NEW ZEALAND RAILWAYS

ENGINEDRIVERS CORRESPONDENCE COURSE

Ab CLASS STEAM LOCOMOTIVES

LESSON NO. 1

DESCRIPTION OF A STEAM LOCOMOTIVE BOILER AND ATTACHMENTS:-

The steam locomotive consists of three main parts, (a) the boiler, where the steam is generated, (b) the engine, where the steam is converted into mechanical work for pulling the train along, and (c) the tender, where the coal and water are carried.

The Ab class locomotive has been selected for the purpose of illustration because it is simple in design and construction. The drawing does not show a complete arrangement of the locomotive, but is intended to show the principal parts of the engine and what they do.

The diagrams issued with Lesson No. 1 will be required for reference in order that the various parts may be quickly identified.

LOCOMOTIVE BOILERS are made up of a cylindrical portion which contains the tubes and flues; a back end which is enlarged and shaped to accommodate the firebox; and at the front a smokebox. The boiler itself consists of two principal portions, namely, the barrel and the firebox.

THE BARREL is made from mild steel plates. These plates are rolled into circular courses of the required diameter, and joined by longitudinal seams, which are butted and riveted together by means of covering plates, inside and outside, secured by double rows of rivets. Two of these courses are then riveted together to form the barrel of an Ab boiler.

THE SMOKEBOX TUBEPLATE (34) is made from mild steel, flanged all round and riveted just inside the front end of the boiler barrel. It is drilled to take the superheater flues (10) and boiler tubes (9).

THE FIREBOX TUBEPLATE (5) is made from mild steel, flanged all round and riveted to the sides of the firebox. Holes are drilled in it in exactly the same position as for the smokebox tubeplate to take the superheater flues and boiler tubes.

TUBES AND SUPERHEATER FLUES (9 and 10) which extend through the barrel from one tube plate to the other serve not only to convey the smoke and the gases from the firebox to the smokebox, but also act as stays for the tubeplates. This adds strength and rigidity to the barrel. At the firebox end, tubes and the flues are electrically welded to the tube plate all the way round to prevent leaks.

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THE SUPERHEATER FLUES (10) necessarily have to be of a larger diameter than the tubes to make provision for the superheater elements. the tubes and flues break up the hot gases into small columns so that the heat is more readily transferred to the water which surrounds them, thereby increasing the heating surface. It can, therefore, be said that the function of the tubes and flues is as follows:-

To convey the gases and products of combustion from the firebox to the atmosphere.

To provide extra heating surface for the rapid conversion of water into steam, and to strengthen the boiler by assisting to support the front and back tubeplates.

The superheater flues house the superheater elements.

THE STEAM DOME (14) is located on top of the boiler barrel just ahead of the firebox. The dome is a reservoir for the collection of dry steam and is placed at the highest point on the boiler in order that the steam is collected from as high a point above the water level as possible. The dome, being the highest point above the surface of the water, is an ideal place in which to put the regulator valve because the steam must travel further before it enters the valve, thus ensuring that the steam is relieved of any water that may be entrained in it. Intake pipes to supply steam to locomotive cylinders and the various auxiliaries are located in the dome. The auxiliaries which are thus supplied are:-

(a) The main steam turret which supplies the blower, the injectors, the lubricators and the electric turbo generator,
(b) the Westinghouse air compressor,
(c) the drifting valve.

THE WHISTLE is secured to the steam dome by an elbow (13). It consists of an inverted cylinder of thin metal with a sharp circular edge against which a circular sheet of steam is discharged. The force of the escaping steam causes the cylinder to vibrate and give out a resonant note, the pitch of which depends on the depth and the diameter of the cylinder.

THE FIREBOX consists of an outer and inner shell and the foundation ring. The outer shell is made up of the following plates:- The wrapper plate, the faceplate and the outer throat plate.

THE WRAPPER PLATE conforms to the shape and size of the rear end of the barrel to which it is riveted. The flat sides of this plate extend downwards and are riveted to the foundation ring. The upper circumference and sides continue back from the barrel to join up with the faceplate. The faceplate, which is located in the cab of the locomotive, forms the back end of the outer shell of the firebox. This plate is deeply flanged with the flanges turned to a larger radius to give strength and elasticity. It is riveted to the top and sides of the outer wrapper plate and extends downwards to the foundation ring to which it is also riveted.

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THE OUTER THROAT PLATE (67) joins the lower portion of the circumference of the barrel curving downwards to the outside of the foundation ring at the front end of the firebox. The mudhole and its door is located in this plate just above the level of the foundation ring.

THE INNER SHELL OF THE FIREBOX is made up of the following plates:-

The crown-sheet, side sheets, the back sheet and the inner throat plate. The crown-sheet forms the inside of the firebox roof and continues down to become the right and left hand side sheets. The back sheet forms the back end of the inner firebox. It is flanged and riveted to the crown and side sheets, extending downwards and being riveted along the bottom edge to the foundation ring.

THE FIREHOLE is located at a convenient height in the faceplate and the backsheet. It is formed by deeply flanging the edges of the holes in these two plates so that the edges butt together midway in the water leg where they are welded.

INNER THROAT PLATE. In order to connect the rectangular portion of the firebox, which is riveted to the sides and back of the foundation ring, to the circular portion that extends beyond it, an inside throat plate of the correct shape is employed. At the front, this plate is riveted at the bottom to the inside of the foundation ring, the sides are riveted to the sides of the firebox proper, and the top flange is riveted to the part of the firebox that forms the combustion chamber.

THE FOUNDATION RING (65) is a casting or forging that serves as a base to connect the rear end of the boiler with the rear end of the locomotive and also serves to space the inner and outer shells of the firebox correctly. The plates of the inner firebox fit within the foundation ring, the lower edges of the plates being flush with the bottom surface of the ring. The outside firebox plates are similarly placed around the outside of the ring and the complete assembly is riveted together. The space formed by the separation of the plates by the foundation ring is known as the water space, or water leg.

THE COMBUSTION CHAMBER (69) is an extension of the firebox forward of the grates into the boiler barrel and varies in length according to the size and capacity of the boiler. The combustion chamber is formed by lengthening the firebox plates and extending them beyond the foundation ring. This portion of the firebox then becomes more or less circular. The evaporation surfaces of the firebox are more effective than that of the tubes. Therefore, the advantage of the combustion chamber is that it gives more firebox heating surface and greater evaporation within a specified grate area. The use of a combustion chamber in large boilers also permits the use of shorter tubes. Tubes of an excessive length cause the draught to lag at their front ends. With a combustion chamber the gases have to travel further before they enter the tubes and they, therefore, have a better chance of being thoroughly burned than if a combustion chamber is not used.

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STAYS USED IN THE CONSTRUCTION OF A LOCOMOTIVE BOILER. The circular parts of the boiler can easily withstand internal pressure, but the flat surfaces surrounding the firebox would collapse under pressure, were it not for the stays tying the plates of the two shells together. The stays vary in length according to the distance between the inner and outer shells. This distance is greatest at the crown sheet and least towards the foundation ring.

The following types of stays are used:-

(i) Short rigid water space or water leg stays. These stays have both ends threaded and screwed through the firebox plates and the ends riveted over, They are located in the water legs or spaces surrounding the firebox.

(ii) Long rigid crown stays. As their name implies they are found in the crown sheet. Owing to the curvature of the outer wrapper, crown stays are spaced radially and are sometimes referred to as rigid radial crown stays. They are secured by being threaded and screwed through the crown sheet and the wrapper plate where the ends are riveted over.

(iii) Short and long flexible stays (flannery flexible stays come under this classification). These stays are designed to permit movement of the plates produced by the unequal expansion and contraction of the plates forming the inner and outer firebox shells without imposing undue strain on either the plates or the stays.

FLANNERY STAYS (68) obtain flexibility of movement by making the outer end of the stay ball shaped. The ball fits into the socket which is welded to the outer shell. Short flexible stays will be found round the under portion of the combustion chamber, between the inner and outer throat plates or, where necessary, to provide for extra movement between any of the curved plates of the firebox.

LONG FLEXIBLE STAYS are used to support the forward and curved parts of the crown sheet. In Ab and older types of boilers sling stays are used instead of flannery stays in the forward part of the crown sheet.

LONGITUDINAL AND ANGLE BRACE STAYS are a different type from those already explained. They both serve the purpose of supporting the upper parts of the boiler. The longitudinal stays used in smaller boilers support both the smokebox tubeplate and the top part of the faceplate, passing longitudinally through the boiler above the tubes and crown sheet. The end brace type (6) is used in longer boilers to brace the faceplate to the wrapper plate and the smokebox tubeplate to the top of the barrel.

THE FIREGRATE is formed by the firebars which are made of a suitable shape to admit the air necessary for burning the coal. These bars are placed side by side and lengthways with the firebox, the ends being supported on carrier bars fixed across the firebox.

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DEAD BARS. The extreme sides of the firegrates consist of heavy cast iron dead bars which are bolted in position along the sides of the firebox, the tops of dead bars and firebars becoming level.

DROP GRATES are fitted in the firegrate, usually at the back end below the firebox door and consist of a rectangular firegrate casting which can be opened manually by means of the drop grate lever when it is necessary to clean the fire.

The condition of the firegrate is important. Cracked or burnt bars are liable to fracture and drop into the ashpan with serious effect on the fire. Attention must be paid also to the condition of the carrier bars. Any warping of the carrier bars may reduce the binding for the firebars and allow them to become displaced when the rake or pricker is used.

THE ASHPAN (63) is fixed below the firegrate, which it completely encloses. Ashpans are usually of the hopper type, each hopper being fitted with a hinged door for removing the accumulations of ash. The sides of the ashpan project beyond and above the foundation ring, to which it is attached, and are provided with hinged damper doors, which control the admission or primary air to the fire and prevent live embers from the fire falling to the track.

Hopper doors are operated through a lever system connected to a dump shaft which projects on the right hand side of the locomotive. The end of the dump shaft is bent to form a short handle and, although it is possible to open or close the hopper doors by use of this handle, it is not possible to lock them securely in the closed position unless the dropgrate lever is used on the dump shaft handle to obtain extra leverage. The importance of closing hopper doors in this manner cannot be overstressed. Live coals and ash dropped from partly open hopper doors are the most common causes of fires on the track and bridges. For the same reason the ashpan must be inspected for holes.

On some locomotives the rear hopper door is very close to the cab bogie axle and instances have occurred where incorrectly closed doors have been carried over the axle and jammed. This can cause damage to hopper doors and train delays and does not reflect credit on the Enginedriver concerned.

Ashpans must be kept clean because overfull ashpans restrict the supply of air to the firebox, causing firebars and ashpans to burn and warp. The fire will also burn dully and become dirty and steam will be difficult to raise.

THE FIREHOLE DOOR is hinged to the faceplate by means of a bracket. An air distribution or baffle plate is secured on the fire side of the door. This plate breaks up and distributes the secondary air admitted to firebox and prevents the overheating of the firehole door and reduces the heat radiation into the cab. A fan plate on the outside of the door is fitted to seal against the admission of air and the emission of smoke when the fire is drawn or banked. The plate can be revolved to regulate the amount of air admitted through the firehole door.

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The practice of opening the firehole door to retard the steaming rate of a boiler admits cold air and reduces the firebox temperature. This is a bad practice and should not be encouraged when the locomotive is working. When standing at stations, however, the firehole door can be used to advantage to control the emission of smoke.

FUSIBLE PLUGS (60). The crown sheet is one of the most vulnerable parts of the locomotive boiler and it is necessary to protect it by the use of fusible plugs.

Fusible plugs (60) and their location in the firebox are shown in Fig. 7.

They are hollow gunmetal plugs which screw into gunmetal bushes in the crown sheet. The hollow portion of the fusible plug is filled with lead and so long as the crown sheet is covered with water to the correct level the lead filling remains intact. However, should the boiler water be allowed to drop below the safe level the heat of the fire melts the lead and steam and water blows into the firebox. Thus the fire is dampened, the attention of the engine crew attracted, and further damage to the boiler prevented.

Wide fireboxes are fitted with drop button type fusible plugs. Drop button plugs consist of a body with a tapered bore in which a thin lead liner and tapered gunmetal button are held. The large diameter of the taper is at the top so that pressure on it tends to seal the button more tightly on the lead sleeve. When a shortage of water occurs the lead sleeve is melted and the button is ejected into the firebox. This type of fusible plug provides for a positive fusing in the event of low water level, there being no chance of a partial and temporary resealing of the lead on account of an upsurge of water.

THE BRICK ARCH (64) is made of firebricks built in the form of an arch so as to be self supporting and is erected from side to side of the firebox. The sides of the arch rest on studs projecting from the firebox sideplates. The arch, which inclines upwards from immediately below the bottom row of tubes, extends towards the firehole door. Where combustion chambers are provided the lower front edge of the brickwork rests against the inner throat plate. The brick arch performs the following very important functions:-

(i) It deflects the firebox gases, causing them to take a circuituous course through the firebox, thereby giving them more time to mix with the incoming air and effect complete combustion.

(ii) It stores and retains heat to assist in the combustion of the fuel.

(iii) It protects the firebox plates and tubeplate from undue stresses and strains which could result if cold air entered the firebox and came in contact with the plates and tube ends.

(iv) It prevents unburned particles of fuel from entering and blocking the tubes.

(v) It assists in protecting the tubeplate and tube ends from the direct heat of the fire, thereby prolonging their life.

BAFFLE PLATE (2). The baffle plate which fits into the upper half of the firehole rests on a baffle plate ring on the lower half. The baffle plate is made to point downwards for the definite purpose of directing the air admitted through the firehole downwards under the arch and onto the fire, so that this air can be mixed with and burn the gases which are given off from the fuel. It functions both when the firehole door is open and closed.

WASHOUT PLUGS (66) are tapered threaded gunmetal plugs with square heads. They are situated at the following vantage points throughout the boiler:-

(1) On the boiler faceplate, (2) along the upper and lower level of the boiler barrel, (3) on the sides of the firebox and all around the firebox just above the level of the foundation ring and (4) in the smokebox tubeplate.

MUDHOLE DOORS (58) are located in the outer throat plate immediately above the foundation ring. Large modern boilers have two of these; older types have one only. They are oval shaped and larger than washout plugs to facilitate the easy removal of larger pieces of scale. As the steam is drawn from a boiler in service, any mud, silt, lime, etc. contained in the feed water remains in the boiler. These impurities form scale and mud deposits on the tubes and in the water spaces or legs surrounding the firebox. For the purpose of removing these deposits mud holes and mud hole doors are provided.

Specially shaped nozzles, either bent or straight, are used to direct high pressure water to all parts of the boiler washing the interior surfaces to carry the scale etc. to the lower openings for removal. The plug and mud holes are also used to enable the inside of the boiler to be inspected for cleanliness.

Washing out of boilers is a very important item in locomotive maintenance. If scale and mud deposits are left in boilers the free circulation of water is prevented, adversely affecting the steaming of the engine; or it may cause the plates to bulge and could even result in a boiler explosion. (See Special Instruction No. 62 re washing out).

Blow down cocks for the purpose of removing boiler impurities while the boiler is in steam, are situated just above the foundation ring either on the outer throat plate or on the side of the firebox. Some classes of locomotives have two blow down cocks.

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THE SMOKEBOX (32) is cylindrical conforming to the boiler barrel to which it is riveted. It forms an easy passageway in which the products of combustion are turned from a horizontal to a vertical course in leaving the tubes and entering the funnel. It also serves as a receptacle for cinders that have been drawn through the tubes from the firebox.

The smokebox contains the blast pipe (30), blower, spark arrester (31), the superheater header (27), and live steam pipes (28). The funnel (29), and the petticoat pipe which is a further extension of the funnel, is bolted to the top of the smokebox and is located directly above and in line with the blast pipe. The smokebox door (33) is hinged to and supported by the smokebox faceplate. Protector and deflector plates are fitted to the insides of smokebox doors. Where the flat perforated cage spark arrester is used, an angle iron is also bolted across the protector plate so that it fits closely to the cage spark arrester when the smokebox door is closed to prevent the emission of live sparks. Deflector plates are used in conjunction with the horizontal Waikato spark arrester to assist in turning the products of combustion into the drum.

A DRAIN PLUG is fitted in the bottom of the smokebox, either just ahead or behind the blast pipe. This plug is removed on washout days to allow water to drain out. It is essential to replace the plug firmly after use, otherwise air will be drawn into the smokebox and difficulty will be experienced in raising steam.

THE FUNNEL (29) is an iron casting, bolted on the smokebox, and is slightly tapered, being larger at the top than at the base, its function being to help to make a draught and to remove the hot combustion gases and cinders to a height which will enable them to clear the train. Owing to the large boiler diameter of modern locomotives and the restriction imposed by the loading gauge, the funnel has become rather short, and in consequence it has been found necessary to increase its effective length by adding an extension or "petticoat" within the smokebox.

THE BLAST PIPE (30) is an iron casting which forms an extension of the exhaust passages from the cylinders. It must make a steam tight joint at its base where it is secured in the bottom of the smokebox. On modern engines the base of the blast pipe is secured to the cylinder casting itself.

THE EXHAUST NOZZLE is made of such a size to cause the steam to be discharged centrally up the funnel to produce the desired draught on the fire. It is bolted to the top of the blast pipe, either as a solid ring, or, in the case of engines fitted with the Waikato spark arresters, as a hollow casting. In the latter case the necessary small holes are drilled in it to form the blower rose through which the blower steam is ejected up the funnel.

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THE BLOWER. The action of the exhaust steam in passing through the exhaust nozzle produces a draught through the fire only when the engine is working steam. The blower provides a means whereby draught is produced when the engine is standing or running with steam shut off. In its simplest form it consists of a pipe bent to form a ring fitted to the top of the blast pipe. The blower ring is provided with a number of holes through which steam fed from a valve in the cab is directed up through the funnel, thus inducing a draught, in the same way as is done by the exhaust steam when the engine is working. A three-way cock on the side of the smokebox is connected to the blower steam pipe to enable steam from another locomotive, or from the depot steam supply, to work the blower when lighting up.

THE SPARK ARRESTER (31) is a device fitted in the smokebox whereby the red hot particles of ash are pulverised and so broken up that any ejected to the atmosphere through the funnel are rendered harmless from the fire hazard aspect.

On some locomotives, the spark arrester simply takes the form of a flat perforated plate in the smokebox above the level of the tubes. The cinders strike against this plate, and are either broken so small that they can do no harm if they pass through, or else fall to the bottom of the smokebox.

The increased use of soft coal that has taken place in latter years has made an improved type of drum spark arrester a necessity.

The most common type of spark arrester is the "Waikato" type. It consists of a horizontal drum placed between the blast pipe and the funnel. The blast pipe enters the bottom of the drum and the exhaust steam leaves it by an opening at the top situated directly below the funnel. The end of the drum nearest the tube plate is enclosed. The vacuum created by the exhaust leads the waste products of combustion along the outside of the drum to the smokebox door and past inclined vanes which are welded around the front, or open, end of the drum. The vanes impart a swirling motion to the live cinders which are broken up, the heavier pieces falling to the hopper at the bottom of the smokebox, and the lighter pieces being exhausted along with the smoke and gases to the atmosphere.

A modified form of Waikato spark arrester having a vertical drum placed between the blast pipe and the funnel is fitted to some locomotives. In the bottom of this drum there are a number of inclined vanes and at the sides of the drum are a number of slots. The waste products are drawn into the drum past the vanes which impart to them a rapid swirling motion. As they ascend the sides of the drum, being broken up to the extent that they are no longer harmful and are thrown through the slots into the bottom of the smokebox.

The function of any type of spark arrester is to prevent large particles of cinder which are capable of retaining their heat for an appreciable period from reaching the atmosphere in a state whereby they could start fires when they fall to the ground . Pulverising the cinders to a very small size ensures that they will have become dead before they reach the ground.

The smokebox or front end, as it is sometimes called, is one of the most important parts of a locomotive and its condition and the condition of the equipment it contains has a considerable influence on performance. Air leaks at the front plate, smokebox door and hopper doors and around steam pipes where they pass through the smokebox wall can reduce the vacuum in the smokebox and affect the steaming of the boiler. Steam blows from steam pipes inside the smokebox also has the same effect. The steaming of the boiler can also be affected by the spark arrester drum moving out of position and obstructing the draught. A locating stud is supplied to lock the drum in position. Always ensure that the locating stud is in use.

SAFETY VALVES (11) (and Fig. 5) are provided so that when the pressure of the steam under the valves is greater than the maximum pressure for which the boiler is rated, they will lift and allow the excess pressure to escape. The safety valves are proportioned so that steam can be exhausted to the atmosphere faster than it can be generated in the boiler. They consist of a spring loaded valve secured in position by a cop and two studs which are screwed into the pad on the boiler. Each safety valve is provided with a lever so that the valve can be lifted at pressures below that for which the valve is set. Any attempt to increase the pressure at which the valve will blow off steam is prevented by a ferrule placed over each bolt underneath the valve cap.

Ab class locomotives have two safety valves fitted at a point just above the end of the firebox, and a "pop" safety valve (17) and Fig.6) on an elbow in front of the steam dome. A description of the "pop" valve follows:-

THE ROSS muffled pop safety valve is also a spring loaded valve, but is designed in such a way that instead of rising gradually as the pressure increases after it has begun to blow off (as do the safety valves (11)) it lifts suddenly with a "pop" and blows off hard for a minute or so until it has reduced the pressure by about 21Kpa. then it reseats itself suddenly until the pressure again rises, and so on.

ACTION OF ROSS POP VALVE. It is fitted to an elbow projecting from the steam dome.

When pressure in the boiler becomes high enough to unseat the valve against the resistance of the spring, steam from the boiler escapes to the "pop" chamber which is located between the seat and the outer "lip" or rim of the valve itself. Escaping steam at this stage exerts an influence over a greater area of the valve to instantly and decisively lift it clear off the boiler seating, allowing steam to escape freely into the body or casing.

The escaping steam on its passage through the body blows against the under face of the "cap" which is part of the spindle and spring assembly. This blow of the escaping steam has the effect of slightly raising the cap, further compressing the spring and giving additional lift to the valve.

When boiler pressure has been reduced by approximately 21Kpa the spring assisted by steam in the body, reseats the valve smartly with a "pop" action.

The Muffler Cap at the top of the body is fitted with a top plate through which a number of holes are drilled. There is a greater number of corresponding holes in the cap and the volume of steam discharged before the valve reseats can be regulated by means of the top plate. By increasing the number of holes uncovered, the valve reseats after a lighter reduction of boiler pressure. By decreasing the holes left uncovered a greater reduction in boiler pressure is obtained. This means that a harder blow is obtained by closing and a lesser blow is obtained by opening the holes in the top plate.

Advantages:
- (a) Permits very rapid escape of steam generated in excess of the working pressure.
- (b) Due to smart action obtained in unseating and reseating the valve, maintenance costs are reduced.
- (c) A considerable reduction in noise compared with other types of safety valves.
- (d) Escaping steam is directed vertically into the atmonphere and does not obscure the view from the engine cab.

SUPERHEATER HEADER (27) and ELEMENTS (20). The superheater header is a casting carried in the smokebox above the level of the top row of tubes and is joined by means of a flange to the front tubeplate. Flanges on the front of the header connect up the main steam pipes to the steam chests. The header is divided into a series of small compartments. Half of these receive the steam as it enters the header from the internal steam pipe from the boiler and give access to the superheater elements which lead from the underside of the header into the superheater flue tubes in the boiler. The superheater elements are formed in such a way that the saturated steam is fed first towards the firebox end of the flue. It is then returned by a bend to within a short distance of the smokebox end of the flue and then returns to a second bend at the firebox end. It then flows along the fourth end of the element to rejoin the underside of the header and enter the remaining half of the compartments which communicate by way of the main steam pipes in the smokebox to the valves and cylinders. It is thus seen that one end of each element unit is connected to a saturated steam compartment of the header while the other end is connected to a superheated steam compartment. During its passage from the first or saturated steam compartments through the elements to the second, or superheated compartments, the steam has been entirely freed of its moisture, whilst the temperature has been raised, or in other words, it has become superheated. The subject of the header elements and superheated steam will be dealt with in a following lesson.

THE REGULATOR VALVE (15) located in the dome is of the double beat or balanced type, so called because of the equilibrium given to its action by the balancing effect of the steam on its upper and lower faces which are almost equal in area. A minimum of effort is thus required to operate it. The valve is operated by a regulator rod coupled to a bell crank that is pivoted on the stand pipe. The regulator shaft extends back through the back end of the boiler where a steam tight joint is made with suitable packing in a stuffing box on the faceplate.

A STANDPIPE (18) located immediately below the regulator valve, conducts the steam into the internal pipe. It also serves as a fulcrum for the bell crank which converts the horizontal movement of the regulator shaft into the vertical movement required to open and close the regulator valve.

The internal pipe (or dry pipe) conveys the steam through the boiler from the regulator valve and the standpipe to the superheater header.

CLACK VALVES, or boiler check valves, are non-return valves which permit feed water to pass into the boiler. A clack is opened or unseated by pressure developed by the injector in delivering the feed water, and is seated or closed by the boiler pressure when the injector is shut off, thus preventing boiler steam or water blowing back into the injector. On locomotives such as the Ab class, the clack valves are situated, one on each side of the forward end of the boiler.

Boiler temperature is always lowest at the front end and feed water is introduced here to promote free circulation of the water in the boiler, thus avoiding severe temperature changes which would adversely affect the steaming qualities of the locomotive and increase boiler maintenance costs.

THE STEAM GAUGE. The working parts consist of a curved brass tube, oval in cross sections, which is open to steam pressure at one end and sealed at the other end. The sealed end is connected by a link and lever to the spindle of the gauge hand. In some cases a slightly different arrangement is used whereby the sealed end of the tube is connected by a link to a toothed section which actuates a pinion wheel on the gauge hand spindle. Pressure when applied to the inside of the curved oval tube tends to straighten the curve. This causes the link to rotate the gauge hand which registers the pressure in kilopascals on the dial.

In order to operate properly the straightening of the gauge tube must be accomplished by pressure only. The shape of the tube should not be influenced by changes in temperature. Therefore, the pipe between the gauge and the boiler connection is bent around the gauge so that the pipes and the gauge tube will be filled with water that is condensed from the steam. Hence the gauge hand is revolved by steam pressure being exerted on a column of water in the pipe and in the gauge tube.

THE WATER GAUGE. Fig 9 shows the gauge mountings and how they are arranged on the boiler faceplate.

Two separate gauge glass columns are provided so that the water levels shown in each glass can be tested and compared. Also, should one column become defective due either to blockage or the gauge glass bursting, the other is available to indicate the level of the water in the boiler.

Each water column consists of a special glass tube which is connected at each end to the boiler. The top end of the gauge glass connects with a steam cock on the faceplate. The steam cock is placed high above normal water level. The bottom end of the gauge is connected to the boiler through a gunmetal casting which is fixed to the faceplate below minimum water level. The pad or water column mounting is positioned so that the bottom of the gauge glass coincides with the top of the crown sheet, i.e. it is the height of water above the crown sheet that the gauge glasses show. The bottom connection to the faceplate is controlled by a water cock. A try cock or test cock is fitted beneath the water cock and a drain pipe from the try cock is taken down below the cab floor.

With the steam and water cocks open and the try cocks closed, water enters the gauge glasses and rises to a height corresponding with the level of water in the boiler.

When an engine is under steam, the steam and water cocks are open and the try cocks closed.

The correct method of testing boiler water level is as follows:-

(a) Close steam cock, open try cock, see that water blows through freely.

(b) Close water cock, open steam cock (the try cock being already open) and see that steam blows through freely.

(c) Open water cock and blow through, (all cocks now being open). Close try cock and see that water returns smartly in the glass.

(d) Repeat this test on the other gauge glass and finally compare the levels in both glasses.

See also instruction No.5 in the Enginedriver's Handbook which lays down the frequency and responsibility of testing the water levels.

To reduce the risk of injury to the crew in the event of a gauge glass bursting, each glass is provided with a brass shield having windows of toughened glass. In addition to this safety feature, the nipple connecting the bottom of the gauge glass to the water cock is fitted with a gunmetal ball which is retained by a brass wire fitted across the bore of the bottom portion of the nipple (see detail on Fig.9). Should the gauge glass burst there is no longer equalisation of pressure above and below the ball and the ball is forced upwards where it seats against the small diameter hole connection with the gauge glass. This prevents the ejection of scalding water into the cab. Steam will also issue at boiler pressure from the top nipple of the gauge glass. Close the steam cock and water cock and the water column concerned is isolated from the boiler.

To replace a broken gauge glass proceed as follows:-

(i) Shut off the steam and water cocks then slacken off the nut securing the steam pipe to the steam cock. Then slacken off and remove completely from the top of the water column the other end of the steam pipe. Move the pipe to one side.

(ii) Remove the packing nut or nipple from the top of the water column.

(iii) Remove the water column by unscrewing at the base.

(iv) Remove the old packing and clean up the inner faces of the water column.

(v) Place the new gauge glass in the water column and then fit I.R. washers on each end of the glass.

(vi) Screw the packing nipple on to the top of the column until it is just comfortably tight.

(vii) Screw the water column on to its base on the water cock casting, taking care that it is screwed up just confortably tight. Then the top nut on the steam pipe must be screwed gently and firmly on to the top packing nipple. The nut on the steam cock is then tightened again. (Once the "Clinkerite" washers at each end of the steam pipe have been disturbed they will most likely have to be renewed before the nuts are tightened up).

(viii) Open the test cock wide. Then open the steam cock off the face to allow the gauge glass to warm up. Then open the water cock and allow both steam and water to blow through. Finally close the test cock and see that the water returns smartly to the glass. Ensure that the steam and water cocks are fully open.

(ix) Test the water levels in accordance with instructions and compare the levels in both glasses.

LAGGING To prevent loss of heat by radiation the boiler is lagged with asbestos which is held in position by thin steel lagging plates. The insulating material is either in the form of suitably shaped asbestos sheets, or is pugged and applied to such parts as around washout plugs and on other portions where sheet material is not used.

THE HEATING SURFACE of a locomotive boiler is the area of the plates and tubes exposed to the direct heat of the fire or the gases of combustion on one side, and which has water available for evaporation on the other side.

EFFICIENCY OF HEATING SURFACE The efficiency of the heating surface depends on the following factors:- The location and condition of the heating surfaces, and the arrangements by which the water has rapid and free circulation throughout the boiler. The location of the heating surface has an important influence because the surface in direct contact with the fire will evaporate water at a much higher rate than an equal amount of heating surface that is not in direct contact with the fire such as the tube heating surface.

If the tubes and flues become coated with scale on the water side, or are partly or entirely plugged with soot on the fire side, these surfaces will conduct less heat to the water, and the efficiency of the surface is lowered because it does not evaporate the amount of water that it should.

Of the different heating surfaces of the boiler, the crown sheet surface is more effective, than that of the side, tube, and back sheets in the order named, and the tube and flue surfaces last.

DIRECT AND INDIRECT HEATING SURFACES The heating surface of the firebox sheets is termed the direct heating surface, as these parts are subject to the direct action of the fire. The surfaces of the tubes and flues are called the indirect heating surfaces because these surfaces are only exposed to the heat of the gases that have passed out of the firebox. The sum of the direct and indirect heating surfaces is the total heating surface of the boiler.

LESSON NO. 1

ATTACHMENT OF BOILER TO ENGINE FRAME The smokebox at the front end of the boiler is rigidly bolted to the saddle of the engine frame stay which is located between the cylinders. Cast steel brackets are bolted to the top of the engine framing and support each corner of the firebox on similar brackets bolted to the underside of the foundation ring. These expansion brackets allow the boiler to slide backwards and forwards as it expands and contracts. On the Ab locomotive expansion brackets as described are fitted at the front end of the firebox. At the rear end each corner is attached to the frame by means of ¼" steel plates which are bolted to foundation ring and to the engine frame; the plates being flexible enough to allow for boiler expansion.

ENGINEDRIVERS CORRESPONDENCE COURSE

Ab CLASS STEAM LOCOMOTIVES

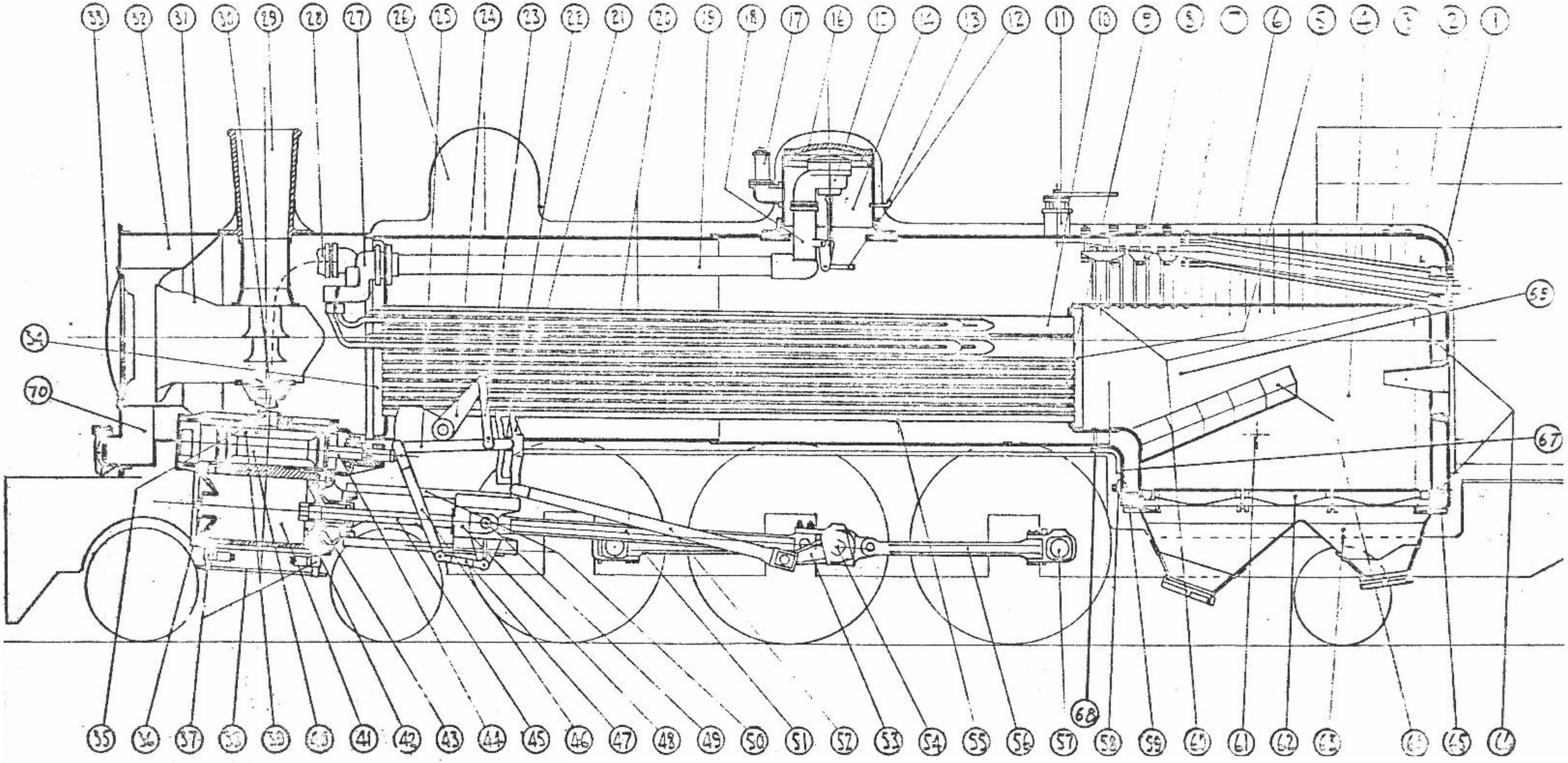
LESSON NO. 1 LIST OF QUESTIONS

1. Describe the boiler fitted to an Ab Class Locomotive?
2. What is the purpose of the foundation ring ?
3. Explain the advantages of a combustion chamber?
4. Describe the particular care that must be given to ashpans and ashpan hopper doors, and why?
5. Name the spark arresters in use and describe their operation?
6. Describe the Ross pop safety valve and its advantages?
7. State what you know about the heating surfaces of a locomotive boiler. What is the order of their effectiveness?
8. How is the boiler attached to the engine frame?
9. Describe the correct method of testing water levels in the gauge glasses?
10. Describe the procedure of replacing a broken gauge glass?
11. What is the purpose of fusible plugs in the locomotive boiler and give their location?
12. What is the purpose of the steam dome on the locomotive boiler and state what is housed in it?

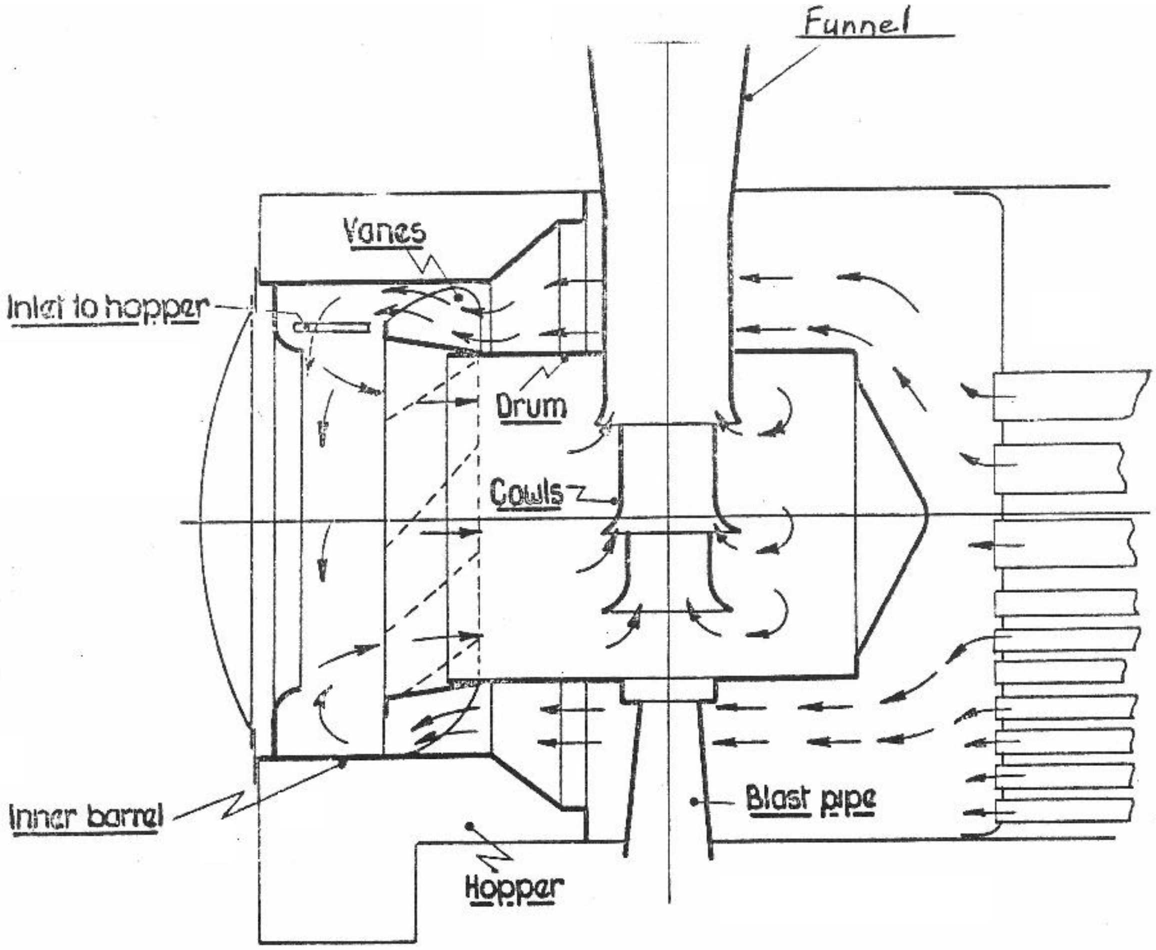
LESSON NO. 1

KEY TO FIGURE 1. SECTIONAL DIAGRAM OF Ab. LOCOMOTIVE

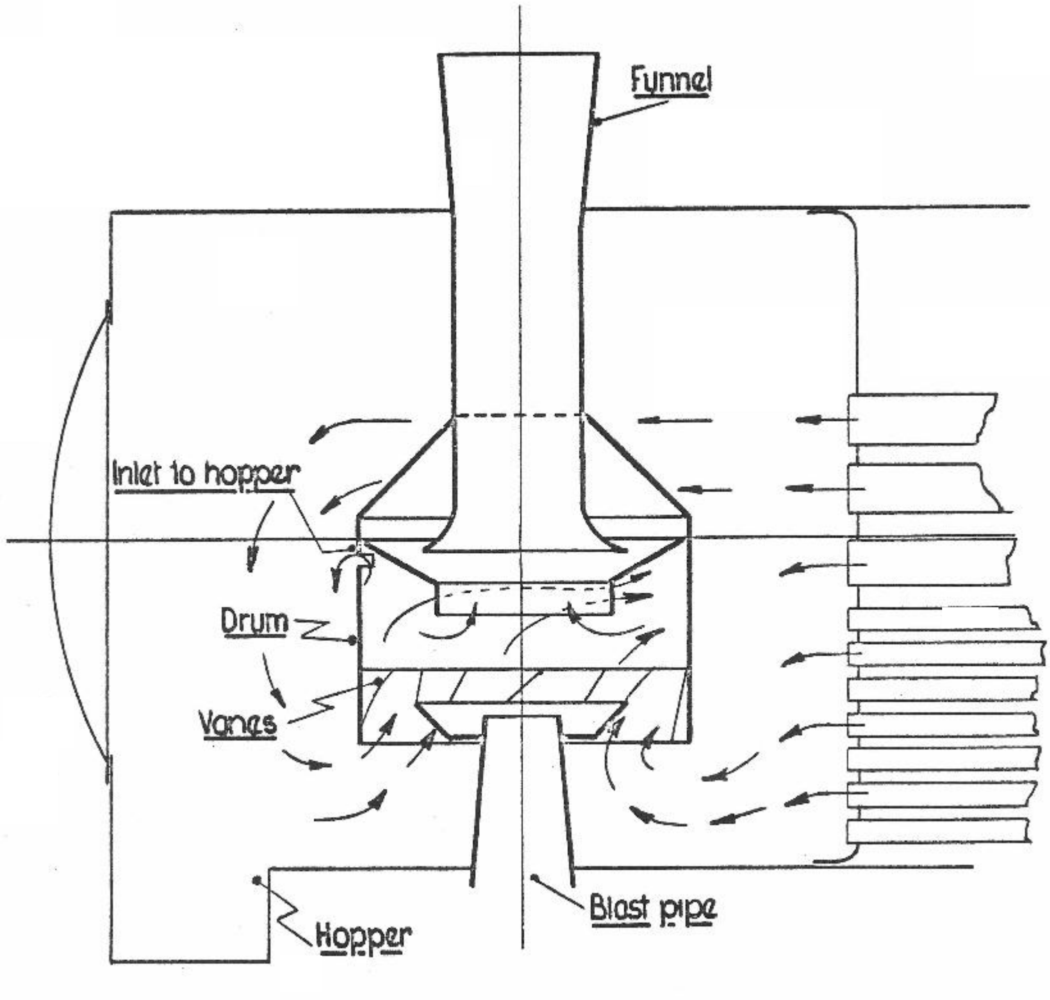
1	Face Plate
2	Baffle Plate
3	Steam Mitre Mounting
4	Firebox
5	Firebox tube plate
6	End Braces
7	Crown Stays
8	Sling Stays
9	Boiler Tubes
10	Superheater Flues
11	Safety Valve
12	Regulator Shaft Rod
14	Steam Dome
15	Regulator Valve
16	Dome Cover
17	Pop Valve
18	Stand Pipe
19	Internal or Dry Pipe
20	Superheater Elements
21	Expansion Link
22	Die Block
23	Lifting Links
24	Weighbar Shaft
25	Radius Rod
26	Sand Dome
27	Superheater Header
28	Main Steam Pipes
29	Funnel
30	Blast Pipe
31	Spark Arrester Drum
32	Smokebox
33	Smokebox Door
34	Smokebox Tube Plate
35	Steam Pipe
36	Front Cylinder Cover
37	Cylinder Cock
38	Cylinder Cock Operating Rod
39	Valve Chest
40	Piston Valve
41	Cylinder
42	Piston Head
43	Back Cylinder Cover
44	Valve Spindle
45	Piston Rod
46	Lap and Lead Rod
47	Union Link
48	Crosshead
49	Little End Pin
50	Crosshead Guide Bars
51	Connecting Rod
52	Eccentric Rod
53	Eccentric Crank Arm
54	Crank Pin
(55	Washout Plugs
(61	" "
(66	" "
56	Coupling Rods
57	Crank Pins
58	Mud Hole Door
(59	Foundation Ring
(65	" "
60	Fusible Plugs
62	Firebars
63	Ashpan
64	Brick Arch
67	Outer Throat Plate
68	Flannery Stay
69	Combustion Chamber
70	Ash Hopper
71	Ash Hopper Door
72	Dropgrate Section



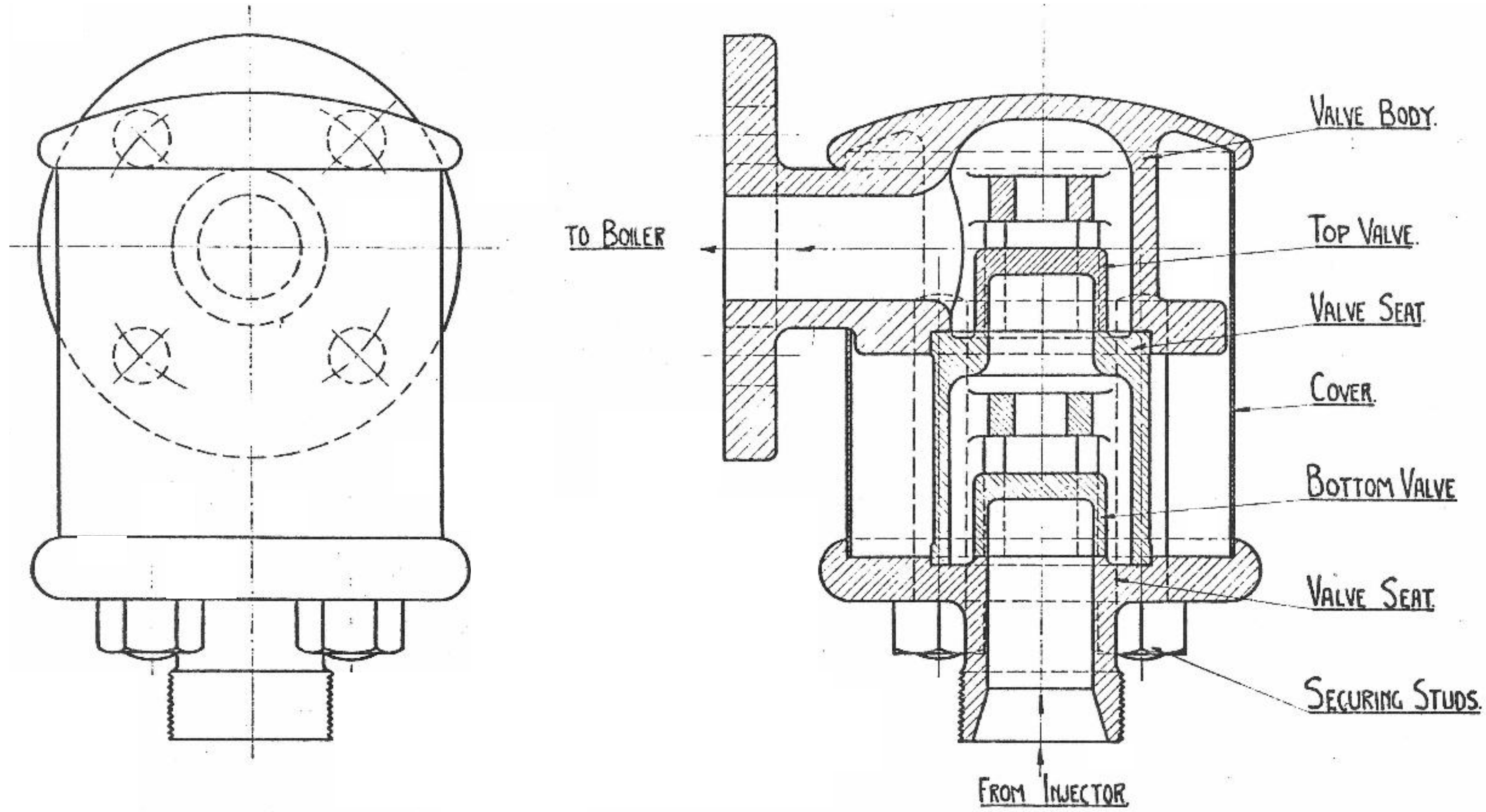
SECTIONAL DIAGRAM OF LOCOMOTIVE



HORIZONTAL WAIKATO SPARK ARRESTER

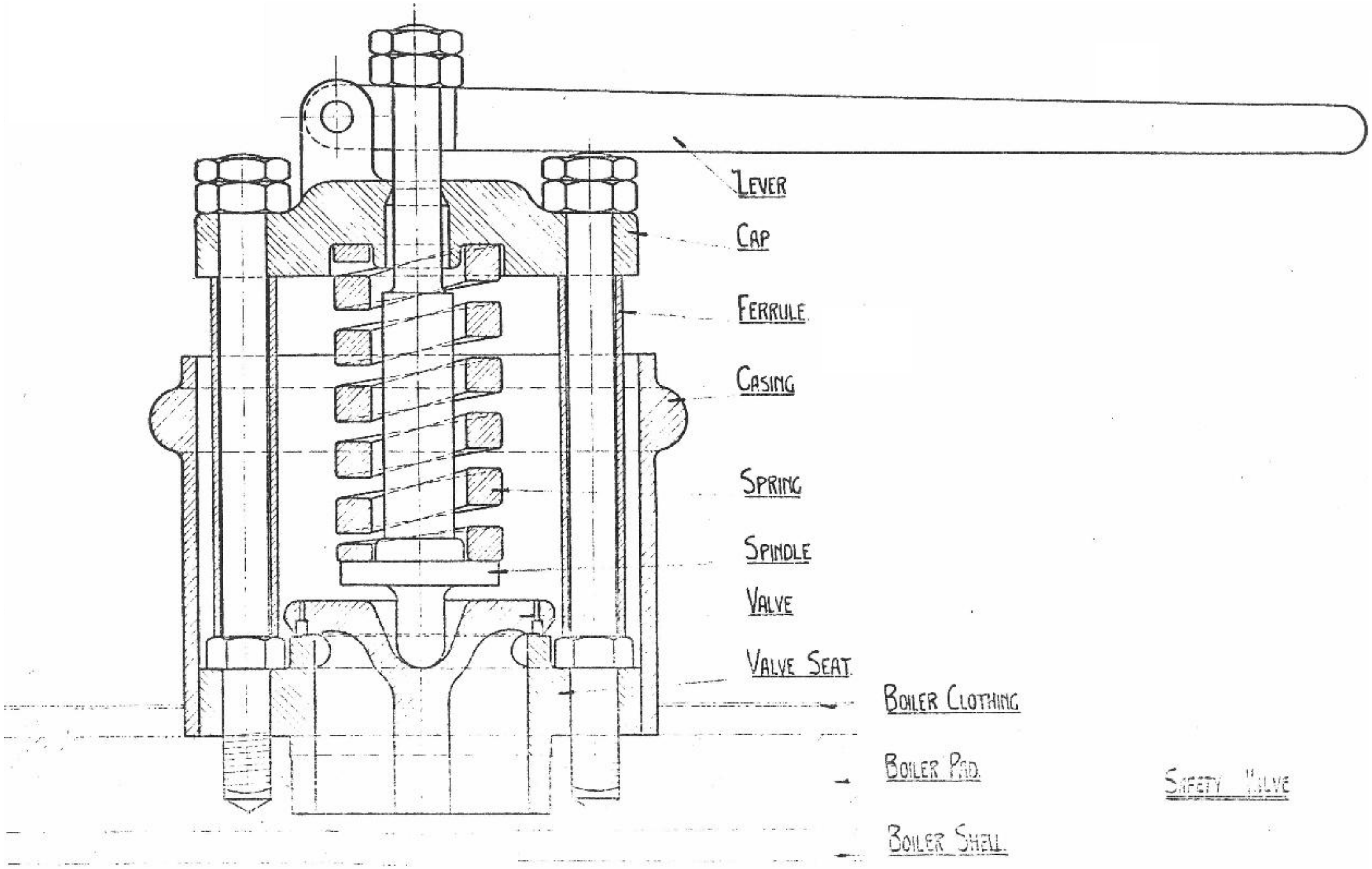


VERTICAL WAIKATO SPARK ARRESTER



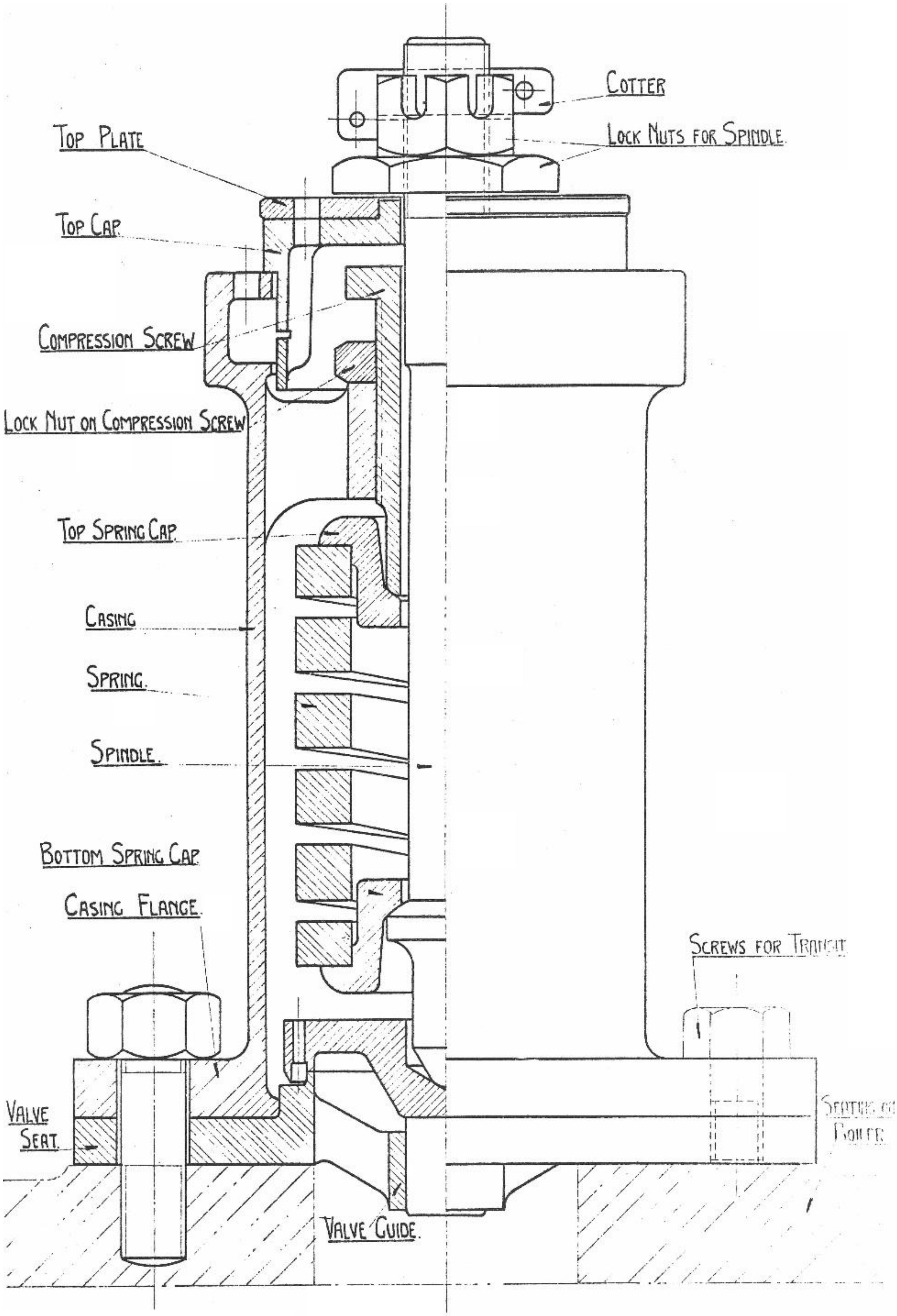
STANDARD CLACK BOX.

FIG. 2.



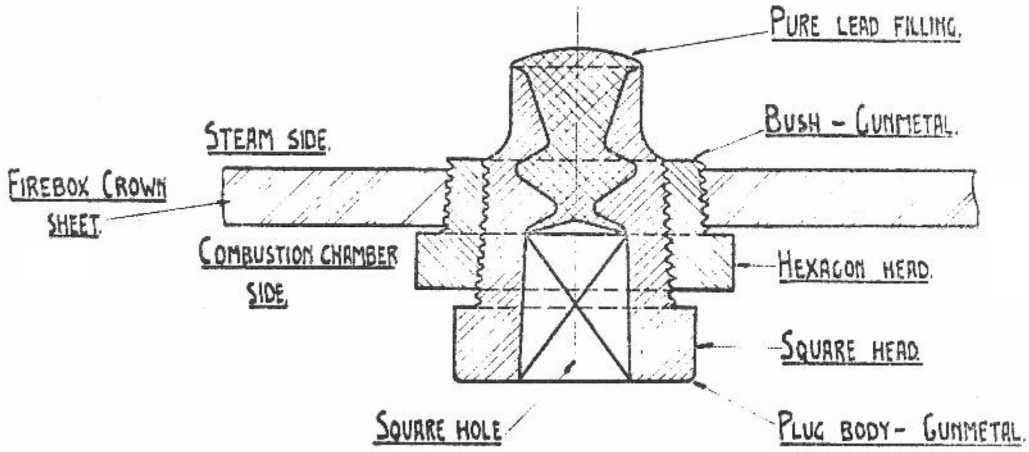
SAFETY VALVE

FIG. 5.

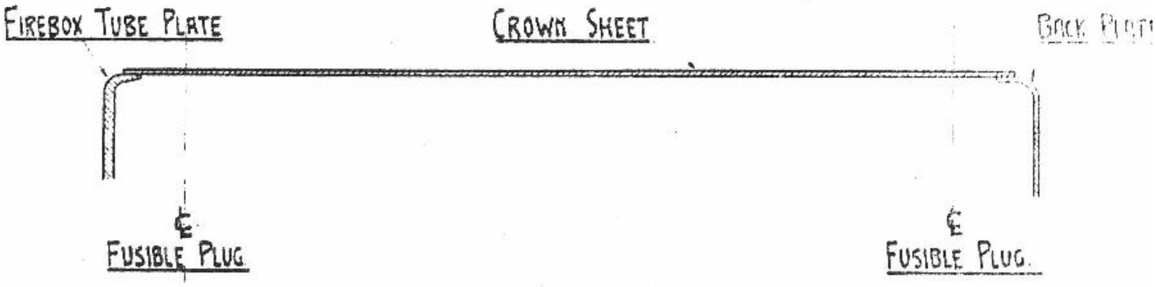


Ross Pop Safety Valve.

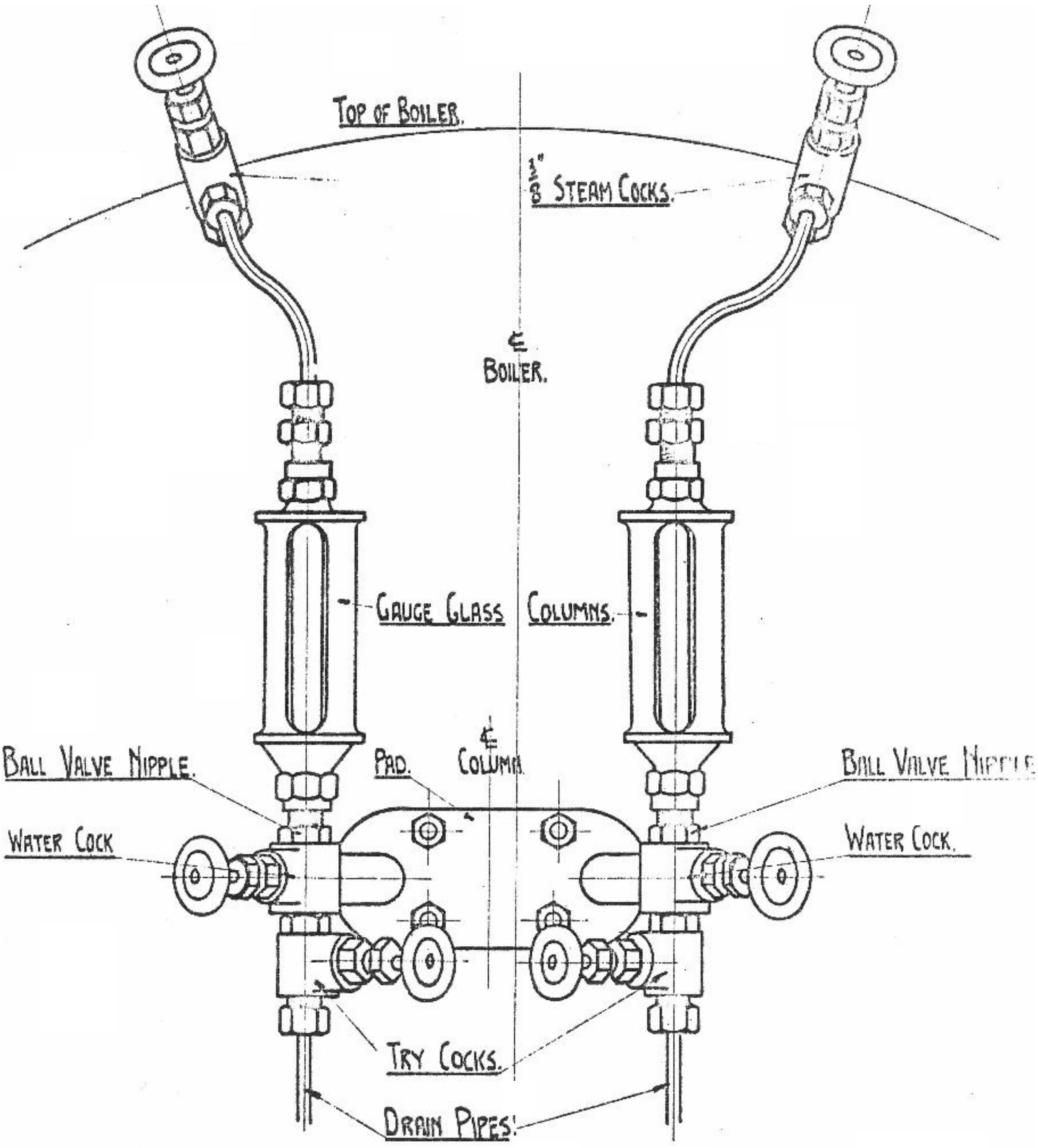
Fig. 6



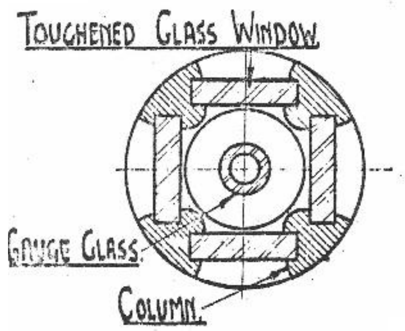
SECTION THROUGH FUSIBLE PLUG AND BUSH.



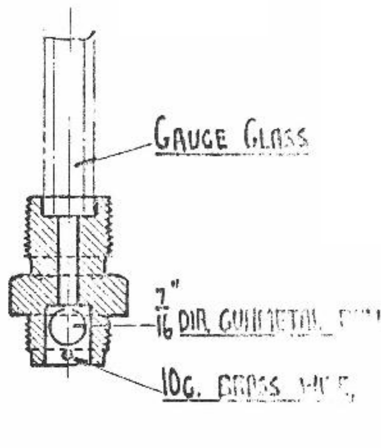
SECTION THROUGH INNER FIREBOX SHOWING LOCATION OF FUSIBLE PLUGS ON BOILER CENTRE-LINE.



ARRANGEMENT OF WATER GAUGE MOUNTINGS.



SECTION THROUGH COLUMN.



SECTION THROUGH BALL VALVE