Will boiler maintenance and safety of operation be aided by the multiple application of

FUSIBLE PLUGS

Committee

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While it may be expected that all persons affiliated with the manufacture, operation and repair of steam boilers have at one time or another discussed fusible plugs and their reliability to function at the opportune time, we believe it incumbent upon this committee to review briefly the many disappointments experienced in the past when using a fire-actuated fusible plug as a means of warning to prevent boiler disasters, with the result that in some quarters the activity toward their use is not very pronounced.

The designs vary, because of the efforts made to effect improvement in their operation. In the majority of these cases, and perhaps all, the fusible metal consisted of a solid core of alloy metal. The common design is shown in Fig. 1.

Another design, shown in Fig. 2, was used for a period between 1903 and 1914. This design was thought to be an improvement over the design shown in Fig. 1.

The experience in both cases was that the plugs had to be renewed at least once every two months, because the alloy metal disintegrated to the extent that the plug would not function, regardless of the temperature reached.

In many cases where the plugs were still in good condition it was found that in cases of low water, although the plug was duly heated, the alloy metal would start to melt but before the entire body of alloy metal would drop out the action of the steam through the small opening first made had the tendency to cool off the metal to the extent that the plug would not properly fuse, and the result would be that the plug was practically useless and therefore unreliable.

Adhering to the theory that fire-actuated fusible plugs are sound in principle and provide an economical means by which to forestall damage to firebox crown sheets on account of low water, further research developed the design of plug shown in Fig. 3.

In this instance the objectionable features above explained were eliminated by the application of a drop plug button, which was cemented in place with fusible metal. Therefore, the fusible plug, heretofore always referred to as such, has developed into a practical drop plug. In other words, the boiler pressure forces the button out of the hole instantly when the alloy metal fuses, and the full unrestricted opening for the escape of steam is thus obtained. Experience with the use of this plug since 1914 has conclusively demonstrated that the design of this drop plug is fundamentally sound.

This deficiency, to a large extent, was caused by the plugs not being manufactured at a central point on the railroad using them, resulting in slight variations from exact dimensions governing the relative diameters of the hole in the plug. The consistency of the alloy metal was not always exact, and the method of handling

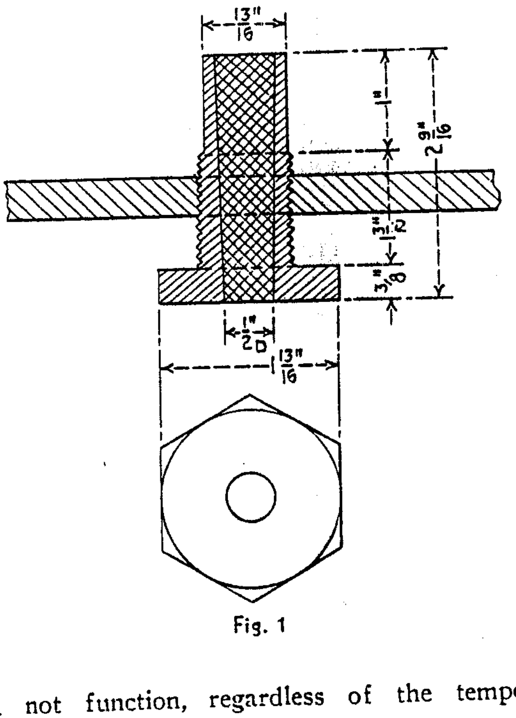

Fig. 1

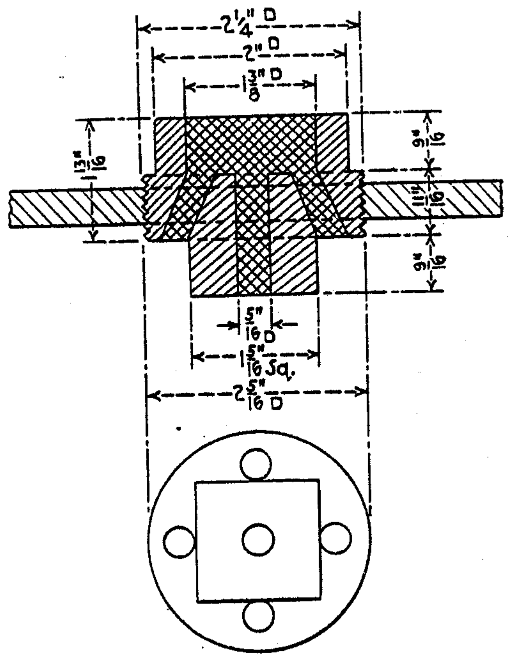

Fig. 2

Note: The committee which submitted this report consisted of the following: O. H. Kurlfinke, boiler engineer, Southern Pacific, chairman; F. A. Longo, welding and boiler supervisor, Southern Pacific; E. H. Paepke, general boiler inspector, Union Pacific.

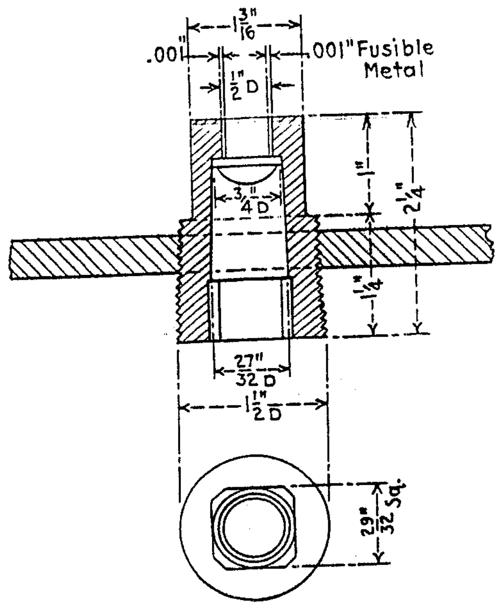

Fig. 3

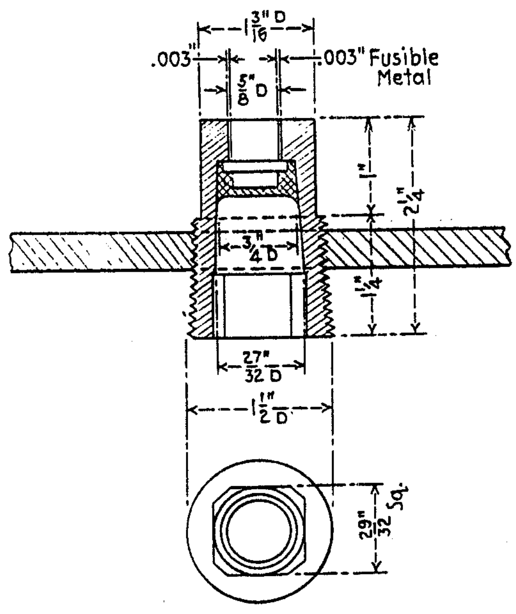

Fig. 4

the plugs after the button had been sweated in place impaired their consistent operation.

The railroad in question submits the following interesting record covering the application of drop plugs since the year 1914 and up to and including 1932, which gives the number fused on account of low water, and the number fused on account of being defective.

Record of Drop Plugs *

The combustion chamber engines were equipped with two plugs, and the others with one. In both cases a plug was located at the highest point of the crown sheet, approximately 8 inches back of the tube sheet. The second plug, when applied, was located further back over the forward end of the firebox mud ring.

The locomotives referred to, excepting the 4402, were equipped with one plug. The 4402 had two plugs. In all these cases excepting the 2436, the engines were working hard at the time, and, while in each case there were undetermined circumstances regarding the cause of low water, the effect of the steam blowing into the firebox through the plug orifice was apparently not noticeable, since the draft was apparently severe enough to carry the escaping steam along with it through the tubes. On the 2436, the button did not drop, but was moved slightly as the engine did not have full pressure.

Whatever conclusions were reached at the time investigations were held to determine the exact contributary cause of these accidents, the final analysis was that the plugs should be made and so applied as to number and location that they would function in an absolute manner.

In the latter part of 1931 further improvements in the design and manufacture of this drop plug were made with a view to obtaining the objective that when the plugs fused the fire would be so interfered with it would be difficult and perhaps impossible for anyone to continue to manipulate any device that would continue the operation of the locomotive under such conditions.

The drop plug thus designed and perfected is shown in Fig. 4.

In general appearance, the plugs shown in Figs. 3 and 4 are similar; but we invite your particular attention to the dimensions governing the application of the button. During the period when the plug shown in Fig. 4 was being developed, the conclusion was reached that the diameter of the button should be enlarged from ½ inch to ⅝ inch. This change increased the area of the opening 56 percent.

It was also considered necessary to increase the thickness of the fusible metal between the button and the plug body. The plug in Fig. 3 had 0.001 inch thickness of fusible metal around the button. The plug in Fig. 4 has 0.003 inch thickness of fusible metal. The reason for this increase was that oxidation has a deteriorating effect on the fusible metal, and the quicker fusible metal is heated and cooled down the quicker oxidation.

As these drop plugs fuse due to the rise in temperature through the plug body, the larger the button diameter (of course, within certain limitations) the more rapidly the plug will function under the same boiler pressure. For instance, when the heat gradually increases, the fusible metal will begin to soften, and, when it reaches a certain degree of softness, the pressure on the button will force it out of the plug body. Where a boiler is fired up without sufficient water and the pressure in the boiler is very low, the thickness of fusible metal is such that it will melt to a liquid state, and, in so doing, the button will fall out at the first indication of a load upon it. As the pressure gradually increases and the

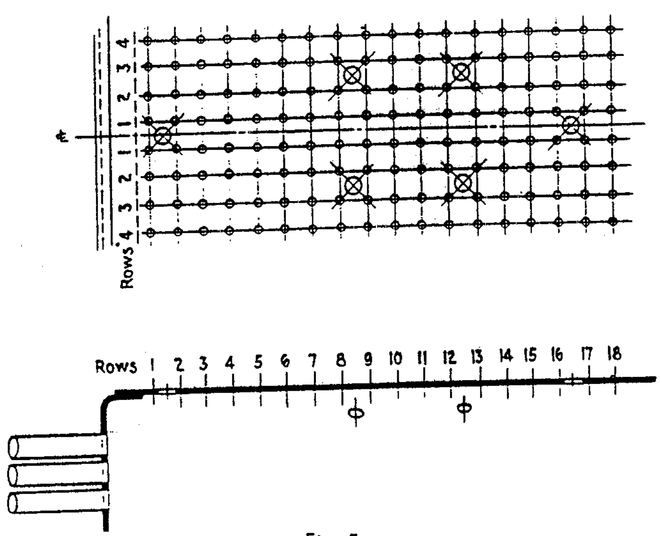

Fig. 5

RECORD OF DROP PLUGS APPLIED TO LOCOMOTIVE BOILERS

Year	Locomotives Equipped	Equipped with Drop Plugs						Plugs Fused Account Low Water — Responsibility: Crew	Yard or Roundhouse	Total	Total Plugs in Use	Plugs Fused Acct. Defective: No.	Percent of Total Plugs in Use	Explosions: No.	Remarks
								This data not available prior to 1927.				This data not available prior to 1927.		1	Eng.4037-Edison-Low water.
1914		All												1	Eng.2763-Ogilby-Low water.
1915		"												1	Eng.2602-Ordway-Low water.
1916	1361	"												0	
1917	1375	"												0	
1918	1403	"												0	
1919	1441	"												0	
1920	1458	"												0	
1921	1483	"												0	
1922	1506	One	Two								1655			0	
1923	1492	1329	163								2000			0	
1924	1760	1520	240								2005			0	
1925	1742	1479	263								2052			0	
1926	1749	1446	303					7	* 5	12	2044	5	0.245	0	
1927	1723	1401	321					8	14	22	2044	1	0.049	0	
1928	1704	1364	340					14	ø 16	30	2072	3	0.145	1	Eng.4017-Wall Creek-Low water.
1929	1691	1310	381					5	7	12	2108	0	0.000	0	
1930	1682	1256	426					5	8	13	2117	40	1.889	2	Eng.2436-Sacto.R.H.-Low water-May 22. Eng.4402-Richvale-Low water-Dec.23.
1931	1667	1217	450												
		1⊙	2	3	4	5	6								
1932	1603	257	103	491	455	246	51	4	6	10	5292	2	0.00037	0	
1933	# 1597	234	103	498	462	249	51	3	4	7	5340	0	0.000	0	

* - Two cases fire started without water in boiler.
ø - One case " " " " " "
- To include 6-22-33.
⊙ - These locomotives out of service.

plugs fuse in multiple, the hazard of accident is less prevalent.

Our experience satisfies us that our locomotive boilers have increased in size beyond the capacity of one or two plugs, as we have had cases where these large boilers can be continued to be fired and the engine worked against the blowing of two drop plugs.

To overcome this it was necessary to equip large fireboxes with an increased number of drop plugs to obtain the effect similar to that of a sprinkler system such as is successfully used in large buildings and which releases a spray of water automatically in case of fire. Such an application of drop plugs is termed a multiple application. Fig. 5 shows a plan view of the crown sheet of a locomotive firebox with a combustion chamber having 513 square feet of heating surface and a grate area of 139 square feet. The number of drop plugs, viz., six, is based on the application of one plug at the highest point of the crown sheet between the first and second rows of stays and one additional plug for each 400 square inches of gas area of the flues.

Fig. 6 shows the inherent effect of the escape of steam through the drop plugs on the fire, preventing the rise of heat to the crown sheet.

Again referring to the record covering the application of drop plugs, it will be noted that during the year 1932, and especially during the first three months thereof, a total of 5292 drop plugs of the type shown in Fig. 4 were in service on 1603 locomotives. Since reliable drop plugs can be manufactured, no inconvenience is being experienced with faulty or defective plugs, as the record shows that, of the 5292 in service, only two fused with ample water over the crown sheet.

This committee feels that the report on this important topic would not be complete if we did not quote herein official reports made covering the circumstances involved in a portion of the 10 cases where plugs fused on account of low water. Lack of space is the only reason why we have not included the entire 10 instances, but you have our assurance that those we have omitted are parallel in fact to those quoted below:

Engine 2266 failed on train No. 334 near Danebo on account of fusing of drop plugs in the firebox. Investigation developed the fact that water was allowed to become low in the boiler. Right and left back plugs fused. Lot No. 100 of fusible metal. No damage to firebox.

Engine 2663 dropped two plugs in the Los Angeles Yard. This engine is equipped with four plugs. Examined boiler and found that water was allowed to get low enough to fuse the plugs but

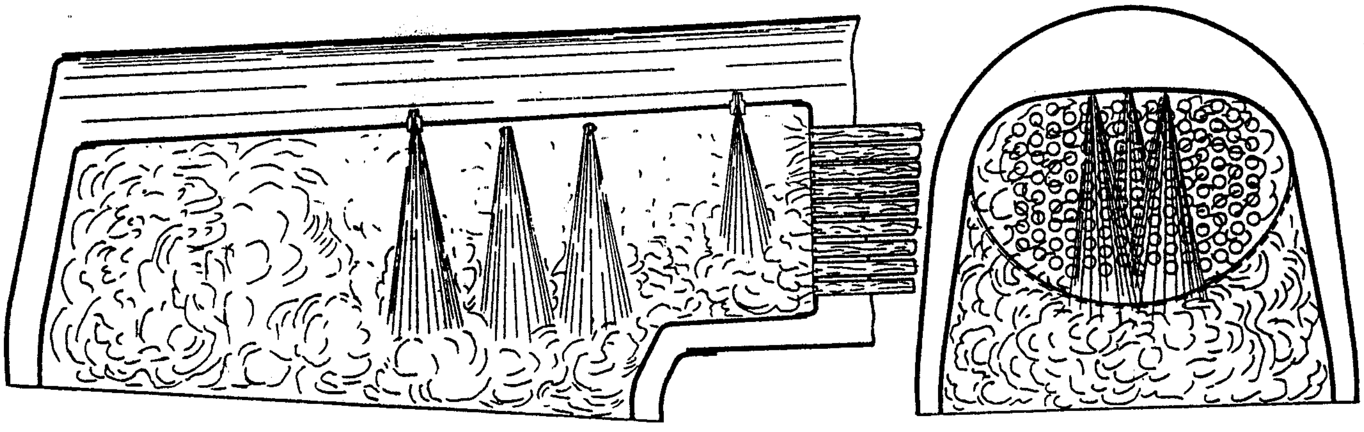

Fig. 6

not low enough to do any damage to the boiler. Water glass, spindles, and gage cocks were in perfect condition. Right injector worked perfectly. Left injector was inoperative. Although the master mechanic reports that the left injector was found to be inoperative on account of a defective intake valve, the fireman, in his statement, repeatedly brings out the fact that the left injector was working satisfactorily all night and was, in his opinion, working all right at the time the drop plug functioned. No doubt the injector failed previous to the engine losing water, the fireman thinking he had the injector on when it was not delivering water.

Engine 1621, being used temporarily as a stationary boiler at Calexico, dropped button of fusible plug and was taken out of service. Could find no indication of boiler being harmed. Water glass, spindles, gage cocks and blow-off found in good condition. Had engine fired up and both injectors worked perfectly. Water was allowed to get low enough to fuse plugs but not low enough to harm boiler. This is a case where the engine watchman permitted the water to become low and upon discovering it put out the fire. Then, after the firebox had cooled down some, operated the injector and before getting the required amount of water in the boiler, as indicated by water glass and gage cocks, started a fire. He seems to have become excited when the stationary boiler was required to operate the fuel pump to supply oil to an incoming train and took a chance on getting up steam without the required amount of water in the boiler. The engine watchman accepts responsibility for failure to follow instructions in connection with firing up locomotives and maintaining proper water level in the boiler while under fire.

Engine 2819, while being watched by an engine watchman at Bowie, failed on account of drop plug fusing on account of low water for which the watchman was responsible. Back plug dropped bore heat serial No. 51. Water glasses, gage cocks, water hose, strainers, connections, injectors were found to be in good condition. No damage to the boiler.

It is possible to imagine what the probable results would have been had these fireboxes not been equipped with a multiple application of drop plugs, not only in injury to crown sheets and company property, but possible injury and loss of life to persons.

When these drop plugs are manufactured, heat tests are conducted on one plug in each 100. If that plug fails to meet the requirements, then five more are selected at random. If any one of these five fails, then the whole lot of 100 will be discarded. The requirements are that the button must not break loose at temperatures less than 550 degrees or more than 575 degrees. These drop plugs actually fuse at a temperature of approximately 560 degrees. Considering the temperature of the water in the boiler at 200 pounds pressure to be 388 degrees, it will be seen that, due to a rise of but 172 degrees on the plug extension, their prompt action to function is assured when the plugs become bare of water and at a time considerably before the maximum temperature is reached that would affect the security of the crown stays.

We, therefore, believe that the foregoing remarks incident to the multiple application of fusible plugs will impress those concerned with the fact that such an application increases the safety of operation.

The term "boiler maintenance" as referred to herein must not be taken to mean that expenses incident to the repair of staybolts, tubes, firebox sheet defects, etc., will be reduced because the boiler is equipped with a multiple application of drop plugs. However, we do believe that when the crown sheet of a firebox in a locomotive type boiler is subjected to excessive heat, due to the water becoming low, much damage can be incurred.

Knowing that boiler explosions caused by crown sheet failures were the most prolific source of fatal accidents, explosions may be expected to increase in violence with the increasing size of locomotive boilers and the higher pressure carried therein. We have been told that the most prolific source of casualties due to failure of fusion welded seams has been in firebox crown sheets, and that experience has shown that these failures depend very largely upon whether or not the sheets or seams tear. Further, it is claimed that riveted seams are superior in strength to welded seams under these conditions, since the latter in some cases may be of unknown quality.

We believe that when the welding is done by competent operators a welded seam in a locomotive firebox will give superior service to a riveted seam, and, while it is known a welded seam can be made at reduced first cost and maintained at comparatively less cost than riveted firebox seams, we do not believe that a premium should be placed on welded seams by discriminating against their application to firebox sheets on locomotives with a multiple application of drop plugs.

Our conclusion is that, when the crown sheet is equipped with a multiple application of reliable drop plugs, so located and spaced that in event the water in the boiler becomes low from any cause and before the crown sheet becomes overheated these drop plugs will fuse and admit steam to the firebox in sufficient volume so the crown sheet will be protected, the procedure to allow welded seams in applying patches or new sheets or portion thereof is desirable economy and should not be discriminated against.

Better methods used in threading and applying

STAYBOLTS

Committee

G. B. Usherwood

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The committee on "Better Methods used in the Application and Threading of Staybolts, Iron, Nickel and Special Alloyed Steel, Flexible and Rigid, with Details and Tools Used" has endeavored to collect data on the subject, particularly of threading and tapping.

A wide variation in practice was found on a number of roads checked, which would indicate the need for a thorough investigation of the subject. The committee believes that the subject should be continued and the committee enlarged, or sub-committees appointed, each to investigate and report on one of the subdivisions

Note: The committee which submitted this report consisted of the following: G. B. Usherwood, supervisor of boilers, New York Central, chairman; E. S. Fitzsimmons, sales manager, Flannery Bolt Company; J. A. Graulty, general boiler shop foreman, American Locomotive Company.

of the subject, and that each subdivision be handled and discussed separately at the next regular convention.

Thread Form. The first question taken up was the form of thread most desirable from the point of view of economy and satisfactory service.

The committee finds that there has been a gradual and quite general change from the V form to the U. S. form of thread over a period of years, and that at the present time much thought and consideration are being given to the Whitworth, or British Standard, and that many advantages are expected from those roads that use this form.

The advantages claimed are greater output per 0.001 wear on either taps or dies. At least two of the important trunk line roads have standardized this form, and we are informed several other roads are giving the matter serious consideration. The committee has not been able to secure sufficient replies to enable it to make definite recommendations, but believes there is sufficient merit to warrant further investigation.

Diameter Tolerances. The committee finds there is also a wide variation in practice as regards threading tolerances. Some roads use outside diameter measurements, others use pitch diameter, still others have no definite rule and depend on cut and dry methods.

Those having definite tolerance rules vary considerably. Some use the nominal diameter for maximum and permit variations down to 0.006 minus. Others use a maximum of nominal plus 0.002 and a minimum of 0.002 to 0.004 minus, from which it will be seen that there is lack of uniformity, and that there is obviously an opportunity for improvement.

Lead Error Tolerances. The committee likewise finds similar variations in tolerances on lead error. Some roads use plus 0.915 or minus 0.0015, others use plus 0.003 or minus 0.003, which is just double the former, while on some other roads no particular attention is given the subject, or any definite tolerance used.

Type of Tap. The committee also finds that many railroads prefer the straight-fluted type of staybolt tap, while others insist on the spiral-fluted type staybolt tap. It further finds that where there is no special tool to gage, much difficulty is experienced in getting the correct size of the tap, whether the same be the pitch or outside diameter, if the tap is of the five-fluted type.

Your committee recommends the following for the approval of the association, pending further investigation and report:

(1) That all thread dimensions and tolerances be measured on the pitch diameter.

(2) That nominal be used for maximum and a tolerance of minus 0.005 for minimum bolt size.

(3) That lead error be limited to plus 0.003 or minus 0.003.

(4) That bolt ends be chamfered or pointed ⅛ inch at an angle of 45 degrees to permit of readily entering the bolt.

(5) It further recommends that consideration be given to having the staybolt tap made of a standard six-fluted type, in order to simplify the gaging of the tap for its correct size.

As a result of checking actual applications and gaging and measuring many bolts over a period of several months, your committee believes that observance of the above recommended practice will result in work of satisfactory quality so far as the bolts are involved.

Tapping. A check of practice on a number of roads again indicates a variation in the use and checking of staybolt taps.

Much of the difficulty encountered in the application of bolts is found to be due to worn and undersize taps. Your committee believes that this condition is probably due to the depression of the past three years, and that with the revival of purchasing this condition will improve.

It is obvious that little can be accomplished in regulating bolt sizes, when tap wear is permitted below the maximum bolt sizes.

Pending further investigation, as above suggested, we recommend for consideration and trial the following practice, which has been suggested to the committee, and which we believe to be worthy of further study and trial, as affording economical use of taps and securing high quality of work in bolt application:

After the firebox has been tapped and made ready for staybolts, in the usual manner, we recommend an additional operation.

This additional operation is: To re-tap, or second tap, every hole in the firebox, using for the work a new full-sized tap, and a light motor of just sufficient weight and capacity to perform the small amount of work to be done. This will clean up the threads and size the holes on which small or worn taps have been used.

The amount of work to be done in this re-tapping will not be sufficient to heat up or perceptibly wear a new tap, therefore only one will be needed. Likewise, since only a small light-weight motor will be required, no dragging or sagging on the tap need be expected, and the result will be holes of uniform diameter with full clean threads to which the bolts may readily be fitted.

Fusion Welding

(*Continued from page 199*)

Fig. 2(c) shows the type of vertical seam being used in some designs of water tank cisterns. In this design the welt strap is placed on the water side of the plate, which has a tendency to produce a stiffening effect on the flat vertical sides of the tank plate.

Where repairs are made to the present riveted type of tank construction, there are times when it is necessary to remove large plates, especially in the sides of tank cisterns, in order to repair the defect and maintain their uniform appearance. Before fusion welding was developed, large sections were usually riveted in place, the cost of which was high. The cost of this class of repair has been greatly reduced because smaller sheets are now welded between the horizontal riveted seams of angle or tee braces, as outlined in Fig. 3, following the center line of braces and not changing the appearance of the outer portion of the tank where the section is applied. Some railroads now consider it a standard practice to insert the lower one-third section in this manner as it becomes necessary.

Fig. 4 shows a fusion welded rib which is applied to the fire side of firebox plates where cinder cutting is causing the heads of staybolts to be cut away. These ribs are welded in place while the water is in the boiler, and have the effect of minimizing the cinder cutting action on the fire ends of the bolts.

The chairman of your committee wishes to advise that the fusion welding process is also being utilized in the smoke arches of locomotives to prevent air leaks. The front end angles are now welded into place, instead of being riveted or bolted.

Your committee also reports that certain types of washout plug bushings are being successfully welded in the outer casing sheets. The same may be said regarding flexible staybolt welded type sleeves.