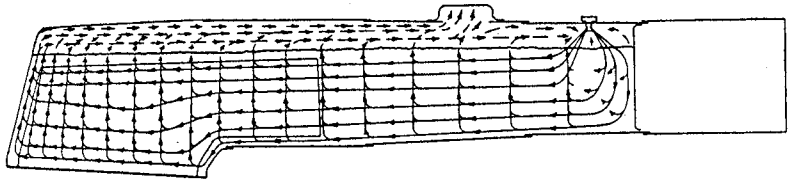
When heated water is again supplied to the boiler, the temperature of the water flowing along the lower side sheets will increase to a point close to saturation temperature of the boiler. The variation in temperature along the lower portion of the side sheets and the more constant temperature along the upper portion of the side sheets cause expansion and contraction along the lower sheet which set up stresses eventually causing fatigue failure of the side sheet.

It is thought that whenever water is fed through a side boiler check even though the feedwater is properly heated that variations in temperature occur along the lower side sheets due to the variation in feed-water temperatures which depend on locomotive exhaust pressure while the saturation temperature in the boiler remains constant.

To illustrate diagrammatically the assumed circulation in a locomotive boiler which is fed through a side boiler check, Sketch No. 1 has been drawn. The water entering through the side check will flow to the bottom of the boiler and back toward the firebox to replace the water being evaporated. As the feedwater flows over the flues toward the firebox and picks up heat it will tend to rise. On the sketch, the vertical solid lines are placed closer and closer together as the flow continues to and around the firebox to show the heating of the feed-water by the flues and firebox. The number

of arrows has been increased as the water flows back around the firebox to indicate a higher evaporation rate around the firebox sheets. Also the dashed lines, which indicate steam release and flow, are spaced to indicate the evaporation rate throughout the length of the boiler. Such circulation as shown in Sketch No. 1 is not considered desirable and would be conducive to side sheet failures due to stresses set up by variation of water temperatures over the side sheet surfaces.

In order to eliminate the possibility of variations in the temperature of the water along the side sheets, a trial application of a top or steam space boiler



SKETCH Nº 2

——— WATER FLOW
------ STEAM FLOW

Sketch 2. Assumed Circulation with Top Boiler Check

check valve was made to one of the L-4 locomotives. Through experience gained in testing open type feedwater heaters, it has been found that if water falls through steam for as little as 10", the water will gain a temperature very close to saturation temperature corresponding to the exhaust steam pressure in the heater.

Mr. Leet: I am going to deviate from the paper here, page 45, Official Program, and I want you to remember that one point, that if water falls through as little as 10" of steam in a feedwater heater of an open type it will come very close to the saturation temperature corresponding to the exhaust pressure in the heater at that time. That becomes important later in the discussion on what happens in the boiler when we pump cold water through the steam space.

It is felt that the heating of feed-water in the steam space will be even more rapid as saturated steam will give up its latent heat to the water more rapidly than the exhaust steam in the heater which has some superheat. Following this reasoning, it is assumed that the feed-water entering the boiler through a top boiler check equipped with a spray valve is heated to saturation temperature corresponding to boiler pressure by the time it has fallen through 6" of steam,

Now we have a condition within the boiler where every drop of water is at the same temperature. There will no longer be a flow of colder water to the bottom of the boiler and back to the side sheets to set up stresses in the sheets. Again a sketch has been made to show the assumed circulation with a top boiler check. It is hoped that Sketch No. 2 will show with a top

boiler check there is a more uniform flow of water throughout the entire cross sectional diameter of the boiler toward the firebox. The greatest flow will be to the points on the sheets having the highest firebox temperature. However, all water in contact with firebox sheets will be at the same temperature which will relieve the stressing condition as set up with a side boiler check.

Since all water in the boiler is at steam temperature, the tubes and flues will now evaporate a larger quantity of water. The firebox will also evaporate more water but there will be a tendency for the tubes and flues to assume slightly larger percentage of the total evaporation.

You will note it was stated above that both the tubes and flues and firebox will evaporate more water with the top check than with the side check. When fed through a side boiler check, the tubes, flues and sometimes the firebox must supply heat to the feed-water to raise it from entrance temperature to boiler temperature. When fed through a top boiler check, steam does this heating — so a greater amount of heat is available for evaporation from tubes and flues and firebox. However, when heating water with live steam with a top check, steam is condensed. Therefore, the heat balance will remain unchanged and the increase in evaporation will be the amount of steam condensed under the top check. You will note that Sketch No. 2 shows steam flowing from the dome to the boiler check. This must be true for when working at high evaporation rates, as much as 20% of the total steam evaporated will be condensed under the top boiler check. That portion of the tubes and flues between the dome and the front flue sheet cannot evaporate this amount of water due to the low flue gas temperatures in this portion. More will be said on this subject later in connection with carryover.

When the top boiler check was applied to the class L-4 locomotive, new side sheets were also applied. This was done in January 1944. The locomotive was later shopped in June 1945 and May 1947. No patches were necessary at these shoppings or between shoppings. Finally in June 1949, the third shopping after the complete application of the top check and side sheets, it was necessary to apply ¼ sheets on both right and left sides after 485,416 miles. Long before the above trial was completed, the top boiler check had proven itself and applications were made to all class L-3 and L-4 locomotives as they entered the shops for classified repairs. There can be no doubt that the improved circulation with the top boiler check is the answer to high side sheet maintenance costs. This has since been borne out by the subsequent applications.

With the boiler check valves located on the side of the boilers, evidence of oil was found on the water side of the side sheets when patches or renewals were necessary. It was assumed that any oil pumped into the boiler along with the feedwater would tend to follow along with the feed-water toward the firebox and contact the side sheets before it could rise to the surface of the water. When the feed-water is pumped into the boiler through a top boiler check, any oil in the feed-water will remain on the surface and do no damage.

The satisfactory performance of the top boiler check on L-3 and L-4 locomotives — which are combination freight and passenger locomotives, led to extending the program to J-3 locomotives used in passenger service. Later, it was extended to J-1 power in passenger service and L-2 locomotives in freight service. In all cases, the results have been the same and firebox maintenance has been reduced to a minimum.

It would seem from the above that the top boiler check is a satisfactory answer to firebox maintenance on all classes of power. It was applied to

six different classes and the same results were obtained in all cases as far as the firebox maintenance was concerned.

A study of the assumed circulation in a boiler equipped with a top boiler check as shown in Sketch No. 2, coupled with the fact that use of the top check must create an increase in physical evaporation to supply steam for heating the feed-water to boiler temperature, led to the conclusion that the mechanical carryover is possible and comes from the rear of the boiler to the dome.

When water is fed to a boiler through a top boiler check, there is no flow of steam from the area ahead of the dome to the dome when boiler is worked to capacity. Rather, there is a counterflow from the back of the boiler past the dome to the boiler check. This must be true and can be proven by simple calculations. To raise the temperature of the entering feed-water from entrance temperature (225°) to boiler temperature (405° for 250#/ sq. in.) requires that approximately 180 b.t u. be added to each pound of feed-water. It is common to work J-1 locomotives to an evaporation rate of 75,000 pounds per hour. So 180 x 75,000 or 13,500.000 b.t.u./hr. must be supplied to the water by live steam in the boiler. Each pound of steam involved in heating the entering feed-water will give up all of its latent heat and condense to water at boiler temperature. The latent heat in a pound of steam at 250#/per sq. in. pressure is 820.7 b.t.u. Consequently, the steam condensed is 13,500,000 divided by 820.7 or 16,450 lbs — so that total evaporation in the boiler is now 91,500#/hr. or increased approximately 22%.

Since the gas temperatures in that portion of the flues ahead of the dome are the lowest in the boiler, less than 22% of the total evaporation is possible in this area. Consequently, steam must flow into the top, boiler check area from the rear of the boiler. The heat available from heating surfaces to generate the 22% increase in steam is that used to heat feed-water from entrance temperature to boiler temperature in locomotives equipped with side checks.

Since the evaporation increases with the top boiler check, it follows that the velocity of the steam through the steam space to the dome increases. This increase in velocity occurs along with an increased agitation of the water surface due to a greater number of steam bubbles escaping from the water surface which tends to lift more particles of water into the steam space. This results in a condition within the boiler that is conducive to priming.

The C.M.St.P. & P. RR. report Mr. E. H. Heidel refers us to some tests conducted on this road of a developed method of feed-water entry which involved piping the discharge from the check tail pieces to a point just over the tubes; this was found to be more successful than the spray nozzle method. This avoids sprays and acts as a pre-heater before entering the boiler water.

On one of the above tests where one short and one long pipe coupled to the check piece was used, it was definitely shown that the longer pipe did not create as great a carry-over disturbance of water as did the short pipe.

In conclusion, the top check permits less shock loss and longer side sheet life but requires greater care in operation of blow-downs to keep the concentrated solids in solution.

The Virginian Railway Co. reports a bad grooving condition developed on their "compound mallets" around staybolt holes, tube sheet flanges and boiler shell courses. We believed this grooving condition was caused by excess oxygen in the feed-water which entered the boiler through side checks in a solid stream where the oxygen could not liberate itself.

Tests were conducted after applying a right and left inside feed pipe to the side check and extending to the top of the boiler above the dry pipe converging into a horizontal perforated pipe, 2½" in diameter, 34" long, with 34½" drilled holes and clamped to the dry pipe giving the same effect as a top boiler check with spray nozzle.

In conclusion, the application of these inside feed-water pipes has entirely eliminated all trouble from grooving.

The Washington Terminal reports — less leakage at staybolts on boilers equipped with top boiler checks than with the side boiler checks but a much better performance on engines that are equipped with the top check and spray nozzle than the engines equipped with side boiler checks or top boiler checks.

The Grand Trunk Western RR. reports — since the boiler side checks were removed and replaced by boiler top checks, side sheets staybolts leakage has been reduced to a minimum. The application of the top check to any class of power will greatly increase the service life of the firebox sheets and doubly so if the locomotives are equipped with thermic syphons or circulators.

The Canadian Pacific Railway reports — that they have discontinued the use of side checks in favor of the top check years ago on all classes of power. No spray nozzle attachments used. No records available of increases side sheet life from this application.

The Chicago and North Western Rlwy. reports — advantages from Top Check application improve water circulation within the boiler, salts held in solution in the feed-water are precipitated to a great extent settling at the bottom of the boiler barrel in the form of a sludge which is easily washed out.

The Canadian National Railways report — they have long been an advocate of the Top Boiler Check. All locomotives are equipped with a double top boiler check with deflector type tail piece. The performance of twenty (20) Mountain type engines put in service at the beginning of 1945 until the first retube repair have accumulated 8,341,019 miles, an average of 417,000 miles. It was found necessary to renew half side sheets in four of these engines; six required patches on side sheets; the remaining ten engines required no firebox repairs; figures as of March 1950.

Increased firebox performance is not the result of any one method but rather a combination of Top Check, Oil Separators, Proper Cooling Down and Firing-Up Methods, and a good water treatment program.

TESTS CONDUCTED BY THE SUPERHEATER COMPANY ON DIFFERENT RAILROADS.

The opinion was expressed and generally accepted that pumping of cold water into the boiler when the engine was drifting or throttle closed on a feed-water heater equipped locomotive was largely responsible for staybolt trouble in the area of firebox side sheets, also for tubes leaking at the front end.

It was also realized that before boiler feed water could reach either the firebox water legs or back tube sheet, it would have to traverse through a comparatively large body of hot water within the boiler, the path the water entering the boiler takes is dependent upon the temperature of the water when entering the boiler and of course the resultant density. The colder the water the further it would travel.

A test was conducted on a Canadian Railroad on a Mikado Engine, equipped with a Top Boiler Check, 275 pounds boiler pressure on a territory where considerable drifting was done. In preparing for the test, a fixture from a recording instrument was placed in the bottom of the boiler barrel adjacent to the front tube sheet and one was placed in the bottom of the boiler barrel in the second course. The third fixture was located in the front lower corner of the water leg. More than eighty (80) readings were recorded and regardless of water temperatures entering the boiler there was little variation in the temperature of the water at any time in the three locations indicated. Feed-water entering the boiler varied from 90° to 225° over the whole trip. "Boiler water temperatures of 395° at the front; second course 408°; firebox corner 385°; were constant." Any belief we might have had regarding the cold water being pumped into the boiler when the engine was drifting with closed throttle having any detrimental effect on staybolts may be dispensed with because the variation in boiler temperature is so slight we can disregard it.

Further tests conducted on American Railroads proved that the greatest amount of damage to component parts of the boiler is done in the process of firing up cold boilers, when the water is almost stagnant in the lower part of the boiler during the whole procedure of firing up and temperatures vary as much as 200°F. between top and bottom of the boiler. This condition exists until the throttle is opened and natural circulation increases.

Advantages of the "Side Check."

1. Does not create carry-over.
2. Easily accessible for repairs.
3. No spray attachment.
4. Application less expensive.

versus

Advantages of the "Top Check."

1. Feed-water higher temperature.
2. Furthest point away from firebox hot zone.
3. Stresses in boiler shell reduced.
4. Injector and pump can be incorporated into one feed-water delivery.
5. Spray nozzle can be applied.
6. Savings in firebox maintenance.

Disadvantages of the "Side Check."

1. Feeding cold water direct into circulating cycle moving towards firebox.
2. Responsible for considerable amount of cracks in boiler shell and firebox sheets and leaky staybolts.

versus

Disadvantages of the "Top Check."

1. Initial cost higher.
2. Increased blow-down to reduce foaming.

The Advantages of, "Top Check, with Spray Nozzle Arrangement"

1. Diffuses feed-water, picks up higher B.T.U. value from the steam.
2. Salts in solution are precipitated to a greater extent.
3. Oxygen in feed-water dissipated into steam area reducing oxygen corrosion in shell and firebox plates.

CONCLUSION

From operating records submitted by the various railroads to this Committee there can be no doubt concerning the merits of the Top Boiler Check

application. Stresses that were previously set up within the boiler by the induction of cold water from the side check are eliminated, as the top feed produces a constant temperature throughout the whole boiler. Improved water circulation increases boiler thermal efficiency and the ultimate results are a reduction in firebox and boiler maintenance, with increased service life on firebox side sheets.

The "Side Boiler Check" application seems to have outlived its usefulness and has no place in modern boiler efficiency.

The "Steam Space Spray Boiler Check" is not a recognized check but rather an improved tail piece added to the standard top boiler check arrangement, to diffuse the feed-water and is accepted by some railroads as a decided improvement increasing boiler efficiency, while other railroads report that when the steam demand is greatest or when trading steam for water that the spraying effect of the feed-water in the steam area, creates a carry-over condition, reducing engine performance.

It is recommended that the Committee fully endorses the Top Boiler Check and that the application of the spray nozzle be considered by railroads seeking to improve boiler efficiency and reduce boiler maintenance at a minimum cost.

As Chairman, I am grateful to my Committee, and thank the officers of other railroads for information submitted and used compiling this Topic Report.

President Gilley: Gentlemen, you have heard the reading of the Report on Topic No. 5. What is your pleasure with regard to this report, please?

R. W. Barrett (Chief Boiler Inspector, Canadian National Rys.): I move that we accept the report as read and that the topic be opened for discussion.

. . . The motion was seconded by Secretary Stiglmeier and upon vote was declared carried . . .

President Gilley: Mr. Chairman, will you open the discussion?

Comments and Discussion on Topic No. 5

Mr. Godwin: Gentlemen, before I open the discussion period, I would like to take this opportunity and thank Mr. Leet of the Superheater Company for his fine contribution on this topic, it certainly is a credit to him. He has done a considerable amount of work in research work and has a lot of answers that will be a benefit to us. Being a supply man may put him on the spot in answering some of the questions put to him but I can assure Mr. Leet that he can feel free to discuss anything he wishes that will help the Master Boilermakers' Association. The reason, gentlemen, I make reference to this, you will note in Mr. Leet's paper that he states that the "Top Check Application" has increased boiler evaporation 22% over the side check application. I challenged Mr. Leet to prove his point on increased evaporation and after some discussion I find that he has the figures to prove his point and we as a Committee will have to accept the figures submitted by him until we can prove otherwise. This can only be accomplished by someone conducting tests on a boiler working under operating conditions to determine temperatures at different parts of the boiler.

As this paper covers a very important subject, I expect a very lively discussion period.

Mr. Leet points out, as Mr. Godwin spoke to you a minute ago, that the top boiler check had increased boiler evaporation 22%. I believe we are going

to prove this with cold facts, that you will increase the efficiency of the superated steam, that being one of the questions we anticipate to prove in the test we are conducting at the present time.

I am not in position as yet to give to you the procedure we are following in this test, but I would like to say to you gentlemen, I am in favor for this association to continue this topic in the year of 1951, for there is much involved, so much can still be learned in the next year, that will be of much benefit to all Railroads, still using steam locomotives, and I am going to again say to you gentlemen, that I am not in the least doubtful to tell anyone, that the top boiler check with a spray nozzle will improve firebox conditions, it will overcome much of the staybolt leakage in the side sheets.

At this time I would like to ask Mr. Leet to give to you a few figures of what he has brought out in his test on the increased temperature of superheated steam. Mr. Leet as I had said before, has worked with me continuously on this work for the Railroad I am connected with, and as Mr. Godwin stated this morning, very satisfactory results are being obtained, he is quite familiar with the increased temperature in superheater steam obtained on the test they had conducted on his railroad.

Mr. Leet: Thank you, Mr. Stiglmeier.

Well, to begin with, on one particular type of locomotive we began to notice low superheat temperatures with the top boiler check arrangement; we were getting superheat temperatures of around 620 to 640. At various times during the operation of the locomotive, particularly during acceleration periods with heavy trains, the superheat tended to fluctuate, probably 620 to 640 and maybe down to 580, and the fluctuations occurred in that range.

The arrangement that we are trying now, which as Mr. Stiglmeier said we cannot speak too much about at the present because we have not completed the tests on it, we are now getting superheat temperatures as high as 745 and 750 degrees on the same locomotive, indicating that we are whipping this slight carryover condition that we have been getting with the top boiler check.

I have a few remarks that I would like to make in connection with this subject. When I stated that we had increased evaporation 22%, please remember that I was talking about a locomotive primarily designed for a side boiler check and operating with a side check; then if you take the boiler check off at the side and put it on the top, go out and pull the same kind of a train at the same speed with the same throttle opening, and use the same amount of steam out of the boiler, your actual evaporation in your boiler will increase, and the increase is much bigger than anybody thought possible. If you are feeding through a side boiler check and we'll say that your water is entering at 225 degrees and the saturation temperature in your boiler is 405 degrees, then you have to heat that water from its entrance temperature up to saturation temperature before you can make it into steam. In so doing you are taking heat from your tubes, flues and firebox. You are taking heat from your heating surfaces to preheat this water to steam temperature. Now if you put it in through a top check and you are going to spray it through steam, you are going to condense steam.

The point to remember is this: If we are working, we will say, 75,000 lbs. of steam per hr. to the cylinder, with a side check, and we change to a top check and work the engine the same, still using 75,000 lbs. of steam to the cylinder, but are now spraying it through steam we are going to be condensing steam. If we are spraying 75,000 lbs. of water in and taking 75,000 lbs. of steam out, where are we going to get this steam to condense under the boiler check? We are getting that because we no longer are going to have to pre-

heat this entering food-water, we are now doing it with heat from steam, so that the heat that was primarily used for preheating the entering feed-water is now absorbed by the water in the steam space of the boiler and that heating surface that we were using to preheat is now available for generation of more steam, and the increase in the steam generated is exactly equal to the condensation that you get underneath your top boiler check.

This does not disturb the heat balance of the locomotive at all. Sometimes when you tell people you increase the evaporation 22% by changing from a side to top check they look at you like you are crazy, but it is simply a case of heating the water from its entrance temperature to steam temperature by a different method; we are heating it by steam instead of heating it from the heating surfaces.

Some may question how rapidly the heating occurs. I would like to recall to you that this paper is primarily involved with steam space spray boiler checks; in other words, boiler checks with a spray nozzle. If there is no spray nozzle on a boiler check and the water is being dumped in a solid stream into the boiler, the heating might not be as rapid as it is through the spray nozzle.

Those are all the comments that I wanted to make but if there are any questions in the minds of any of you gentlemen about this subject I would certainly be happy to have them brought up now.

W. H. Keiler (I.C.C. Locomotive Inspector, Bureau of Locomotive Inspection, St. Paul, Minn.): I would like to ask a question. Where you increase the evaporation 22%, what effect would that have on fuel consumption?

Mr. Leet: It would have absolutely no effect on fuel consumption for the reason that you are not changing the heat output of your boiler at all. Your heat input and output would be the same so your fuel would be the same.

F. R. Milligan (Gen. Boiler Inspector, Canadian Pacific Rys.): Were these Superheater temperatures Type E or Type B?

Mr. Leet: Type E.

Mr. Milligan: The reason I asked that, we have the Type E and our difficulty has been to keep the Superheater temperatures down. We have had 740 and 780, and one time it was at 800 but that was disputed.

Mr. Leet: That will vary with different locomotives on different Railroads because so many locomotives were custom built you might say. Each Railroad wanted its locomotives built a certain way and we could never standardize on the superheating surface, so you may find one locomotive with different Superheat temperatures than a similar locomotive on another road.

But what was interesting in our studies was that on the same class of locomotive, with the same superheating surface, when we used the top check with the spray valve we were losing superheat, indicating that there was some carryover occurring in the boiler. The only way the carryover could be explained was the fact that with the increase in evaporation in the boiler, more steam was passing through the steam space. A greater amount of steam traveling through the same space causes velocities to be higher and a critical velocity is reached where water is picked up and carried into the drypipe. When we were making our efforts to correct this condition, we got increased superheat (up to 740 and 750 degrees), and we knew we were no longer permitting water to enter into our units and cylinders.

Mr. Milligan: I think we had trouble with return bends burning out very rapidly.

Mr. Leet: With return bends burning out? The usual cause for return bends burning out is scale build-up. Maybe your locomotives were getting a little bit of carryover.

Mr. Milligan: There was no indication of carryover.

Mr. Leet: Superheaters as a general rule have a sufficient margin that they can handle a small amount of moisture without a reduction in the superheat temperature. It is when you go beyond that maximum moisture that they can handle, that you start getting a drop in superheat. That small amount of moisture, while you may be working steam of a quality of 96- or 97%, or 3- to 4% moisture in your steam, may not be enough to indicate on your pyrometer that you are working any water. However even that small amount where it makes a 180-degree turn in your return bend, will precipitate out any solids that might be in that little bit of moisture that you are carrying over. When the scale begins to form in the return bends it acts as an insulator. You can no longer carry the heat away from the metal. We depend upon the steam to carry the heat away from the metal to keep the metal temperatures in a safe range. If we get a little scale in the return bend and the steam can no longer carry the heat away from the metal, the temperature that eventually follows can burn out the return bends.

Then general tendency is to say, "I cut the return bend open after the failure and found nothing in it." The thing to do is not to cut the one that failed. When you have that occur, cut the one that hasn't failed, because a lot of times when it fails and the return bend opens up it will crack loose the scale, and of course it blows out through the opening.

Mr. Milligan: One more question. The thickness of your return bend on the end is four and five times the thickness of your tube. Don't you think that has something to do with the bend burning out? Why can't we have the same thickness around the bend?

Mr. Leet: You might carry your heat away from your metal better, but there is a limit to how small we can go with that in the forging procedure we use in building the units. Another thing then that you would have to worry about is the possibility of cinder cutting. If you get it too thin you will have units fail due to cinder cutting. You might cinder cut it out rather than burn it out, so you have to use a happy medium.

John Marcroff, Jr. (Supv. of Boilers & Welding, The Virginian Railway Co.): Would you care to express an opinion on how much oxygen is dissipated by using the spray nozzle?

Mr. Leet: I hesitate to say that. Every water that you use will have a different oxygen content. By the same token, some waters have sewage gases which are more corrosive than oxygen, and you cannot say definitely how much would be dissipated because you don't know how much oxygen is in the water. But it is reasonable to assume that if you spray it through a top boiler check you are going to almost completely deaerate your feed-water. In other words, you won't have any oxygen or corrosive gases along your heating surfaces if you use a top boiler check and a spray nozzle because the high temperature will drive the gases and oxygen off into steam space where they can go on and pass out through the dome of the locomotive without damaging the interior of the boiler.

George Cousins (Foreman Boilermaker, Steel Company of Canada, Hamilton Works, Hamilton, Ont., Canada): Mr. Speaker, do you feel there would be any advantage in applying top checks to a horizontal boiler or wayside boiler?

Mr. Leet: Oh, yes, I think there is an advantage in any type boiler. You mean in stationary service?

Mr. Cousins: Yes.

Mr. Leet: I think it is advantageous and I think you will find that most of your boiler manufacturers today that manufacture stationary equipment are putting their water into the steam spaces of their boilers. Nearly any large manufacturer of boilers now uses that method. It has been adopted.

Mr. W. S. Douglas (Chief Boiler Inspector, Canadian National Rys.): How do you arrive at the fact that the top check is responsible for carry-over?

Mr. Leet: Well, in my opinion the big question is this: It is a question of velocities in the steam spaces. We have put top checks on locomotives with varying steam spaces, from relatively small to relatively large steam spaces on locomotives which were all working at somewhere near the same steam output when they were on the road. Where we had larger steam spaces we got no carryover. If you are going to increase the evaporation of the locomotive, which necessarily does occur if you spray water through the steam and condense steam in your steam space, there are going to be more bubbles of steam forming on your heating surface and rising to the surface of the water. There will be more pounds of steam moving through the same steam space. Since you are moving more pounds of steam at the same pressure, your velocities through that steam space necessarily have to be higher. The increased velocities coupled with the increased agitation of the surface of your water due to a greater release of steam bubbles on your heating surface rising to the top, creates the condition that causes the steam to be whipped up into the dome.

Every effort was made to correct this condition. First it was thought to be entrainment coming from the spray valve to the dome. Well, you all know that if you spray water into steam you are going to condense steam. If you condense steam in a small area you are going to reduce pressure. There is going to be a flow of steam into the spray. There has to be a flow of steam into the spray to replace the steam being condensed. If that flow of steam is going into the spray, there is not going to be any flow of water going the other direction towards the dome. That is what brought it all back to a question of velocities. Then in studying steam spaces on various locomotives operating at the same evaporation rates we find that with the smallest we would begin to get the carryover. When we would get to the large steam spaces, we did not get it.

Mr. Douglas: If it is true that the top check with the spray nozzle increases the temperature to such an extent that it becomes almost boiler temperature when it enters the boiler, we could do away with the feed-water heater.

Mr. Leet: No, because with the feed-water heater you are utilizing exhaust steam which you would normally be throwing away and you are saving a certain amount of heat that you don't have to add with coal fired. With a top boiler check you are not changing your coal fired in the least. You are not changing the heat balance of your boiler in any way. You are simply setting up a condensing and evaporating cycle in that boiler as long as you are superheating and pumping water through that steam space. If you did away with your feed-water heater you would find you would have to fire more coal. The thing to do is to look at the heat input and heat output of the boiler. If your heat input and heat output are the same in both cases and you eliminate your feed-water heater you will have to fire more coal, because the feed-water heater is using exhaust steam for adding heat to the water in generation of steam, whereas without the feed-water heater all of your heat has to come from your coal pile.

L. J. Johnson, Jr. (Gen. Foreman Boilermaker, Florida East Coast Ry.): Mr. Leet, may I have a word to say in regard to the top check? I cannot discuss the side check with you because that was discontinued on the Florida East Coast Railway in 1908. Since 1908 we have used the Nathan top boiler check, double check type, but we do not have a spray valve in it. We used to have a little 6-inch nipple from either side and a baffle or deflector plate under the plate which acts as a spray. We get around 300,000 miles between flue renewals, and we have about two to three wheelbarrows of scale or loose mud in the boiler which builds up from the front flue sheet back about 18 inches. Now I think that is a contributing factor because we have side sheets in our locomotives that were applied in 1926 and I defy anyone to find leaky staybolts. I think that you know it, you have been out on our Railroad.

Mr. Leet: You are referring to the fact that the solids, etc. are being precipitated out of the feed-water?

Mr. Johnson: There are a lot of other contributing factors to this. I would not say the top boiler check, but in my opinion it must have something to do with it.

51- 1134

Mr. Leet: It no doubt would cause the temperature of your side sheets to run at a lower temperature because side sheets are the same as a unit or anything else. Scale is an insulator and if it is insulating so that the water and steam cannot carry the heat away from the metal, the metal temperatures are going to go up to a higher point than they should, which eventually will shorten the life of your side sheets.

Mr. Johnson: There are other contributing factors to this firebox maintenance. It is limited water space on the side sheet for one thing.

Mr. Leet: There are a lot of factors that contribute to it. However, we have felt that probably one of the most important factors that has contributed to firebox maintenance is the location of the boiler check valve, due to the fact that by changing the location of it, we increased side sheet life on the New York Central from about 100,000 miles before sheets had to be renewed, up to 480-some thousand miles before they had to be renewed. And in connection with that you note in this report that Mr. Godwin read on the test that was made by the Superheater Company on the temperature of water along the barrel of the boiler and also along the side sheets that that test was conducted with the top boiler check and with drifting and closed-throttle conditions. In any condition of that nature there was no reduction in temperature back along those areas at any time.

Now I don't have any of the figures available but there have been tests made on Railroads with the side boiler check where thermocouples were located at the back of the firebox just above the mudring and the boiler brought up to full pressure and the feed-water pump operated with the throttle closed. Temperature drops of as much as 150 degrees were recorded back along the lower side sheets. Now that condition is not going to contribute to long side sheet life.

R. W. Engelke (Boiler Engineer, C., M., St. P. & P. R. R.): We conducted several tests on top boiler checks, after we renewed five side sheets in one month we were forced to investigate. We had twelve thermocouples, two ahead of the dome and the others distributed back, even beyond the first combustion chamber site. About a quarter had one more combustion chamber siphon of the riveted type. We had no serious carryover with the riveted type such as we experienced for the welded boiler. The riveted type

carried the side checks. Our superheat dropped about 50 degrees in the case of the welded boiler over the riveted boiler.

Mr. Leet: The riveted boiler had the side checks?

Mr. Engelke: Yes, but I think there were other factors contributing to that.

Mr. Leet: Then with your welded boiler you did get a drop in superheat and that was with the top check. That is more or less confirming some of the data here, I believe.

Mr. Engelke: We put a number of baffles, one ahead of the dome, just an ordinary plate suspended from the dry pipe with a number of perforations to allow the steam to come through, and also one in the rear of the dome about 4 feet, and these thermocouples were hooked up to the dynamometer car and we had a board with Christmas tree bulbs in there and we could see at a glance just how this stress of the water in the boiler was performing. The greatest stress occurred over the combustion chamber syphon. We removed that first syphon on that one test and found there was a slight decrease in that stress; however, we then went to the 3-inch copper pipes welded on to the tail piece of the top boiler check; that was carried down to about 3 inches above the tube and at a 45-degree longitudinal line. That seemed to be the most successful arrangement we had; however, there is one thing, just for the sake of investigation, that might occur from that point: the steam is taken from the back tail pieces, there are 2" and 2½" pipes coming up in the dome, and in heavy steam demands those two pipes act as a syphon to bring that steam and water up to that point and then the dry pipe entry, of course, takes over. I think that is one theory, that those two pipes contribute to carryover. That is one thing that was not followed through as we did not conduct any more tests after we were reasonably successful.

One thing, of course, is the operation, how the engineer handles his engines, and steam demands and so on. Periodic blowdowns were a great help in reducing carryover disturbance of the water. Another thing we did was to get an ideal entry into the dry pipe so that we got our smooth flow where the coefficient of entry there would be as high as we could get, and with all those different angles contributing to a reduction in carryover the entire thing was dropped at that point.

I just wanted to let Mr. Stiglmeier know that we did have some thermocouples, 12 of them; they were the pronged type. The water got up to that point, of course.

Mr. Leet: When you applied copper pipes to the tail pieces and brought them down close to the water level or close to the tubes it reduced the carryover?

Mr. Engelke: Yes, it did, although I think on this particular type of engine that our steam space may have been reduced over the riveted type.

Mr. Leet: If you take the water from the tail piece of the injector and pass it down through the steam space inside a copper tube and admit it to the boiler under the water level you are getting away from the advantages of the top boiler check.

Mr. Engelke: Yes, we may have improved that top boiler check.

Mr. Leet: You would improve it as far as carryover is concerned but you would be defeating the purpose of the top check, which if worked to the greatest advantage should heat entering feedwater to saturation tempera-

ture to give you the improved circulation which you can get in your locomotive with the top check.

Mr. Engelke: You would get a more intimate mixture with the spray than you would with just plain water slugging in there. We had a tail piece without the spray, which I think was not as efficient as the spray but we were a little afraid to use the spray because of the condition that had developed.

Member: We built 35 engines in the early '30s and we had top checks. We experienced quite a bit of carryover, superheater return bends bursting, valve bushing renewals, etc. We lowered the horizontal portion of the crown sheet 3⅛", stopped the carryover, cut the valve bushing renewals probably 90% and reduced our superheater maintenance at the return bend. But the top check was not a cure-all for leakage, not in side sheets. We weld side sheets and we still have some leakage.

The gentleman who talked about reducing the return bends on the units, I don't know what he would do about his cinder cutting. Of course he would certainly cut a lot faster than he is cutting now.

Mr. Leet: We try to hit a happy medium between thinness from the point of heat transfer and thickness from the point of cinder cutting.

Member: The gentleman down in Florida speaks of 1926 side sheets. He does not give us boiler pressure or tonnage. I would like to hear that.

Mr. Leet: Incidentally, the remark he made that the crown sheets were lowered 3⅛" again confirms some of the opinions expressed here that the whole question is a matter of velocities. In other words, by increasing the steam space in the locomotive you are reducing the velocity of flow through the steam space, which can eliminate the carryover condition to a certain extent.

Mr. Johnson: For that gentleman's information, we don't have anything over 210-lb. steam. I think that is part of the information also.

President Gilley: Gentlemen, this is a very live subject and I know there are some other problems on which you would like to ask questions, but we are working on a schedule and trying to get a four-day agenda into three days so it will be necessary to close this topic at this time and go ahead with other work.

Mr. Godwin: Thank you, Mr. Chairman. Unfortunately, we cannot complete our business, but I think, as Mr. Stiglmeier suggested a moment ago, there might be an opportunity to carry this discussion over until next year. It is a live topic and very interesting.

S. E. Christopherson: Mr. Chairman. Before you close the topic, may I ask one question? A challenge on this topic was made last year on the same topic. When someone here today stated that the top boiler check with spray nozzle is a cure-all. It is not so. Boiler check alone, even with a spray will not cure our side sheet trouble or leaky staybolts. Treatment must be added to feed water, and for those of us that do not treat water 100%, seal welding of staybolts will prolong the life of side sheet trouble. The challenge is that some railroad with top boiler check, spray nozzle, and 100% treatment, discontinue the treatment for just one week and note the results.

Secretary Stiglmeier: I would like to answer the question raised by our good friend, Mr. Christopherson. When I spoke today, and said it improved the side sheet condition on our railroad, I did not say it was a cure for all conditions. You must understand you must take your own railroad into con-

sideration. We believe that the top check with spray nozzle will help condition, not cure them all. You must have water treatment also.

J. L. Callahan (Chief Boiler Inspector, National Aluminate Corporation): Mr. Chairman. Supply men are supposed to be seen and not heard, but, as a boilermaker I just want to say that for years I have been a very strong advocate of the over-head boiler check. I have had the opportunity of observing the effects of the side boiler check as compared to the over-head boiler check. In the discussion on this topic reference has been made to carryover—priming—feed water heaters—water treatments—boiler water circulation as possible causes for many of our boiler problems that has resulted in so much heavy boiler repairs. Apparently we have not taken into consideration that boiler design is an important factor. We cannot make the present day modern boilers any wider, higher or longer so the designers have designed for what would be considered pure water and have increased the heating surfaces thru the use of circulators, syphons and longer combustion chambers. By stealing on the steam space it has been necessary to apply baffles, cross plates and dry steam throttle to prevent carry over. The over-head boiler check in my opinion plays no part in carryover or priming. By putting the feed water in the top front of the boiler the feed water is thoroughly tempered by the steam and boiler water and the shock to flues, circulators, syphons and side sheets is eliminated. Our job is to preserve the life of the boiler and in my opinion the over-head boiler check is the answer to the elimination of this frequent and heavy boiler repairs that many of you are compelled to make because of the side boiler check.

President Gilley: Thank you.

Owing to the time limit, out of necessity Topic No. 5 is closed.

We will now come to the "Good of the Association." Have you anything, Mr. Secretary?

GOOD OF THE ASSOCIATION

Secretary Stiglmeier: Gentlemen, as in years past I had always asked all at these meetings for the membership, to report to me the names of those members that have passed away since the last meeting, also those members who had retired from active service, for as you know the Constitution and By-Laws of your association states, that any member in good standing when he retires from active service, is entitled to be made an honorary member, and you may be assured that any names so reported will be very much appreciated.

President Gilley: Is there anything else on the Good of the Association? If not, the meeting will be adjourned until two o'clock this afternoon.

. . . The meeting adjourned at twelve o'clock . . .

MONDAY AFTERNOON SESSION

SEPTEMBER 18, 1950

The session was called to order at two o'clock by President Gilley.

President Gilley: The afternoon meeting of the Master Boiler Makers' Association is now in order.

Secretary Stiglmeier: Gentlemen, it gives me great pleasure to again introduce to you Mr. Earl R. Benedict, Convention Manager of the Hotel Sherman, who has always given us what we call one hundred percent support in holding these meetings. Mr. Benedict. (Applause)

PRESENTATION OF GAVEL TO PRESIDENT GILLEY

Mr. Benedict: It is certainly good to see you all. We have been doing this for about twenty years, but it is always a pleasure. You certainly have got a full program this year and I know you have got to get started with your afternoon meeting. We wanted to present to your President a souvenir gavel that he can take home to remember this event by, but we know you are going to behave so he won't break it before he gets out of the hotel.

Mr. President, it is a pleasure to present you with this gavel.

President Gilley: Thank you, Mr. Benedict, and I am very glad to accept it. Thank you again.

At this time we will have the Report of the Executive Board; Mr. R. W. Barrett, Chairman.

REPORT BY CHAIRMAN OF EXECUTIVE BOARD

Your elected Executive Board together with your President E. H. Gilley, Secretary-Treasurer A. F. Stiglmeier and a number of Past President who are ex-officio members of the Board, met in Chicago on four occasions since our last Annual Meeting to deal with important business affecting this Association of Master Boiler Makers.

At our first meeting held at the close of our 1949 Association meetings, R. W. Barrett, Chief Boiler Inspector of the Canadian National Railways was elected Chairman of the Board. Harry C. Haviland, Boiler Supervisor, New York Central Railway was elected Secretary of the Board. At this meeting the topics for the 1950 Convention were selected and Chairmen of Committees appointed. Your Executive Board also considered the appointment of five additional Advisory Board Members and requested the Secretary-Treasurer to approach certain outstanding Railroad Officials and secure their consent to act in that capacity. As a result the following gentlemen have been added to the Advisory Board:

MR. F. BENGER,
Asst. Chief of M.P. & R.S.,
Canadian Pacific Railway.
MR. H. HILL,
Superintendent of M.P. & R. Equip.,
Reading Company.
MR. A. G. HOPPE,
Gen'l. Supt. Loco. Departments,
Chicago, Milwaukee, St. Paul & Pacific R. R.

The few kinks that are shown are handy and can be used almost by anyone to good advantage.

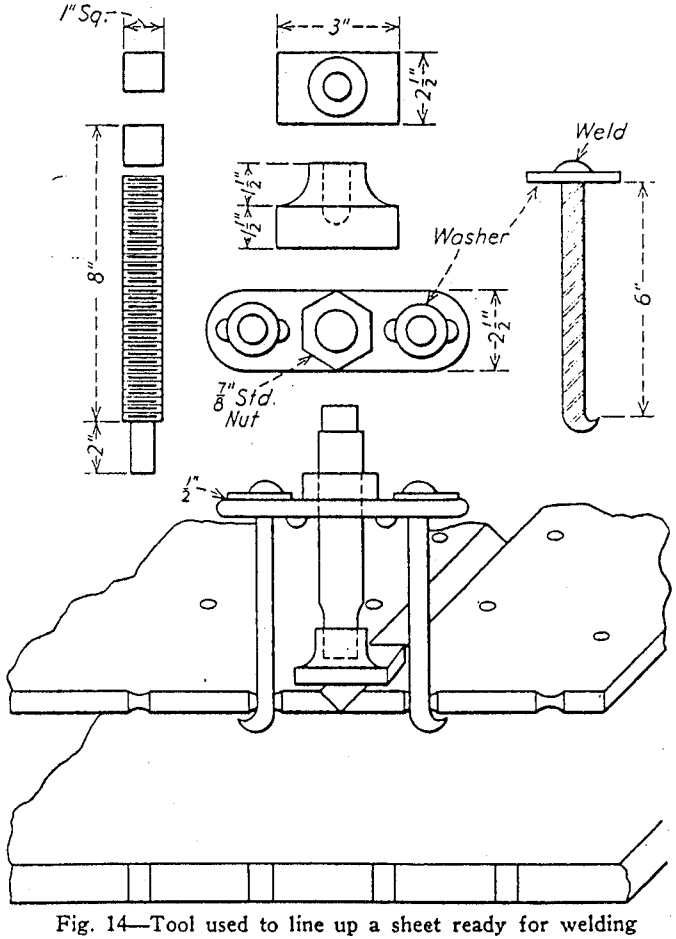


Fig. 14—Tool used to line up a sheet ready for welding

A useful tool for many occasions is shown in Fig. 15

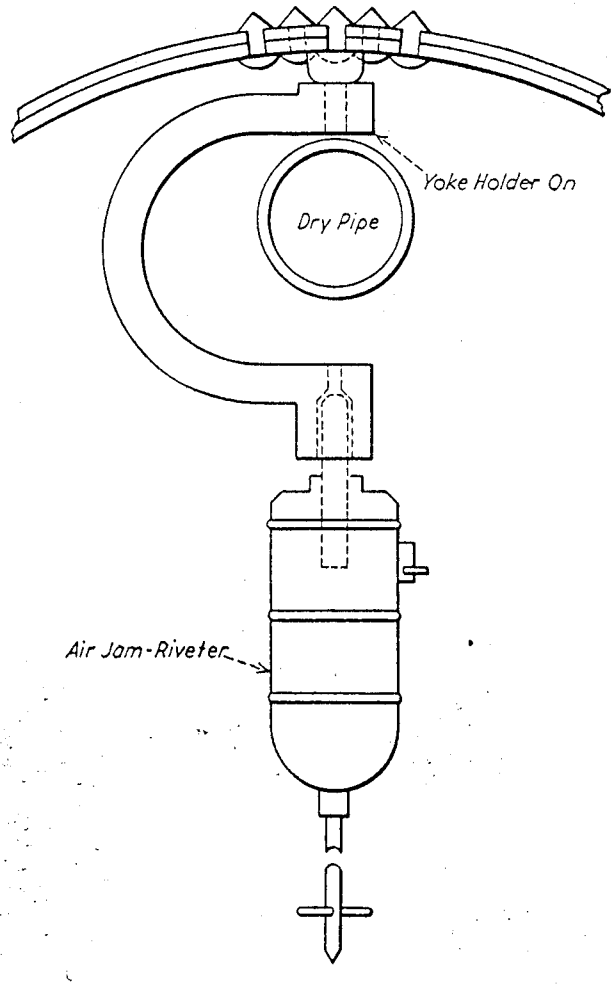


Fig. 15—Home-made yoke holder-on—uses: shell courses without removing drypipe; outside throat sheet without removing combustion chamber sheet, etc.

These handy tools are easily made, and their uses are shown in Fig. 16.

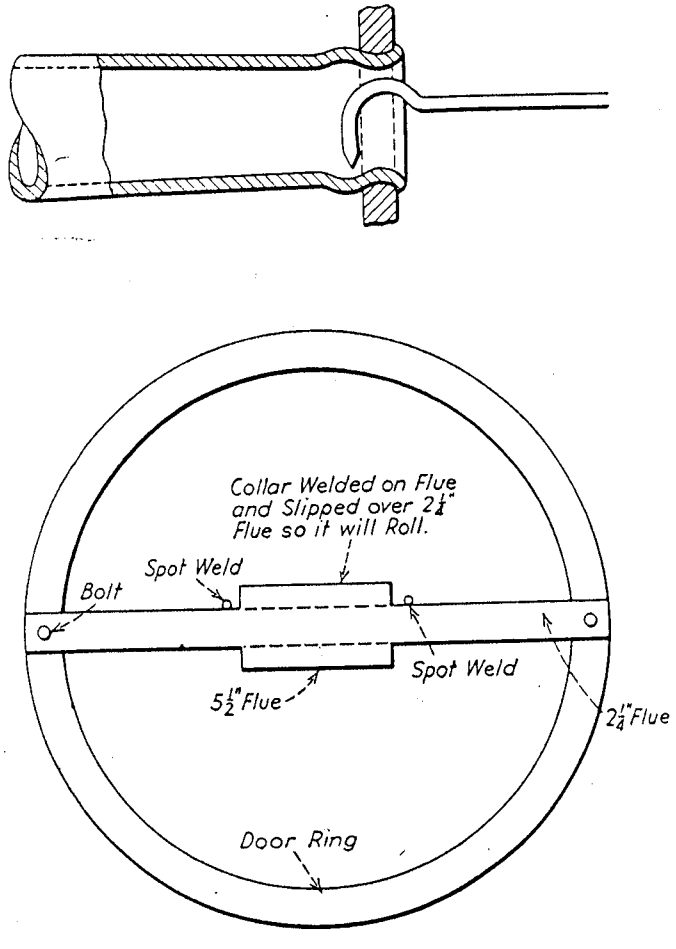


Fig. 16—(Above)—Handy bar for detecting soft flues when cinder cut is just back of prosser mark; (Below)—Handy arrangement placed in front at smokebox for removing flues from the boiler.

A solid and strong staging is safety first in any shop, and I recommend the use of this arrangement as shown in Fig. 17.

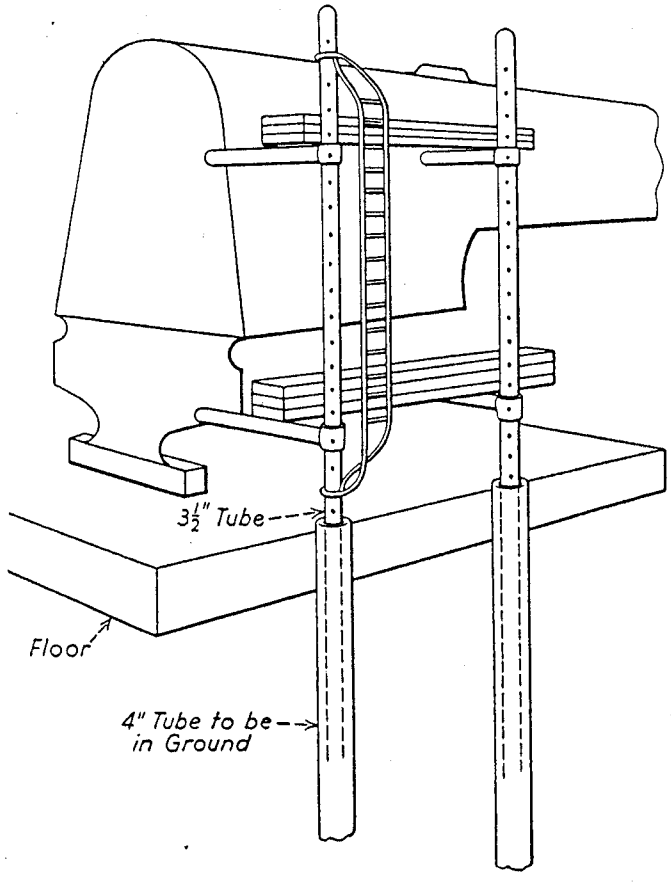


Fig. 17—Handy staging arrangement made of old flues—Ladder attachment is welded to flue and is of light tubing