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"LOCOMOTIVE BOILER WASHING"

BY

Mr. W. H. PEARCE (Member).

Locomotive boiler washing is an essential factor in the attainment of economical locomotive operation. Hitherto it has not been commented on before this Society, and therefore a description of the development of present G.W. practice may be of value and probably some useful data will be forthcoming in subsequent discussion. Any changes in maintenance methods that will eliminate trouble and tend to increase efficiency or reduce cost of repairs are always welcome subjects for discussion and investigation.

Boiler construction has been improved by attention to details of design or method which have been found desirable, either for reducing the renewals required when under repair or for obtaining better results in service, and in this connection it is essential for observations under service conditions to be allied very closely with examinations when stripped down for repairs.

The aim of the maintenance department is to keep all appliances in as good a condition as possible, thereby securing a high percentage of the original efficiency. This needs special consideration when dealing with the boiler, as it is the unit in which the heat is first transformed. It is thus important to keep the surfaces of all intervening plates between the heating agent and the water in the best condition for the transfer of heat. Communication of heat is best when the surfaces are clean, both on the fireside and the waterside.

The conductivity of metallic surfaces under different conditions of scale deposits varies with the nature of the deposits. To describe in detail how such deposits may adversely affect the earning capacity of a locomotive would involve a lengthy description of the ordinary routine work of engines and cannot be fully dealt with here. It may be pointed out, however, that a well designed boiler (in other words a G.W. boiler), when in its initial condition, is an efficient steam raiser.)

In passing, it must be noted that water for boiler purposes is by no means always pure; it might, in fact, be looked upon as a weak solution of various kinds of matter, each item of which plays its own definite part when the water is heated in the boiler. No two waters are exactly the same and in addition, it must not be forgotten that, when being evaporated, the water is totally different from that originally fed into the boiler. A knowledge of these reactions and the methods utilised to deal with them is essential for the efficient handling of power plants. Waters which are naturally soft should always be regarded with suspicion, not because they are soft, but because the small amount of dissolved matter may have an acid reaction when being heated in the boilers. It is sometimes advisable to arrange for boilers operating with soft water to receive a supply of lime occasionally. In this way a thin scale will be maintained in the boiler and thereby protect the surfaces from corrosion. Hard water may be used with impunity, so far as corrosion is concerned, because the heating surfaces become covered with a protective coating of scale.

During the process of steam raising, there is always a tendency for the impurities in the water to adhere to the surfaces that are transferring heat and to accumulate, even without any intermittent cooling process. The ever increasing deposit will more and more resist the passage of heat from these surfaces to the water, until the economic limit of heat transfer is reached. When boilers are forced, comparatively little scale or deposit may cause overheating of the firebox plates and tubes nearest to the firebox.

In order to understand properly the subject of boiler washing it will be well to devote some little attention to the history of its development. Early methods were by means of cold water and were confined to making the best use of the maximum available head of washing water by using large bore leather hose pipes. With most shed hydrants the pressure would only give a horizontal jet of about 12′ from a $\frac{3}{4}''$ nozzle and deliver 20 gallons per minute, thus requiring over an hour to fill ordinary boilers. With such low pressures, the large leather pipes would often "kink" and prevent a full flow. Large nozzles were used so that a good bulk of water was available, which was useful, but often it was without the necessary pressure, thus depriving it of the concentrated stream which is one of the essential factors in the removal of dirt from the water and steam exposed surfaces. The actual removal was, in the majority of cases, largely accomplished by various rods suitably bent or twisted into scraper-like ends. These contrivances made it possible to dislodge some of the incrustations which could then be floated or drawn along with the water toward the outlet holes, until finally removed from the interior of the boilers. But it was often necessary to remove several tubes to allow of more effective cleaning work inside the boiler and to get at the firebox waterways.

When these methods were in vogue the boilers were designed for comparatively low pressures, the number of hours in steam over any given period was small and they were worked by a smaller number of different drivers than under present day conditions. It was not unusual for drivers at that time to be responsible for their engine cleaning and boiler washing operations, and to the latter they gave special personal attention, reckoning it to be the forerunner of reliable and easy engine working throughout each week.

The actual boiler washing was not entirely ineffective, but other changes were taking place and demanded something better than cleaning by means of cold water under normal pressures. The growing demand for increased engine working hours, with increasing boiler pressures and capacities, also an all round speed-up of labour-saving devices to compensate for extra wages in decreased working hours, were a few ruling factors that led to the cleaning problem being made a subject for experimental consideration by the G.W.R.

In the foregoing remarks reference has been made only to cold water washing, but to associate cold water with hot boilers is obviously undesirable. All boilers being at a high temperature when under working conditions, any rapid cooling must be accompanied by contraction strains, whereas the boiler is designed for uniform internal pressures rather than unnecessarily quick cooling stresses. Liability to the latter must be avoided as far as possible. Nevertheless, until shortly before the introduction of superheater tubes (1906) it was the general practice to use cold water for washing out.

A specified day was allotted to each particular boiler, with a view to ensuring that sufficient time should elapse between dropping the fire and releasing the pressure, in order to allow the temperature to fall by natural radiation to a recognised safe limit before application of cold water to the internal surfaces. If the off-duty time of the engine were limited, the pressure was reduced by using the injectors to fill the boiler to the top of the water gauge glass, thus providing the maximum bulk of hot water. The remaining pressure was released by opening the whistle valves, with whistles muffled, and by opening the steam heating or steam lance valves, or blower valve with smokebox door slightly open. With all steam blown out, the taper plugs were removed from the top of the boiler and the hydrant nozzle inserted as near to the smokebox as possible. The blow-off cock was then opened sufficiently to allow the water to escape at the same rate as the cold water was entering the boiler, thus maintaining the water in the gauge glass at a constant level. This continued until the water issuing from the blow-off cock was cold. The water was then shut off and the boiler allowed to empty itself through the blow-off outlet, after which it was ready for washing out. It was very important that the cold water should enter slowly enough to ensure gradual cooling. If any error of judgment were made relative to the difference in temperature of the boiler interior and the washing out water, it would cause undue contraction and stresses in all parts. With such washing it was not unusual to hear of the breaking of firebox stays in the waterways. This alone would call for reflection with a view to introducing an improved system.

When a locomotive fire is drawn and not immediately replaced by a new one, the heating surfaces are exposed to cold air currents and unequal contraction follows tending to cause leaks. The brick arch is composed of several cubic feet of firebricks which will retain their heat for a long period, and will not cool down at the same rate as the boiler surfaces exposed to the cooling down water.

After blowing down, too much time was required for the washing process, thus taking up that which should have been available for any immediate repairs which were required. Not only was this system a source of delay and trouble in arranging sufficient off-duty hours, but other conditions existed which made it desirable to wash out mud or scale more effectively. The real difficulty, in districts that used hard water, was the removal of scale with the low pressure of the washing out water. To improve matters in that respect would obviously be an all round advantage, hence special attention was given to boilers in these districts, so that methods proving effective could with advantage be applied to other districts, providing that the facilities to use the extra appliances could be arranged on economical lines

Some sections of the railway use water which, as already mentioned, does not form scale. Others use water which forms a small quantity of scale but does not cement or adhere to the metal, whilst in some districts the water is corrosive.

To reduce corrosion, boilers must not be left moist after blowing down, but should be washed and refilled immediately, or thoroughly warmed and dried if required to remain empty.

The use of mineral oil solely for cylinder lubrication obviates one cause of corrosion, while the use of injectors with gravity or loaded overflow valves prevents air being carried into the boiler by the feed water, thus eliminating yet another cause of corrosion.

Several sections of the line are equipped with purifying or water softening appliances, which remove some of the scale-forming solids in solution or muds in suspension, before the water is delivered to the boilers.

In all cases there is a concentration of the soluble compounds in the boiler as the evaporation continues, resulting in a condition which produces what is known as priming. This necessitates the occasional changing of the boiler water, the period depending on the water used and the amount of evaporation. In one instance (Radyr) the water was changed every third day and the boiler thoroughly washed out every seven days, if using water from the River Taff when low. Present practice is to use a better source of supply. In another instance the tubes became pitted within a week. This was, however, primarily a case for treatment of water before using it as feed water.

In many instances, just after the railway amalgamation, it was noticed that the life of firebox sideplates had been shortened, owing chiefly to being burnt out, on account of the waterways being practically blocked with sediment. In some cases the plate was reduced to a minimum thickness in eight months and the plates were found to be split from stay to stay. These results were often proved to be due to an accumulation of deposit completely surrounding the tubes, but limited to a distance varying up to 3′ from the firebox end. The waterways were also filled for several inches above the foundation ring. That it should so accumulate on this portion of the tubes may be explained by the suggestion that the evaporative value of the first six inches are approximately equal, area for area, to the firebox heating surface, whereas the next foot is only one-third as effective, and at the last foot the rate of evaporation is very small. Such conditions of the boilers made periodical examinations very frequent, as only a slight forcing would develop excessive tube and firebox stay leaks. The work in this respect was getting excessive and the percentage of engines out of traffic was often above that for other purposes. Running conditions also reacted on factory repairs, as it was frequently noted that there was an exceptional number of frames waiting for boilers.

From previous remarks of working conditions, combined with the fact of such rapid strides in approaching first-rate construction, it was obvious that such boilers were entitled to more careful manipulation when being prepared for steaming duties. In consequence, an endeavour has been made to attain more effective means of maintaining cleaner boilers under modern working conditions.

One of the first steps was to use warm water for boiler filling purposes. This was made possible in a small way by the fact that all engines were fitted with injectors for boiler feed. By admitting water to the supplementary injector and partially opening the steam valve, warm water can be injected through the overflow pipes. These were fitted with screwed end connections, to which the boiler filling hose could be attached, so that water was available for any adjacent boiler. Thus time was saved in raising steam, but the process was still too slow. Also, using injectors in this manner was not desirable as an imperfect jet was constantly passing through the combining nozzle. This was modified by fitting a two-way connection on the delivery pipe; so that, from any injector so fitted, it was possible to pass the full flow, either to its own boiler or to the filling pipe for another boiler. The ordinary hydrant was meanwhile filling the engine tank or tender. These methods were helpful for filling, but for the washing out process it was not economical to keep an engine idle, nor to keep restarting the injector, or even bye-pass the water when changing the position of nozzle to different plug holes.

The advantage of hot water and increased velocity of jet, however, was early realised. Several arrangements have been made up and each large shed introduced some form of boiler washing injector in an endeavour to provide a good jet of hot water. In some cases portability of appliances was aimed at by connecting an injector to the hydrant valve and supplying steam from an engine that could be moved about the shed as required.

In large sheds where boilers were required to be washed out in various positions, a small engine was allocated with a separate injector attached, whereby the hydrant hose could be taken to the injector on the engine, thus providing portability by means of a locomotive, whereas the only portion required was the boiler. Consequently, further schemes led to the introduction of a suitable arrangement of steam pipes from existing stationary boilers in engine sheds and to providing boilers with steam pipes specially arranged for the hot water boiler washing system.

The injectors used were of large size in order to pass the requisite amount of water. Each injector was fitted with a two-way delivery connection that permitted the water to be diverted from the washing out nozzle to a separate outlet while changing to different plug holes (Fig. 1). The hot water delivery from this separate outlet was usually run to waste, though occasionally it was forced back into an adjacent tender or tank. If the injector failed to work properly it was not unusual for a back pressure to be produced in the hydrants, causing burst water pipes throughout the engine shed. Thus it may be said that many of the arrangements failed to be economical or to meet modern requirements.

To improve matters it was necessary to review these requirements, a summary of which may be of value in order to explain the position:

(1) Whenever possible, hot water washing out should be adopted.

(2) The amount of delivery, relative to that existing with cold water, should be doubled through any given size nozzle.

(3) The throw of jet should be at least 50′.

(4) The increase in temperature should be 60° F. above the existing hydrant temperature.

(5) These conditions to be obtainable with 120lbs. steam pressure; also steam to be available over or near to each boiler washing hydrant valve.

(6) A portable injector which admits water before steam and automatically prevents back pressure to either mains, also capable of starting slowly, stopping quickly, and of being controlled by one handle.

(7) Hose pipes fitted for easy extension to any length.

(8) A nozzle hose that permits of any shape nozzle being fitted, of being turned round in any required direction without strain on the hose, when through a plug hole of $1\frac{3}{8}''$ diameter.

These conditions have been met in all sheds that have recently been dealt with. The necessity for the provision of ample steam at 120lbs. pressure has resulted in various arrangements being introduced.

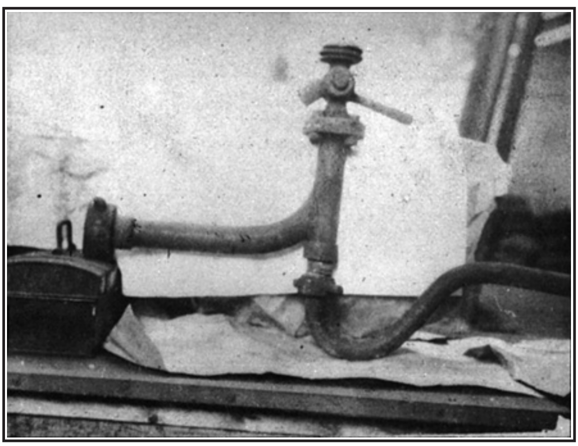

FIG. 1.

Developments of the methods of steam distribution commenced by fitting a 2″ main steam pipe round the outside bottom corner of the turntable pit, with $1\frac{1}{4}$″ branch pipes leading along the sides of engine pits, then across to a valve in a steam pan about 2′ from the hydrant. A suitable 1″ bore copper pipe then conveyed steam from the valve to the portable injector. This was known as the "pan" system but is now superseded.

The pan system gave way to the "trough" system in which a trough for the steam pipes was made alongside alternate straight roads, with short branch pipes adjacent to the hydrants. A suitable steam pipe was then used to the injector. It was found, however, that too much steam condensed with pipes in such a low position, hence the introduction of a protective trough. This was used solely for the steam pipes, thus permitting of suitable covering plates for examination and more effective drainage from boiler washing water and shed floor washing.

As an improvement to this the trough was built nearer to the hydrant valves, thus enabling both valves to be put in the same recess and making them more accessible, besides reducing the length of steam pipe to the injector. In this instance, steam was supplied from any engine that was in steam in the shed, the number of engines allotted not being sufficient to warrant installing a separate stationary boiler.

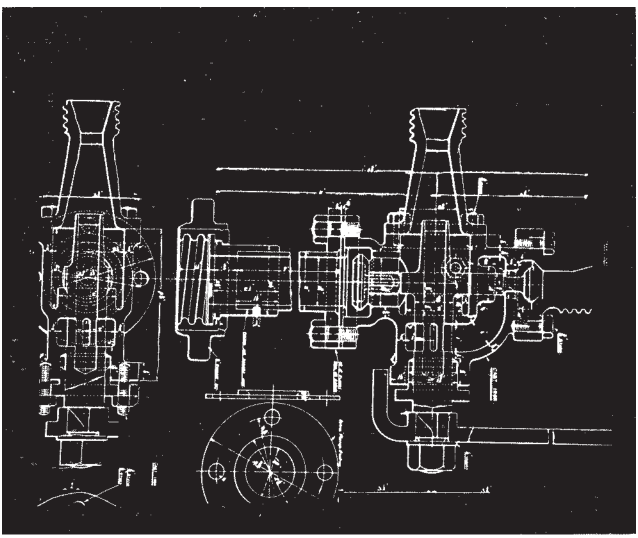

FIG. 2.

As any engine was likely to be required to supply steam for this purpose, a special adaptor was designed that permits of steam being taken from any restarting injector without allowing steam to pass through the injector nozzles. This is fitted, when required, in the cap nut behind the steam nozzle and when in position a semi-circular valve end fits into the cone of the steam nozzle and prevents entry of steam, but leaves the other end open to the connection whence the steam is passed through a suitable length of flexible metallic steam pipe to the portable injector. A diagram of the portable washing injector is shewn in Fig. 2. Fig. 3 shows

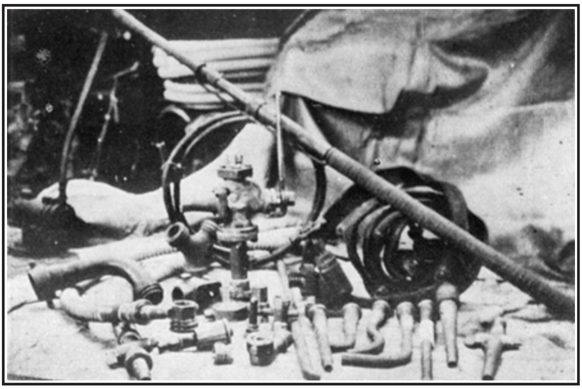

FIG. 3.

the various accessories of nozzles, hose, etc.; the injector mounted on the hydrant, with steam pipe and delivery hose connected is shewn by Fig. 4.

The building of a suitable trough can only be arranged economically in new sheds, consequently for existing sheds it is cheaper to fix the main steam pipe overhead, about 15′ from rail level, carrying down pipes fitted with a steam valve about 8′ to 10′ over each hydrant pan. This height varies according to the distance of the engine cab sides from the valves, in order to prevent injury to anyone when getting on to engine footplates.

Large circular pipes have one main inlet tee-piece, with branch pipes that do not quite complete the circle, thus having two free ends. This permits the various down pipes to move round, but the valves are set, by correct allowance for expansion, so as to be in the correct position relative to the fixed hydrants when steam is on. With the overhead system, a special sliding joint steam pipe is used to the injector, with ball joints at each end, thus permitting a good joint, even when the injector and steam valve are 4″ out of vertical centre. With straight pipes, an ordinary "U" copper expansion pipe is inserted to take up the movement of $\frac{1}{4}$″ per 11′.

In modern sheds the water and steam pipes are fitted in the same pipe race, the steam pipe above the water pipe, with both valves accessible together. This method makes the inspection and renewal of joints an easy item. To contend with the effects of

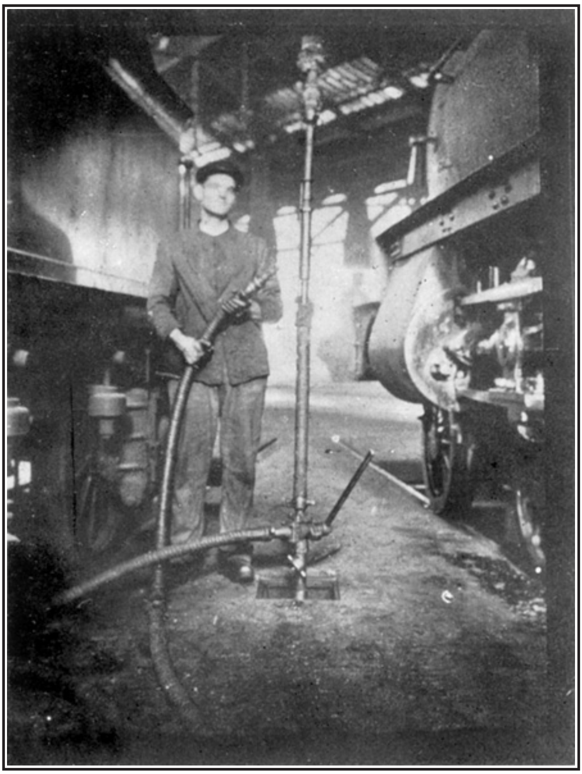

FIG. 4.

condensation, special drain valves are fitted, which automatically remain open until the steam pressure reaches about 30lbs. per sq. inch, consequently a large percentage of the water is displaced while the pipes are being warmed up. It is also an advantage to drain off the water when the steam is turned off for any extended period. If water is trapped in the pipes after the drain valves are closed, this can be safely removed through the portable injector. An item not to be overlooked in a layout of shed equipment, is to avoid having any washing hydrants on the same pipe line as a water crane, unless pipe areas are specially arranged. The outlet of the water cranes, being usually three to four times larger, will intermittently prevent the required flow to the hydrant, thus causing the injector to fail in water delivery. The design of the injector prevents steam getting to the nozzle or hydrants, if the injector is either open for water delivery only or else shut off.

The foregoing notes refer chiefly to the development and present position in the majority of G.W. sheds where the hot water system has been introduced, with reasons for the endeavour to supersede cold water as was being used for this purpose. It is usual to limit the special addition of a stationary boiler to engine sheds that have at least twenty engines as their full complement. This keeps the plant working at an economical rate and permits the washing out of the twenty boilers each week, which is an average in most districts. The size of boiler required is governed by the demands at each particular shed. Where there are a large number of boilers being washed out, day and night, it is usual to provide two stationary boilers, thus providing steam while it is necessary to wash out or repair one of the stationary boilers.

In all smaller sheds without a stationary boiler, the hot water system can equally well be adopted, as nearly all locomotive injectors are made to fit the special adaptors, which enables an ample supply of steam to be admitted to the washing injector through the standard $\frac{3}{4}''$ bore flexible metallic pipes. It is only necessary to arrange a small amount of fire to be kept going to maintain the water level in the engine boiler while supplying steam for washing purposes.

This has provided means for a simple standard arrangement of hot water boiler washing that can be used under all ordinary conditions in G.W. engine sheds.

The outstanding advantages have already been referred to and it is difficult to specify in detail the saving that has been effected due to the far reaching effects of these methods. It might be mentioned that at one station (Stourbridge) since the introduction of hot water washing out, tube renewals have been reduced by 2000 per annum.

Even with the present position of this side line in boiler work there are quite a number of exceptional cases that are still under observation. For instance, at one station the condition of the water is still master of the situation. Clacks and injectors need attention every week on the same engine, if using local water only. The internal feed pipes need mechanical appliances for cleaning frequently and they need renewal within a year. To combat this, other experiments are in hand which have proved very valuable. The boiler water is being treated in the engine tank itself. This is done by the addition of ordinary molasses in a specified quantity, each time the tank is refilled during the course of a day's shunting. This reduces deposit and softens the remainder. Various boiler compounds with great claims have been given trial in the stationary boilers, but recent examination showed 1/5th of the tubes ineffective.

Within twelve miles of this station, the water is exceptionally good and automatically keeps the boilers clean, thus as many engines as practicable are arranged to take this particular water.

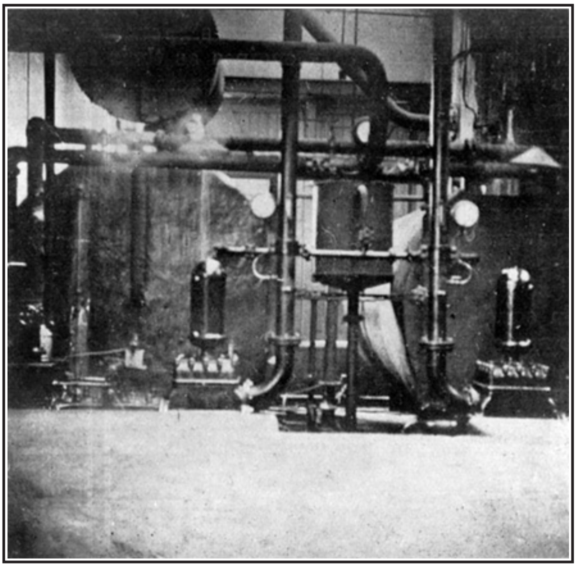

FIG. 5.

The centralisation and amalgamation of engine power has developed the required standard of washing along the right lines. The more continuous routine of engine working has permitted the introduction of a more economical system. An instance of some approach to this may be quoted in a description of the existing arrangement in one of the larger sheds. The number of engines in service at this shed is 170, composed of 16 different classes, thus representing boiler capacities in terms of heating surfaces from 900 to 2,500 sq. feet. These differences affect the washing scheme on account of the time variations in cooling and loss of available steam pressure after fire dropping. In many instances the loss is very slow and would not warrant any disturbing of the conditions prior to the next turn of duty for the engine. Thus it may be suggested that in most cases, where engines finish one turn in a fit condition for the next, that it is a good practice to minimise the off duty time to the amount required for requisite examinations before the next booked turn.

In the event of boiler washing being due, it only means that from three to five hours must be allotted for this purpose, according to the class of engine dealt with. This comparatively short time is due to the system that has been modified from experience of requirements. The object is to utilise all available heat units for washing purposes. The specially equipped shed permits all remaining boiler pressures to be returned to a suitable storage tank, where the water and steam are separated to combine with fresh water that can be regulated to any desired temperature, quantity and pressure. The necessary temperature is thus obtained by saving the heat that had to be generated to run the engine in service.

The "Economical" system separates steam from water, the steam is used for heating cold water from mains and this heated water and condensed steam are used for filling. The separated water is used for washing out and is at 212° F. or even more when blown down from the locomotive boilers. Steam is required for stationary boilers to drive pumps for the supply pressure of filling and washing water, and also to maintain a minimum desired temperature in the filling tank. Fig. 5 shows the general arrangement of this plant; the pipe connections at the pits, for blowing down, washing and filling are illustrated by Fig. 6. The latter is being altered and the plant modified by adding an additional blow down ring, thus adding a percentage of surplus steam from the engines that have to be blown down for engine repair work.

Engines to be washed out require at least $1\frac{1}{2}$ times their boiler water capacity for washing water and this difference has to be raised from 50° F. to 120° F. The average pressure of engines arriving in the shed is 60lbs. per sq. inch, volume of steam 70 cubic feet, and average amount of water per boiler 1,200 gallons. Therefore 3,330 gallons can be increased from 50° F. to 120° F., allowing 2,200 gallons for boiler washing and 1,100 gallons for refilling at 120° F. This shows that each boiler blown down will supply its own washing water and the refilling water at 120° F. only. This latter is required to be at 180° F., therefore extra heat has to be added from other boilers not requiring washing out, and the present scheme is to facilitate the blowing down of other boilers as before mentioned, when they are positioned in the shed away from the present plant equipment.

Two boilers blown down would fill two boilers and wash out one with water at about 120° F., but it would not be economical to blow down practically all boilers for this purpose alone. Any balance of heat that may be required is taken from the stationary boiler. In addition to supplying steam for the washing and filling

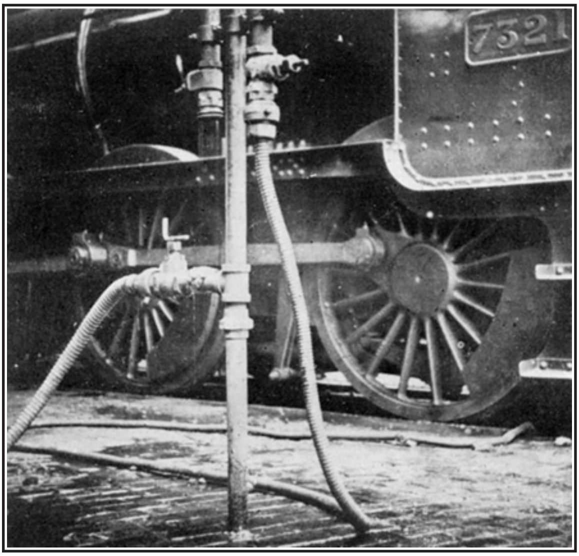

FIG. 6.

pumps, these boilers supply any balance with a total coal consumption of about 2cwt. of coal per boiler washed out. To retain the heat in locomotive boilers after arrival at shed, some chimney cover plates were introduced, thus preventing air flow through the tubes, but the results showed that the saving did not warrant the attention required. The pressure drop was from 10 to 20lbs. per hour, depending on size of boiler and position in shed.

Some systems advocate the blowing down of nearly all engines to reserve the heat units to washing or filling water tanks. Such extra attention to each engine would mean additional staff. Boilers would be subject to more rapid cooling as filling water in all cases would not be so hot as the water ejected from the boilers. Suitable engines for blowing down would have to be selected, thus needing careful supervision, as only those engines likely to be in shed over eight hours should be dealt with on account of the initial heat drop being very small, and also of refilling later, which would require extra heat from other sources. They would often need to be lit up an hour earlier with larger fires to make steam as required.

As is well known, it is desirable to arrange engine working hours so as to avoid cooling and subsequent reheating of the boilers. With cold water washing, however, this is unavoidable, but by the application of hot water washing it is rendered unnecessary and as the result a reduction of 40% in boiler repair work in engine sheds has been effected. This reduction means an increase in available working hours of an engine and represents the equivalent of an additional engine for every 15 engines at any modern equipped shed.

Since 1912 about 40 sheds have been so fitted and about 100 injectors are in daily use to help in the maintenance of G.W. boiler efficiency, together with the added satisfaction of the men concerned who appreciate the advantage over working conditions with a cold water scheme.

DISCUSSION.

The CHAIRMAN (Mr. K. J. Cook) said that much had been accomplished in the matter of locomotive boiler washing, but there was still much to be done. The Author had dealt with some of the difficulties due to feed water which had to be overcome, and perhaps it .would be as well to emphasise the effects of these. The accumulation of deposits had a great bearing an the time which elapsed between heavy boiler repairs, and in a number of cases this could be traced as the cause which had brought an engine into the shops before its normal time, involving additional expense. The part which suffered most due to the accumulation of deposit was the tube plate. Re-design of firebox crown, particularly the substitution of direct staying for the crown bar method, had reduced the overheating caused by accumulation of deposit.

Another direction in which there was room for considerable thought was the method of boiler washing. The method which had been developed chiefly, that of the combination ejector, had a large number of advantages, but it had the disadvantage of not using the heat contained in in-coming boilers. So far, the only scheme which obviated that, was the one described as being at the large shed, but which entailed very considerable capital outlay in the form of tanks and apparatus.

Mr. G. S. TAITT said it was stated in a paper read before the Institution of Mechanical Engineers that top feed trays silted up and caused the water to go over the side, and that they did not carry the water to the front of the boiler. He enquired if that was so, and how far the trays were effective and also if they were designed to carry the water to the front end of the boiler, or to carry a side flow before it reached the front portion of the boiler.

Mr. F. M. LIMPUS stated that there was excessive scum formed along the crown bars on the round top boilers of the Constituent Companies engines, and a good many of the boiler mud plugs were inconveniently situated for cleaning the centre bars, and asked if the Author could give a method for keeping the bars reasonably clean.

Replying to the question of top feed trays, the AUTHOR stated that the accumulation of deposit was rather more excessive at the inlet, and, being uneven, was often due to the left hand injector being chiefly used. The tendency was for the water to be fed over the notches only at the front end of the trays when the engine was on the level, and only when going up gradients of 1 in 10 would the water tend to get over the tray near the inlet.

Regarding Mr. Limpus' remark about mud plugs, he stated that the difficulty had been overcome by introducing special nozzles of flexible metallic hose, which could be inserted between the bars, and the water turned on after they were in position.

Mr. W. E . BULMAN said that on the Rhymney Railway it was found that there was little to chose between similar boilers of round-top and Belpaire design when both were new and clean, but that, in service, the former did not maintain their steaming powers. This was probably due to the extra difficulty of washing out between the crown bars, since, when the boilers were dismantled, excessive deposit was found there. It was probable that the object of introducing lime into pure, soft feed water was to form a protective coating against the corrosive action of dissolved air, which had caused much trouble, more especially at high pressures. The deposit on the side plates was less than on the crown, due to the more rapid circulation and to the scouring action.

On the Rhymney Railway flexible scraper rods were inserted through the mud hole doors for the purpose of cleaning round the foundation ring. At the corners of the box, where the scraper came into direct contact with the plates, there was serious pitting, due to the continual process of scale formation and removal.

The use of direct steel stays on the Great Western might have been made possible by the adoption of hot water washing, as with cold water even copper stays were liable to break through excessive temperature distortion.

The Rhymney Railway experience of boiler fluids was that a pasty sludge was deposited at the bottom of the boiler, and that this was more difficult to deal with than the hard coating of scale.

With regard to the Author's figures for decreased tube renewals at Stourbridge, he concluded that at each period there was approximately the same number of engines in the shed.

With regard to the excessive deposit on the crowns of fireboxes, the Author said it was a good practice to avoid large masses of metal. In the round top boiler with crown bars the mass of metal in contact with the flames would be much more than in the Belpaire boiler with direct stays, which latter would allow a quicker dissipation of heat to the water. Copper stays were naturally much larger in diameter than steel stays for the same area of plate; hence, with an accumulated deposit, the area covered by stay and deposit at the plate was increased and the area free of deposit was considerably less.

Regarding boiler fluids, he quite agreed with Mr. Bulman's remarks.

Referring to the decreased tube renewals, he stated that there were the same number of engines, or the figures would not have been comparable.

Mr. J. F. CUSS asked the Author if he had any knowledge of a pneumatic tool for getting rid of scale. He also enquired if a deposit of soft scale in the bottom of the boiler was preferable to a hard scale clinging round the tubes.

The AUTHOR said he could not enlighten Mr. Cuss about a pneumatic tool for cleaning the deposit off tubes, unless he meant an apparatus for passing along the tubes while in the boiler to get rid of the deposit on the water side; an apparatus which he had not seen in use.

Referring to the scale, a hard scale was the worst deposit to be dealt with. It was a great advantage to find something to soften the scum so that it could be easily removed, and for this purposes experiments were being carried out with molasses.

Speaking of the addition of molasses to soften the scum, Mr. TAITT thought that it would mix with the scale and spread round wherever possible, and for this reason would not be satisfactory. He believed that in a paper read before the Society it was stated that paraffin, used for softening of scale, formed a layer between the water and the boiler, and caused corrosion, and he enquired if molasses would not have the same effect, and spoil the heating surfaces.

The AUTHOR said the properties of molasses were entirely different from those of paraffin, and the effect was not at all detrimental to the heating surfaces, and it was also very effective for keeping injector cones in a clean condition.

Mr. J . C. JONES said that the action of molasses was the least harmful of any boiler compound, its action being a mechanical rather than a chemical one. By its use the deposit was thrown down in the form of a very soft mud, instead of forming a hard scale. Sometimes that was almost as difficult to get out as a scale on the tubes, but one very important reason for the use of molasses was to prevent the clogging of the injector nozzles. In addition to softening the deposit in the boiler, molasses acted on the feed water, and the particles, being in a soft condition, had no opportunity of adhering to the nozzle surfaces. In bad districts the injector nozzles were changed or cleaned daily, but working with molasses they would last a fortnight, purely because the particles were prevented from adhering to them. There was one other point—if the enginemen had to clean their own boilers, they would be far more anxious about the condition of them than they were at present.

With reference to the prevention of scale by the use of molasses, the AUTHOR said that several experiments had been made which led up to its use. A cleaning mixture had been used in a boiler at Westbury for a long time; it was passed through with the steam to the injector. Very little was required and it had the effect of keeping the injector clean, and instead of taking the nozzles out each week they could be left for months.

Mr. C. K. DUMAS asked the Author if he could give the difference in effective power of a boiler when new, and when coming in after repairs, as, judging from the illustrations, there was very considerable difference.

The AUTHOR said he had not been privileged to make such comparative experiments as that.

Mr. JONES stated that different authorities gave varying figures. It had been said that for $\frac{1}{8}''$ scale on the tubes a 20% to 30% reduction occurred in the efficiency of the boiler, but recently published figures suggested that $\frac{1}{8}''$ scale meant only a 5% reduction.

The AUTHOR replied that from practical experience there was certainly a difference between an engine the day before the boiler was washed out, and the day after, especially in the matter of steaming. He did not think it was 25% difference, however, but about 10%.

Mr. C. A. MACKNESS enquired if the G.W.R. had any trouble with damage done to the threads in the plug holes where the nozzles were inserted. He believed that, in America, small steel ferrules were placed in the holes to avoid damage to the threads.

Referring to Tyseley shed and the pitting of the tubes, he stated there were a large number of boiler plants in operation in that district, and enquired if similar trouble was experienced there; if so, what methods were employed to overcome it.

The Author stated that except in special cases, there were no appliances to preserve the threads in use. The chief exception, which did not actually apply to preventing damage by insertion of the nozzle, was on firebox clacks, when a rod was used to clean the internal pipes, and in this case a hollow screwed plug was supplied.

With regard to boiler pitting in the Birmingham district, iron tubes had been introduced instead of steel ones for all boilers working in the district, and pitting had been considerably reduced.

Mr. Bulman enquired if there were any advantages in the use of steel over pure iron tubes, except the matter of price, and suggested that certain of the stays could, with benefit, be made of pure iron.

The Author replied that an interesting point had been raised. Iron, at present, was certainly not cheaper than steel. For stays, the tensile strength of iron was not equivalent to that of steel; for tubes, iron was used because the pitting action of the water was less, but it would be of no advantage to adopt them generally, because in many districts there was no trouble with steel tubes. Sometimes excessive pitting was on the fire side of copper plates, and was due to the fire being made up of printed paper rubbish.

Mr. Dumas said that the portable boiler washing injector was certainly a very sound piece of work, and enquired if it was a patent of the Great Western; to which the Author replied that it had not been patented.