Steam Locomotive Lubrication

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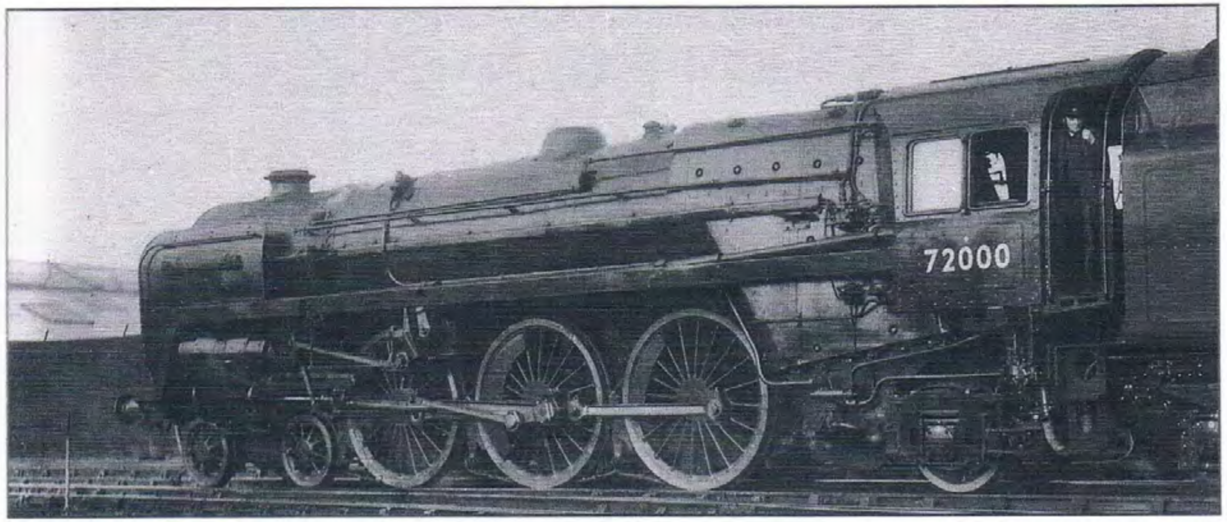
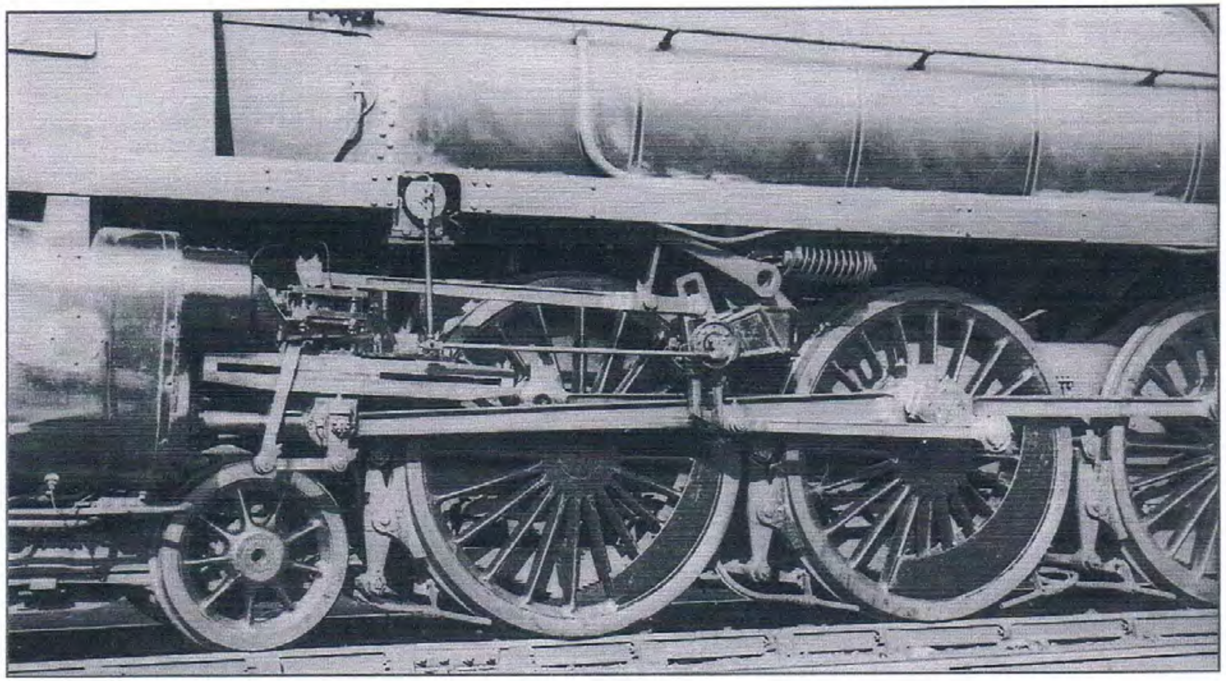
ASTT – 2/3/19

'Clan' Class '6' 4-6-2 Nos. 72000-72009





STEAM LOCOMOTIVE LUBRICATION

Essential precepts The maintenance of an hydrodynamic oil film, first demonstrated by Beauchamp Tower in 1883 and avoiding boundary lubrication conditions

Control of the oil temperature to avoid cracking and degradation with a total loss system

Cylinder wear and leakage Use of narrow rings, invented by Ramsbottom in 1854 Leakage is controlled by pressure acting behind the ring, not by spring pressure

Lubrication systems Mechanical v displacement lubricators.

Atomising delivery v solid oil injection

Anti-cabonisers

Carbonisation Consists of oil plus smokebox ash and boiler salts caused by suction down the blast pipe Essential to avoid vacuum in the cylinders by using drifting steam and correct cut off setting

Anti vacuum valves Snifting valves, Bypass valves- Anderson type

Piston valve type with sliding heads- Trofinoff, Nicolai, Muller, widely used on German standard locomotives

Diesel practice Helical honed cylinder bores, hard chromed piston rings, 20,000 hours service

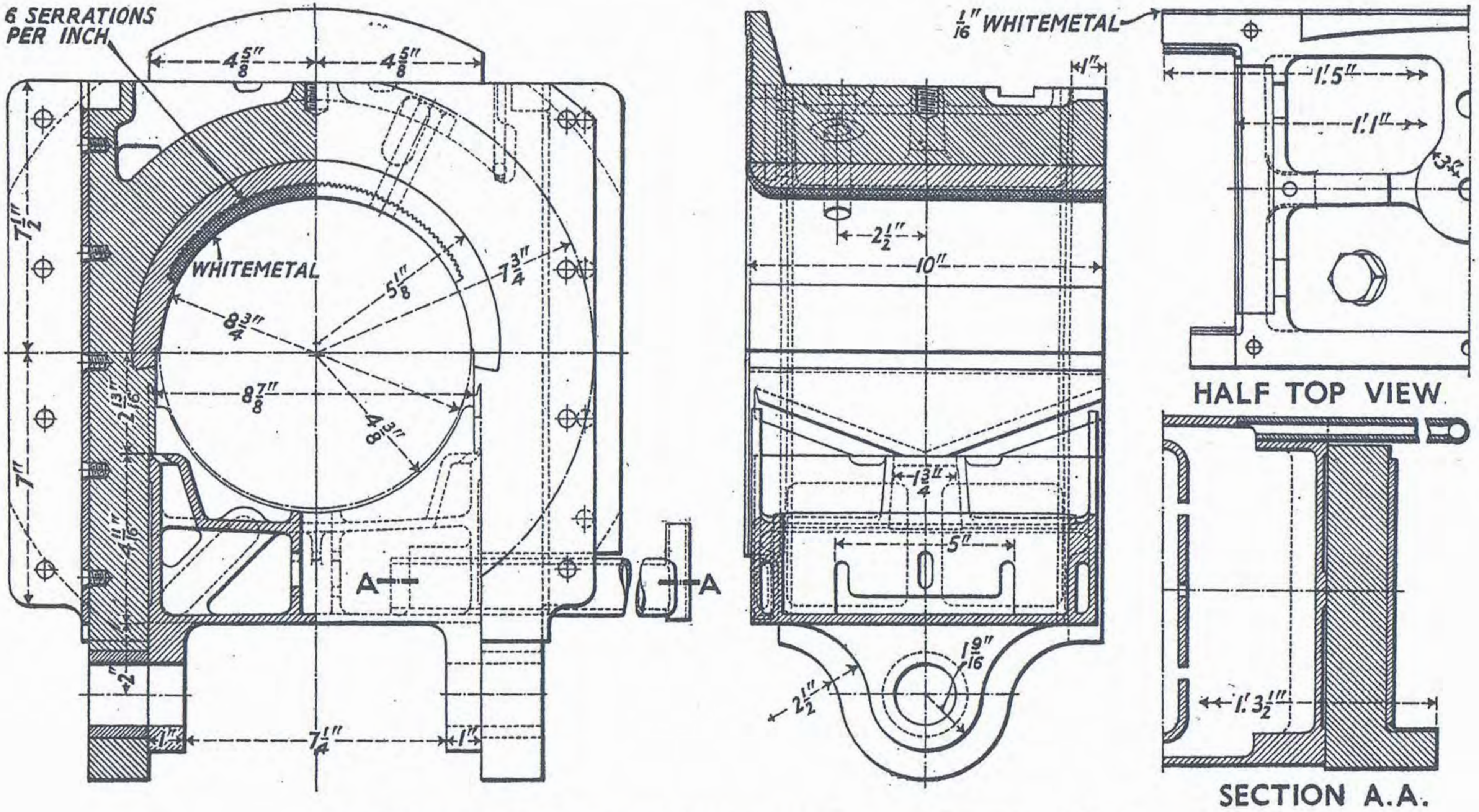


FIG. 65.—SECTIONS THROUGH LOCOMOTIVE DRIVING AXLEBOX, G.W.R.

the bearing from the journal. Feeding oil at a point where the load was greatest, in this case the top of the bearing, was thus shown to be a very poor method of lubricating the bearing, (indeed it proved to be a most effective method of removing oil from the bearing!).

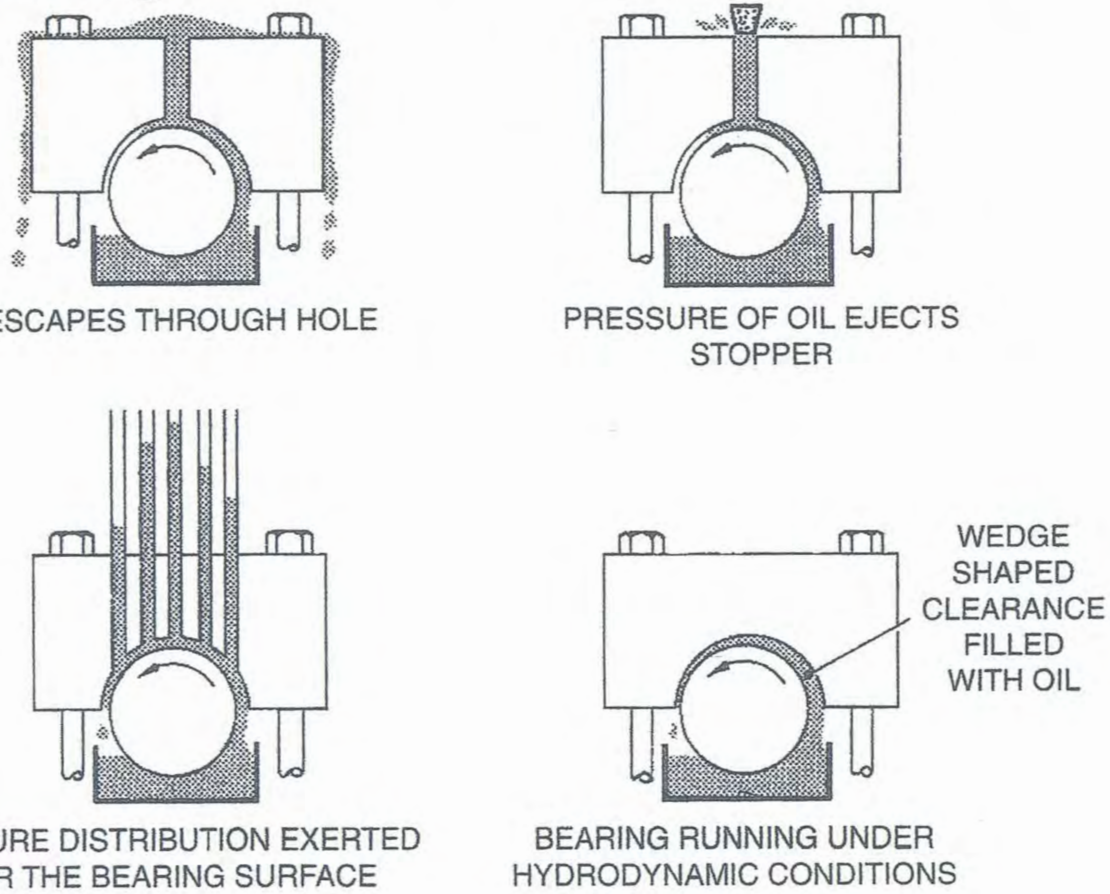


Fig. 1.2 *The results of Tower's experiments.*

By 1885, when Tower published his second

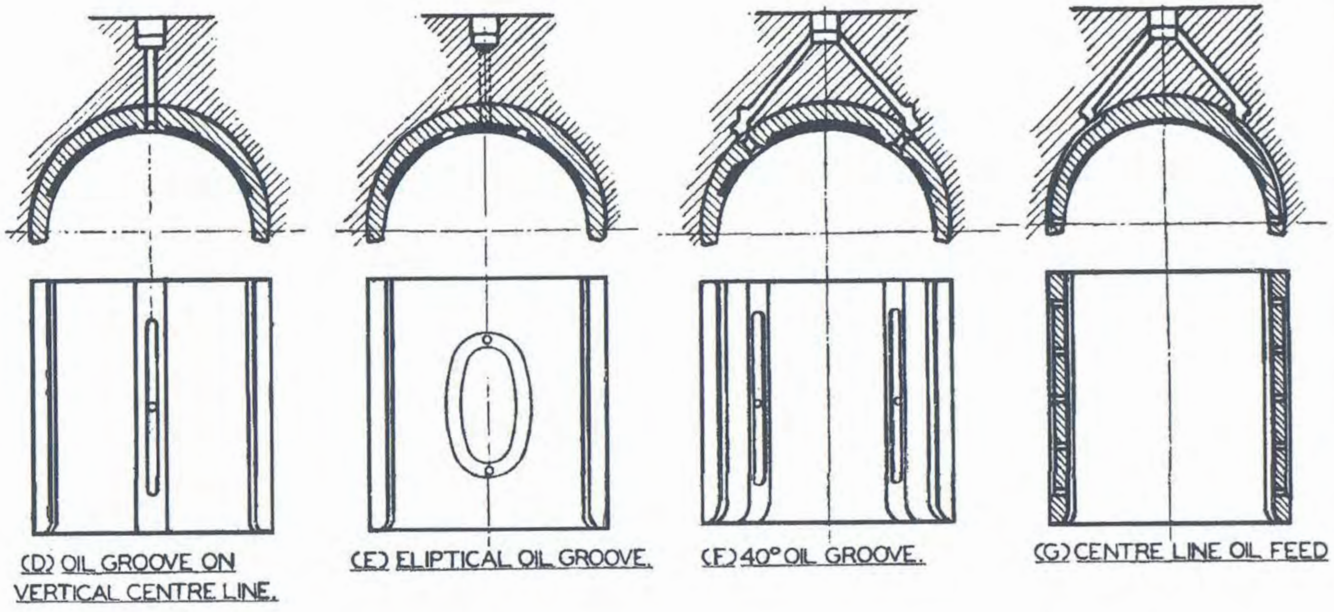


Fig. 2.9 *Common method oil feed to coupled axlebo bearings.* (Mechanicl Engineering Publications)

supply still provided at the top (Fig. 2.9(E)). A better method of increasing the surface area at the crown was to feed the oil into two transverse grooves cut either side of the centre line, at an angle of about 40°, as shown in Fig. 2.9(F).

A variety of tests were undertaken by the LMS to determine the most desirable point at which to apply the oil. For an adequately loaded bearing the final arrangement arrived at was that shown in Fig. 2.9(G). A forced oil feed was introduced through a number of holes situated on the front and back horizontal centre line which then allowed

modified by directing the forced oil suppl underkeep to help maintain its oil level, in to the bearing. The LMS (and subseque axlebox ultimately became almost identica initiated on the GWR under Churchward, f he who had been the first to achieve an coupled axlebox design using Tower's pri

Although Churchward had shown t underkeep pad was a cheap and simple lu and would give excellent results in a p designed axlebox, other methods to provid flow of lubricant to the bearing surface

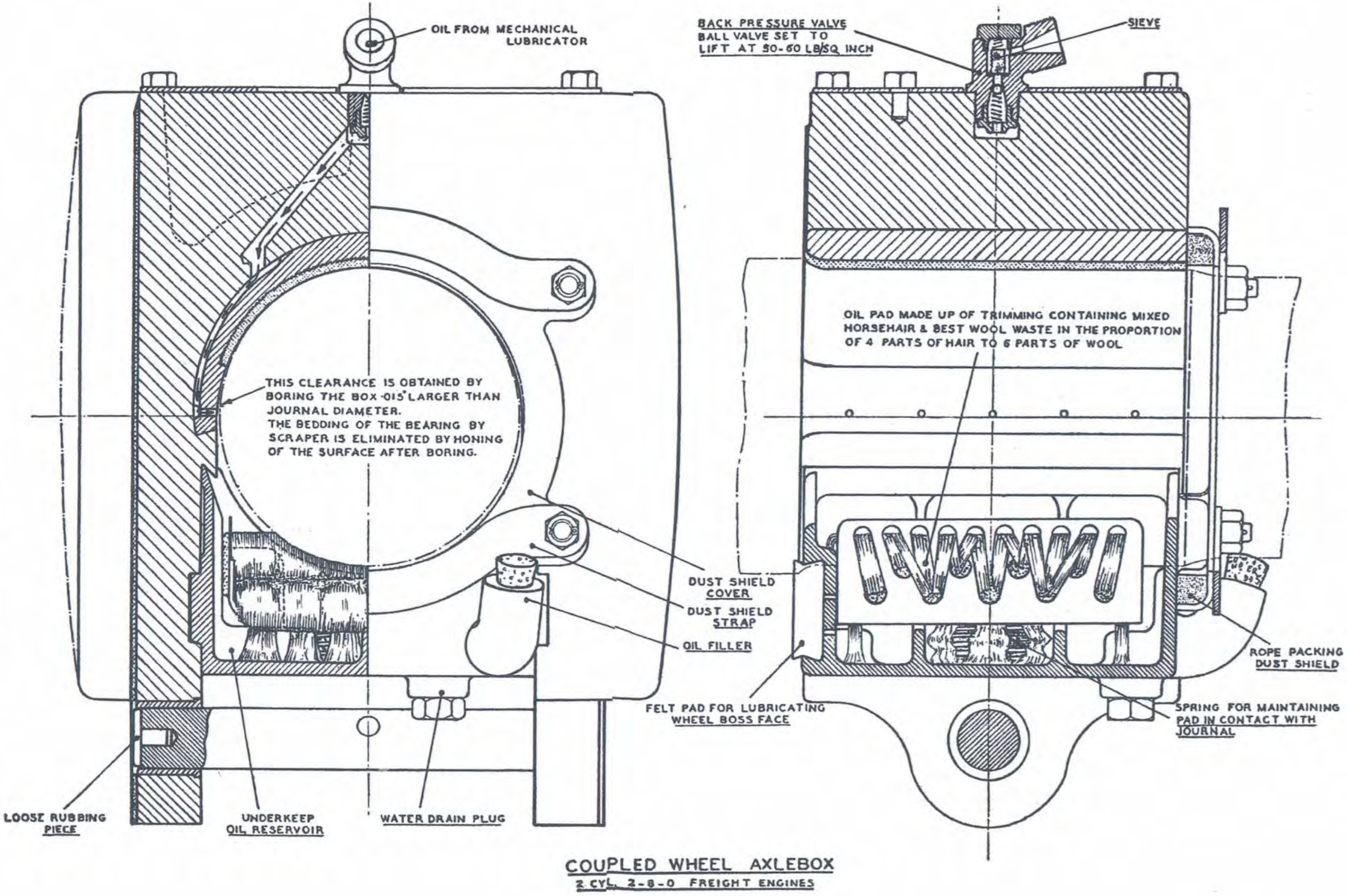


Fig. 2.2 *Coupled axlebox – LMS Class 8F 2-8-0.* (BLS)

large class numerically. By 1939 a considerable number of these engines had been fitted with steel driving boxes identical in design

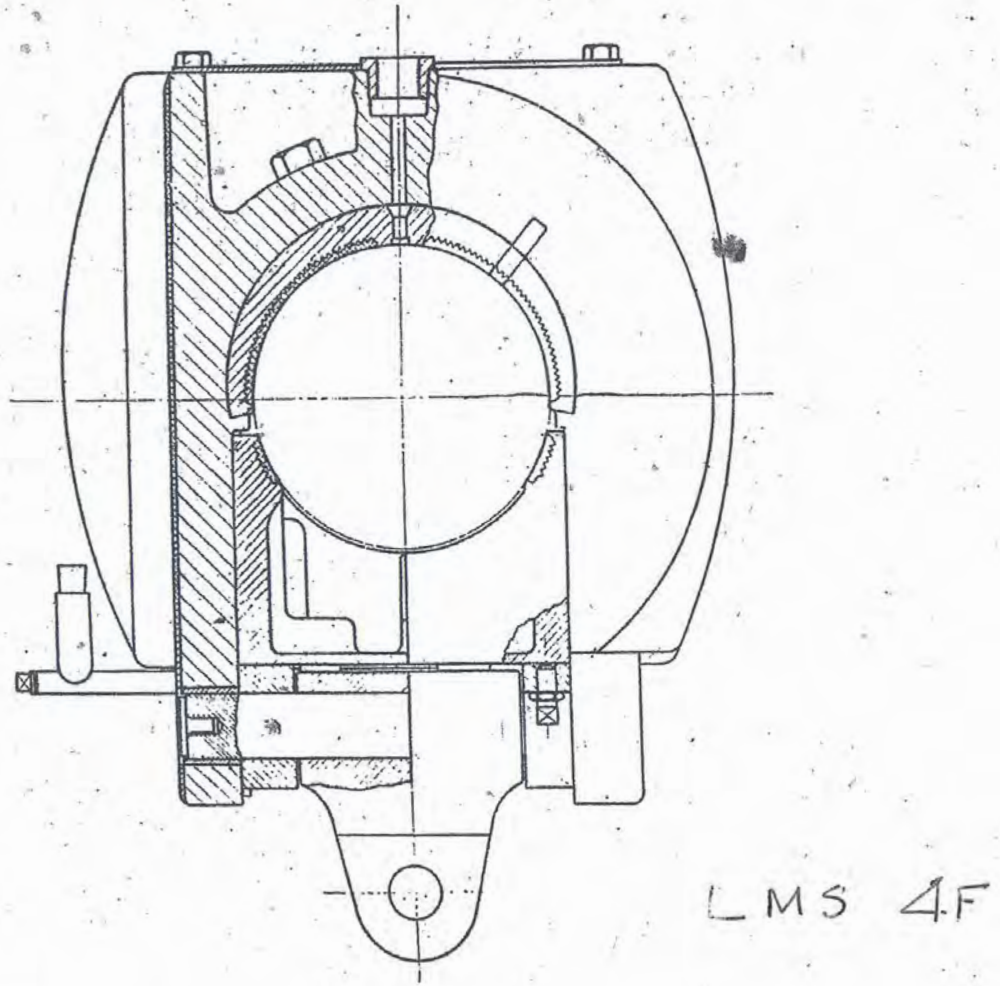


FIG. 15.
AXLEBOX WITH BEARING EXTENDED BEYOND 180°.

In the case of two-cylinder engines, either with inside or outside cylinders, the main driving boxes are subject to heavy forces of a complex nature, and

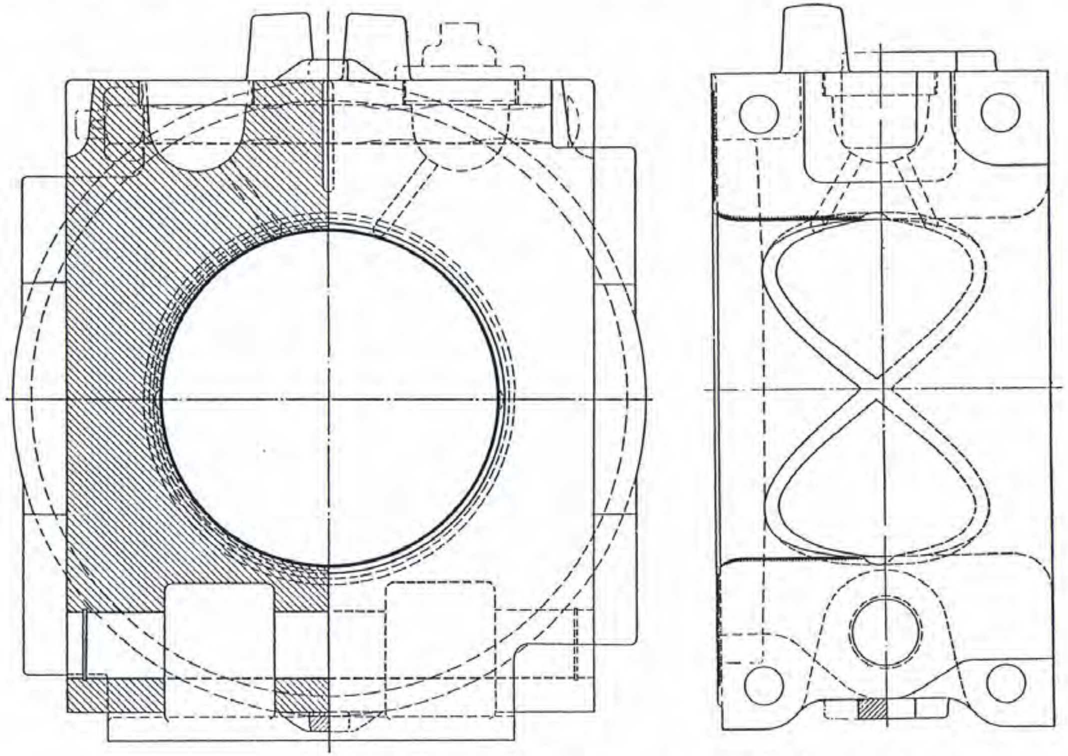


FIG. 83. Solid Bronze Axlebox, for Driving Axles, Split Vertically. S.R.

provision should be made to meet these conditions. This is done by adding to the arc of bearing contact for the main journal bearings. Frequently, also, the main journal bearings are made larger in diameter than for the other coupled axles and often the length is also increased.

Large main journals are standard practice in North America where, both in the United States and Canada, the outside cylinder two-cylinder locomotive has been developed much further than elsewhere. British practice is to maintain one size of journal for all coupled wheels in order to preserve one axlebox design for the particular class of engine. The most usual practice on many railways elsewhere is, however, against this, and larger journals and axleboxes to suit are used for main driving axles.

Lateral and Longitudinal Play.—When the coupled axleboxes are

PISTON RINGS

The objective is to create a seal by bringing two geometrically right faces into contact with two equivalent faces, the ring top and face and the bore surface and groove side. This condition makes the seal and must then be held whilst the piston travels. If the cylinder is double acting the condition must be switched to the opposite side of the groove as the pressure direction is reversed.

As inserted or after standing, the ring can be lying anywhere in the groove. A force is required to push the ring onto the groove side face — only the pressure can do this and then only with some leakage which we must minimise as far as possible. Fig. 1a shows a typical compression ring sitting free in its groove. To enable the ring to expand radially to seal the bore fit it has side clearance a and b. It is these clearances which cause the ring to excite itself by pressure effects and to seat on the groove face.

The high pressure finds a path through the piston to bore clearance then via the restriction of the open groove side clearance to the ring underside. Whilst passing down the groove clearance 'a' the resistance to flow causes a pressure drop and a force pushing the ring away from the pressure source. At the ring far side the leakage meets the other side clearance 'b' and exhausts to low pressure but again with a pressure drop in

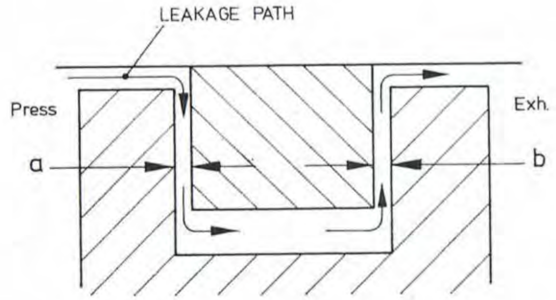


FIG. 1a RING STANDING FREE IN GROOVE

the clearance and a force this time acting towards the pressure source. If the clearances are very small the first groove action takes place a few milliseconds before the second and the ring is pushed onto its face to seal. Fig. 1b.

When the clearances are too large the pressure enters the underside without pushing the ring across axially, because the resistance to flow is too low, and inflates the underside to push the ring outwards onto its bore. A condition of ring locked on bore and not free to move occurs and is accompanied by very heavy leakage. Fig.

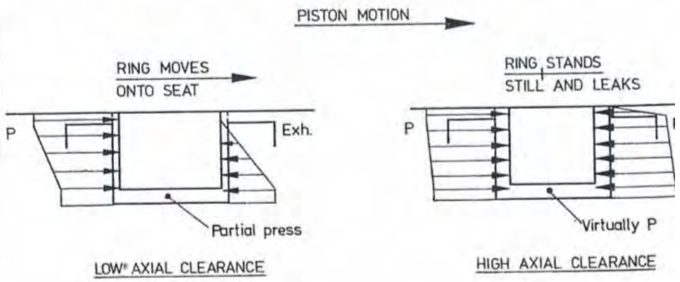
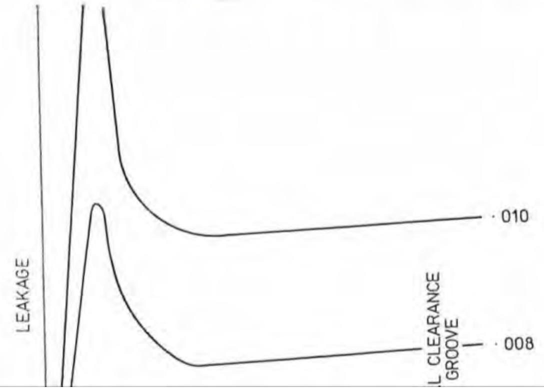
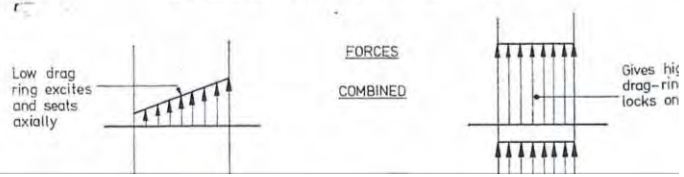


FIG. 1b AXIAL EXCITING FORCES





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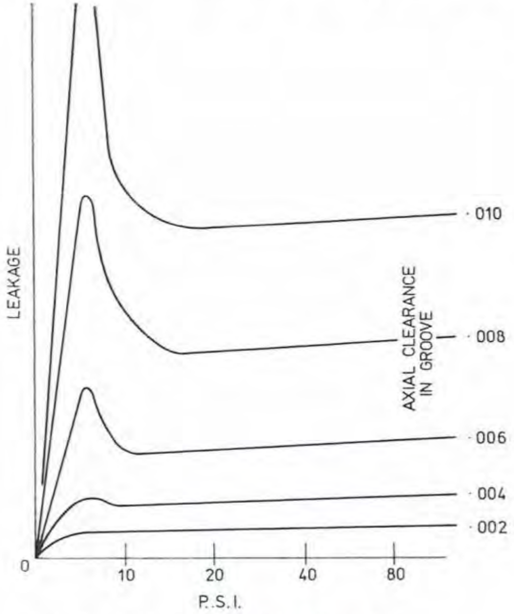


FIG. 2. TYPICAL VARIATION OF LEAKAGE VS PRESSURE DUE TO AXIAL CLEARANCE

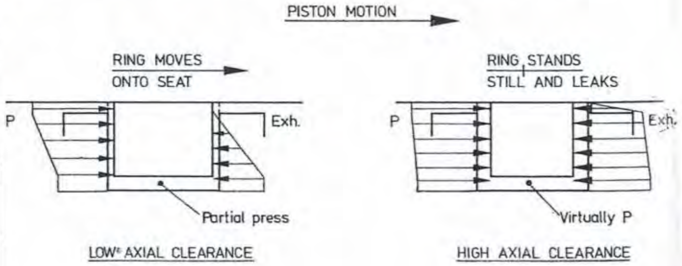


FIG 1b AXIAL EXCITING FORCES

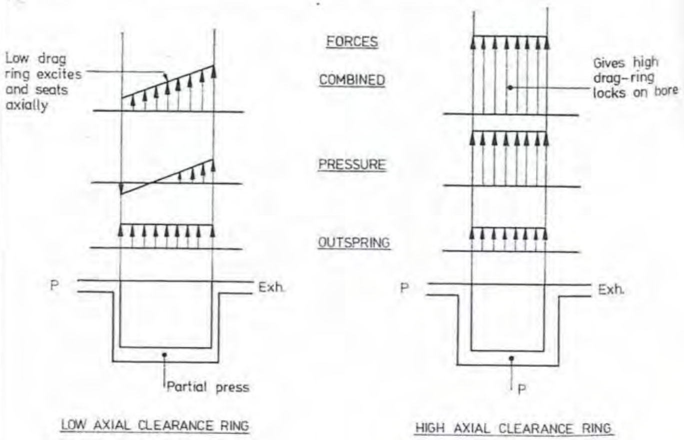


FIG 1c RADIAL FORCES

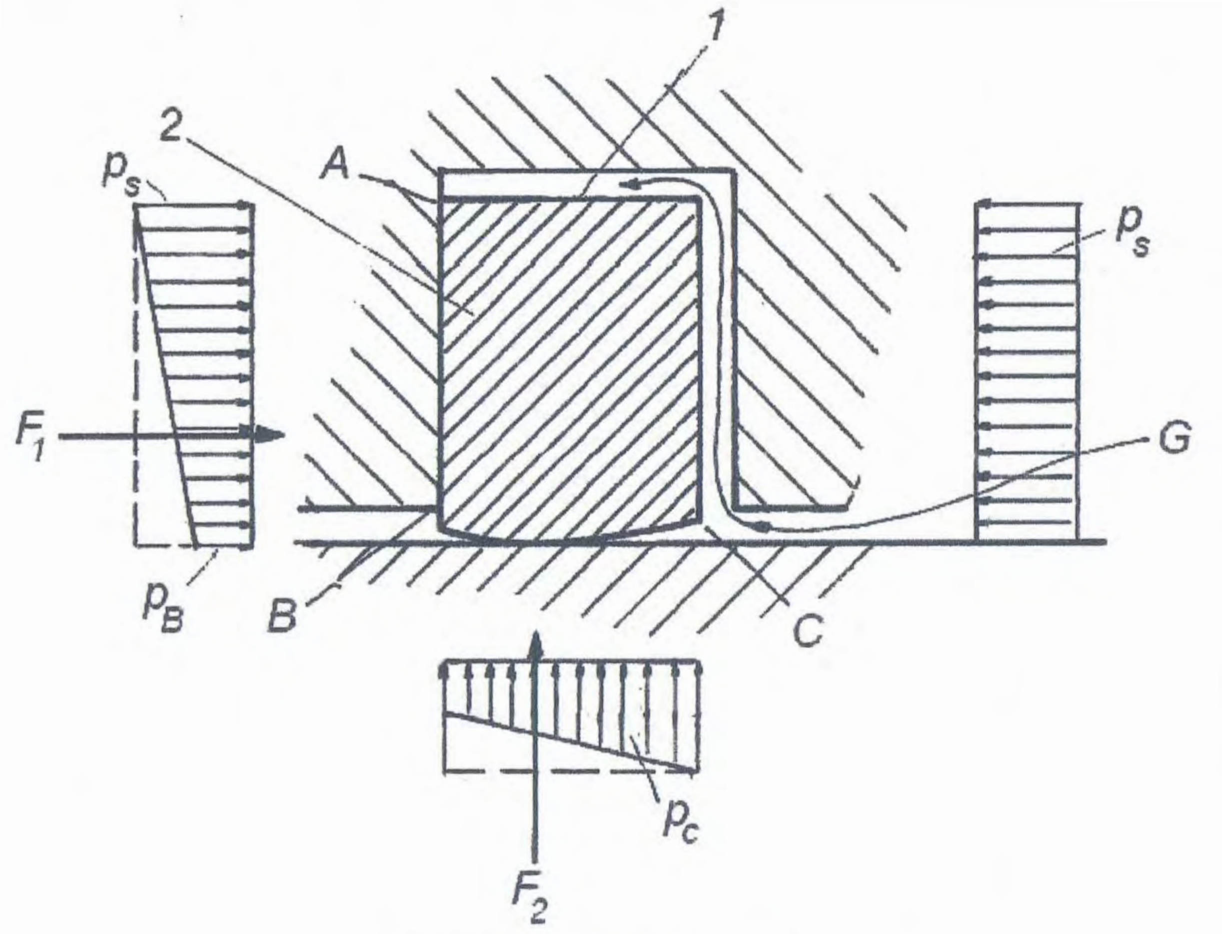


Fig 2: Forces acting on a Ring

An elementary description shows that the gas G gets behind the back (1) of the ring (2) creating the uniform pressure distribution (3). From A to B the pressure falls from the gas pressure p_S to p_B. This partially balances the pressure p_S leaving a component force F_1 which must be supplied by the reaction from the groove side. The same happens with pressure p_C, there remaining a component formed by the wall reaction F_2. This reaction is transmitted by the sum of the oil hydrodynamic pressure and the metallic contact.

Thus the seal is obtained by the pressure of the gas and not by the ring elasticity. The latter has to ensure that it clings at all times to the wall and not to the bottom of the groove as may occur if the ring is broken.

Fig 26

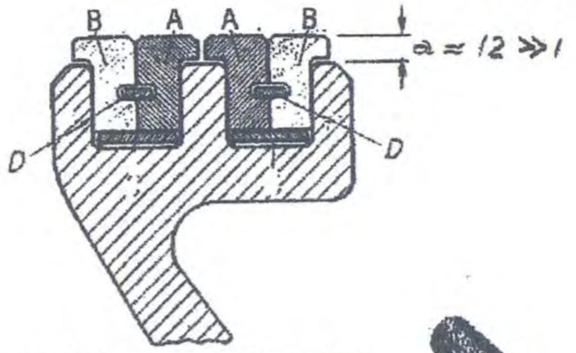


Fig.α—American Sectional Bronze-Iron Locomotive Cylinder Packing—Flanged

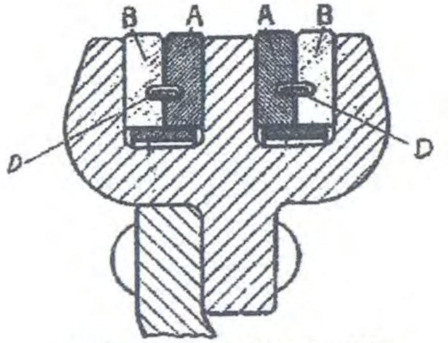


Fig.β—American Sectional Bronze-Iron Locomotive Cylinder Packing—Unflanged

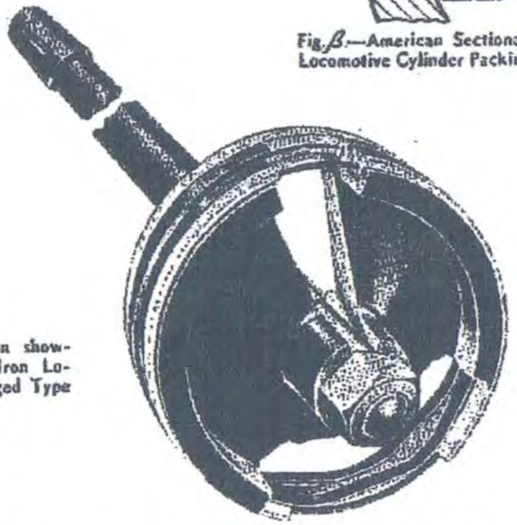


Fig.γ—View of cut-away piston showing American Sectional Bronze-Iron Locomotive Cylinder Packing—Flanged Type

Fig 26: The American Duplex Cast-Iron/Bronze Ring

B are bronze segments alternating with opposite cast iron segments A. During working, all segments get worn down leaving the wear gap on the top. With reference to Fig 38, the leakage area F is very large because '*a*', instead of being (say) 1mm, is ~12mm. This contributes to the very large losses measured in France for the 141R [97].

The retaining ring D forces the bronze sector B to wear out at the same rate as the cast-iron segments A, thereby making the assembly to work as a real composite bearing. The softer bronze shaves off the peaks of the liner asperities, thereby producing a smoother surface leading to an enhanced hydrodynamic support, hence less wear. But the question is not just to have little wear, but to have a small leakage area: even with zero wear, that area is far greater than that of a usual European narrow ring. The Author does not understand why Chapelon was seduced by this design.

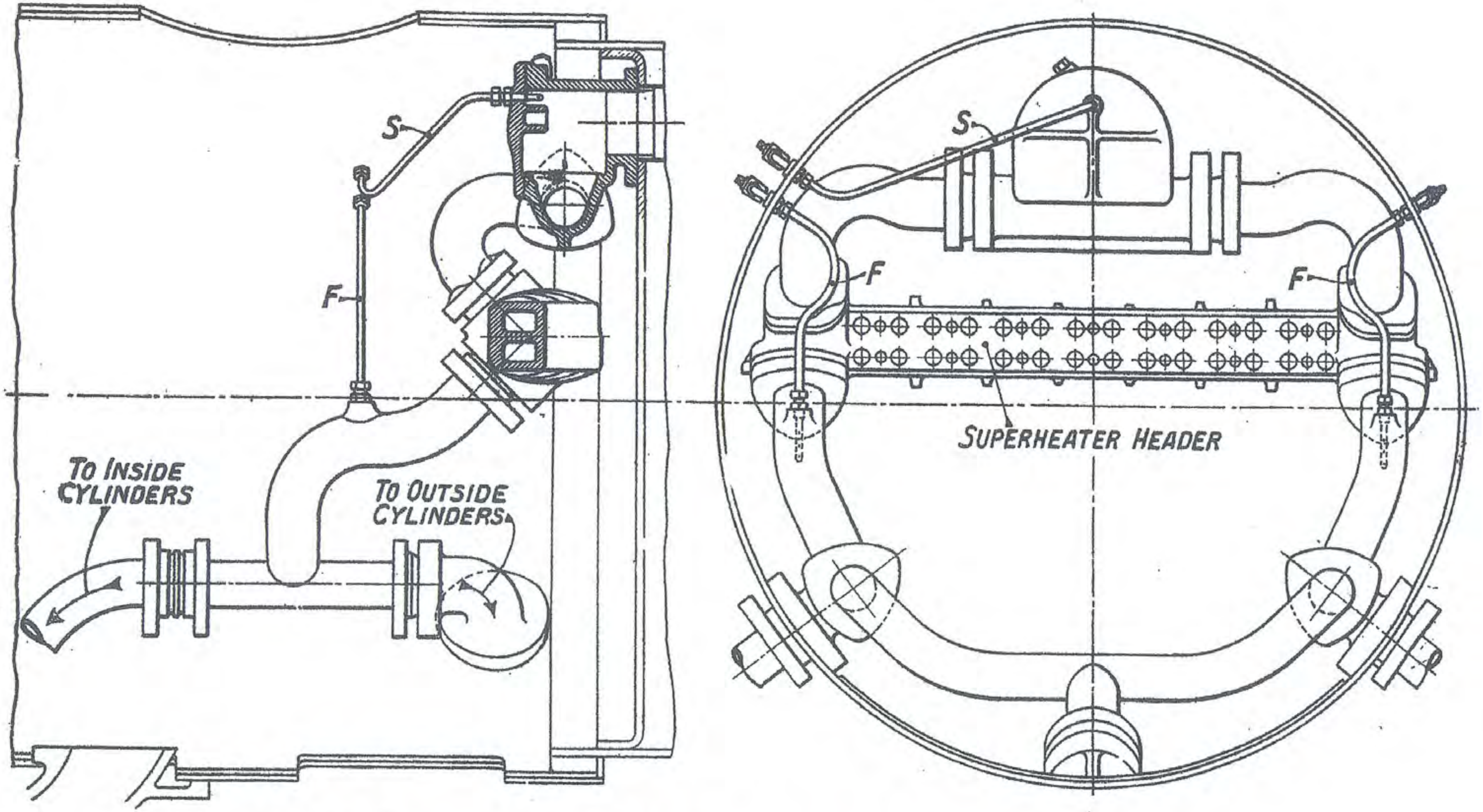


Fig. 235.—Lubrication of Four-Cylinder Engines with Superheater, G.W.R.

(Additional piping omitted in two-cylinder engines.)

rodding to the cylinder cock gear, and a return spring bears on the top of the steam valve to ensure that it will remain firmly seated even in the absence of any steam pressure upon its upper face. Consequently, it must bear always upon the face of the cam.

The atomiser C itself takes the form of a casting which may

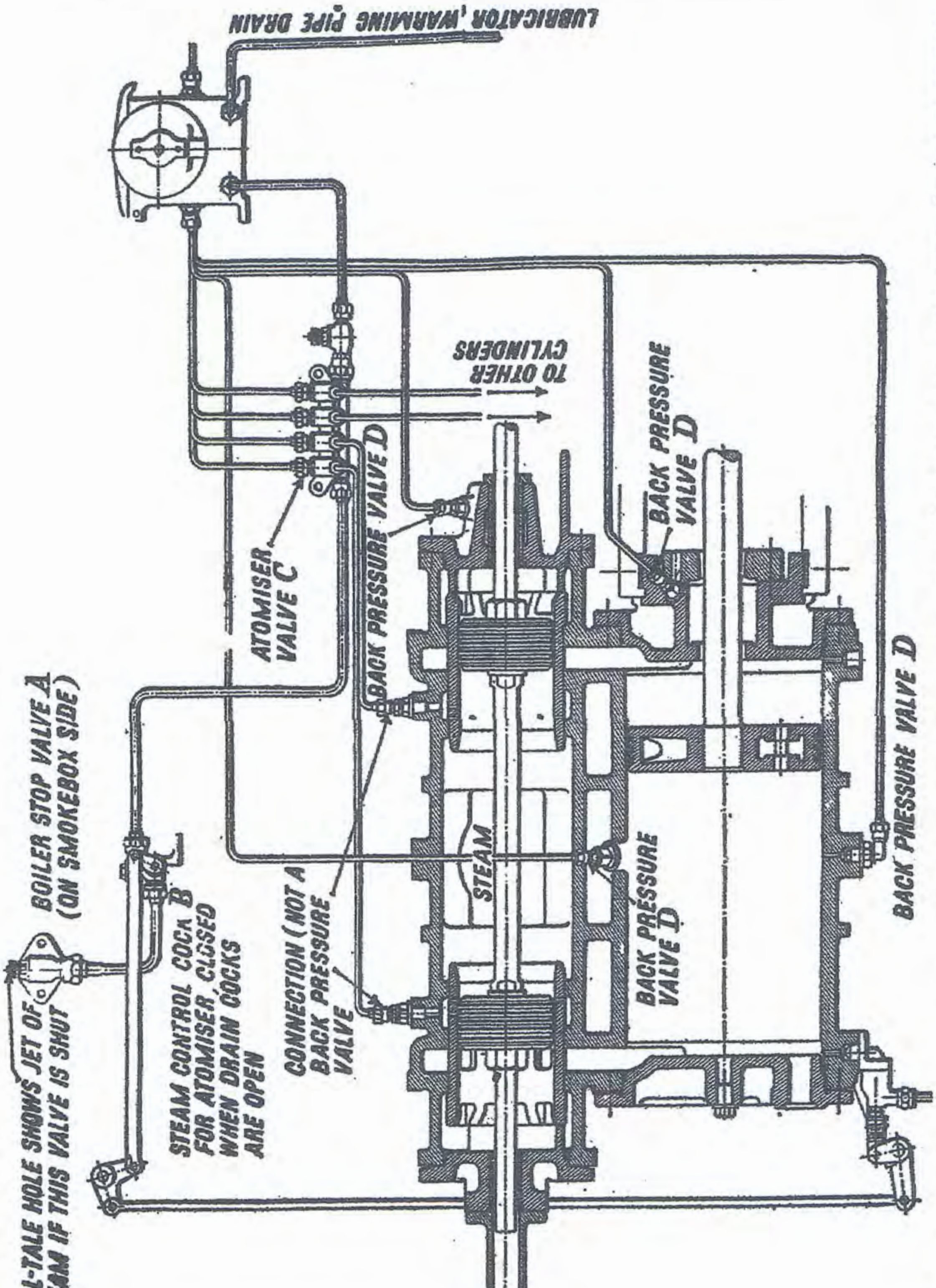
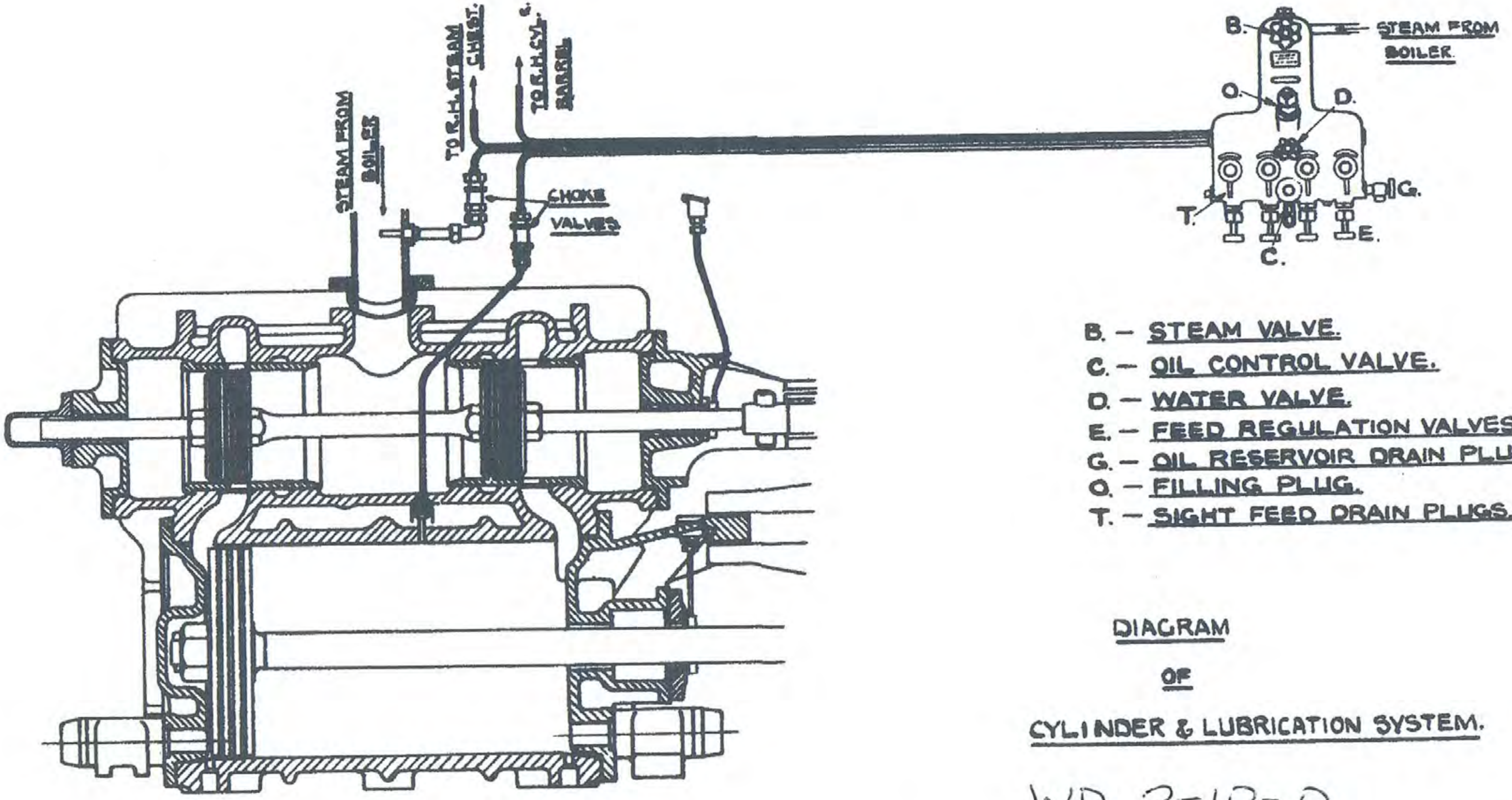


Fig. 236.—Section through Locomotive Cylinder and Steamchest, showing Arrangement of Atomiser Lubrication System, L.M.S.R.

embody four or more individual atomiser valves, according to the number of cylinders on the engine. This valve usually is bolted to a suitable bracket on the footplate, so placed as to keep the respective pipe lines as short as possible. Oil is delivered into the top union of any one of the valves, from the mechanical lubricator, and this inlet normally is closed by a ball forced upwards on to its seating by a spring. Pressure generated by



B. — STEAM VALVE.
C. — OIL CONTROL VALVE.
D. — WATER VALVE.
E. — FEED REGULATION VALVES.
G. — OIL RESERVOIR DRAIN PLUG.
O. — FILLING PLUG.
T. — SIGHT FEED DRAIN PLUGS.

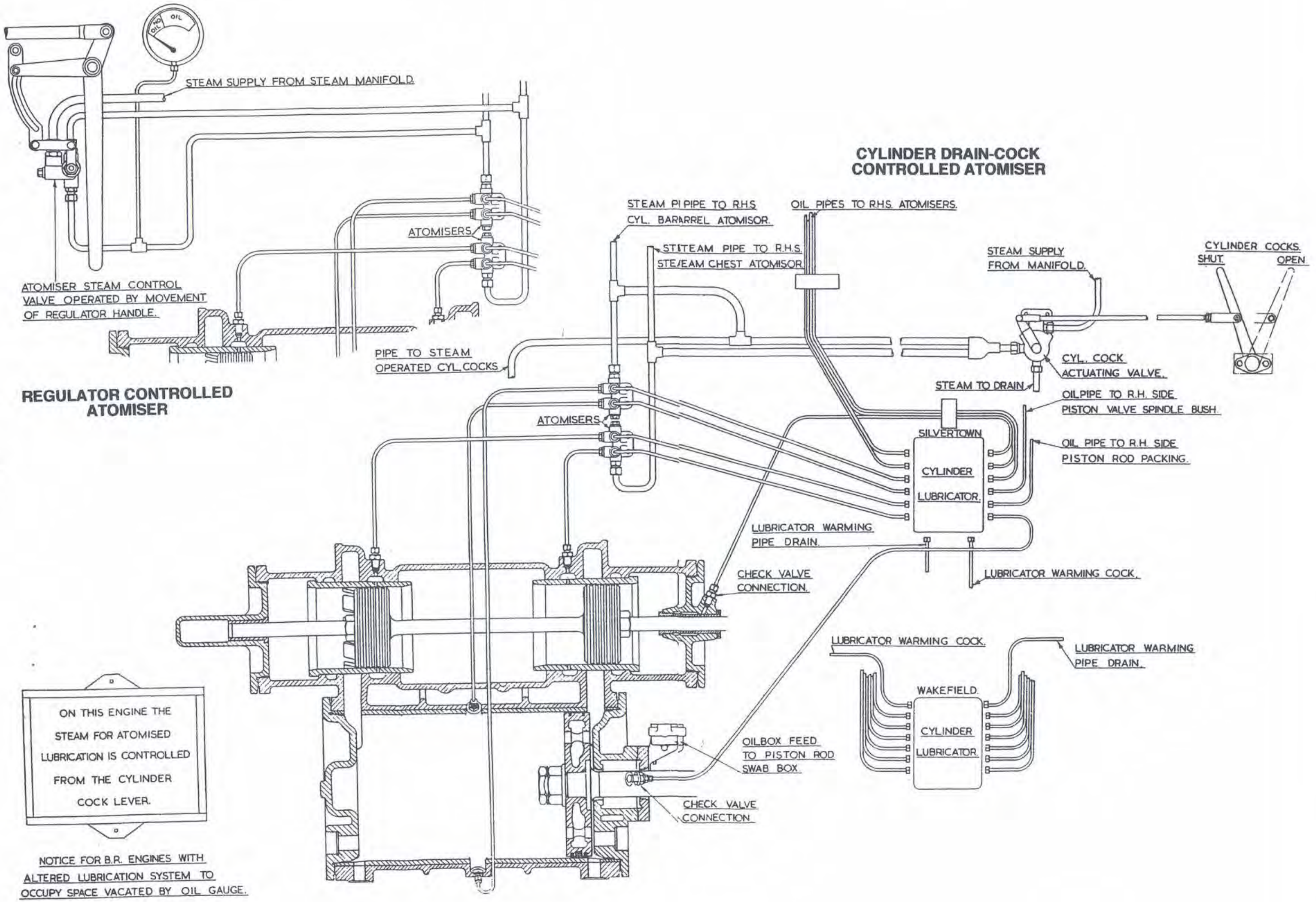
DIAGRAM

OF

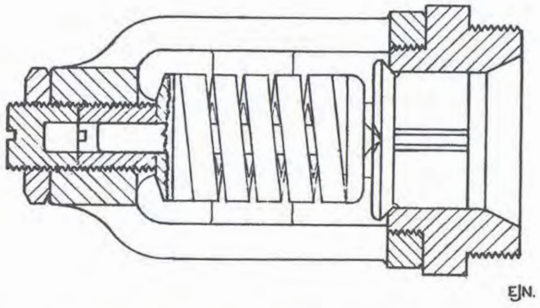
CYLINDER & LUBRICATION SYSTEM.

WD 2-10-0

1945

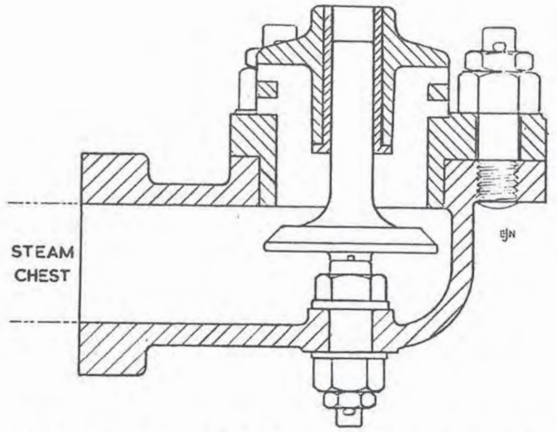


STEAM SUPPLY FROM STEAM MANIFOLD.
OIL
OIL
ATOMISERS
ATOMISER STEAM CONTROL VALVE OPERATED BY MOVEMENT OF REGULATOR HANDLE.
PIPE TO STEAM OPERATED CYL. COCKS
REGULATOR CONTROLLED ATOMISER
CYLINDER DRAIN-COCK CONTROLLED ATOMISER
STEAM PIPE TO R.H.S. CYL. BARREL ATOMISOR.
OIL PIPES TO R.H.S. ATOMISERS.
STEAM PIPE TO R.H.S. STEAM CHEST ATOMISOR.
STEAM SUPPLY FROM MANIFOLD.
CYLINDER COCKS.
SHUT
OPEN
CYL. COCK ACTUATING VALVE.
STEAM TO DRAIN
OILPIPE TO R.H. SIDE PISTON VALVE SPINDLE BUSH.
OIL PIPE TO R.H. SIDE PISTON ROD PACKING.
ATOMISERS
SILVERTOWN
CYLINDER
LUBRICATOR.
LUBRICATOR WARMING PIPE DRAIN.
CHECK VALVE CONNECTION.
LUBRICATOR WARMING COCK.
LUBRICATOR WARMING COCK.
LUBRICATOR WARMING PIPE DRAIN.
WAKEFIELD.
CYLINDER
LUBRICATOR.
OILBOX FEED TO PISTON ROD SWAB BOX.
CHECK VALVE CONNECTION.
ON THIS ENGINE THE STEAM FOR ATOMISED LUBRICATION IS CONTROLLED FROM THE CYLINDER COCK LEVER.
NOTICE FOR B.R. ENGINES WITH ALTERED LUBRICATION SYSTEM TO OCCUPY SPACE VACATED BY OIL GAUGE.



COMPRESSION RELIEF VALVE.

Fig. 27.



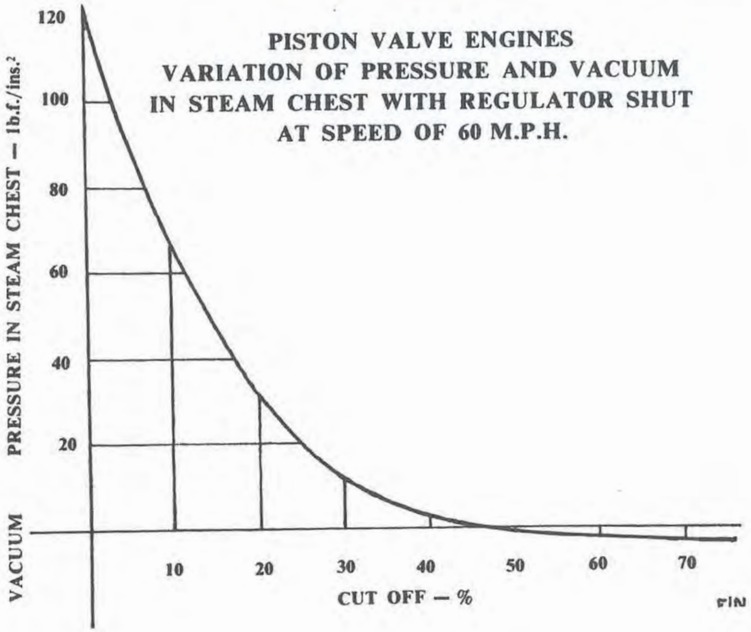
SNIFTING, OR STEAM CHEST AIR VALVE.

Fig. 28.

If, on the other hand, an engine was drifting with the lever in about 20% cut-off, the action of the valves and pistons caused a pressure to accumulate in the steam chests. The pressure was built up from smokebox gases drawn down the blast pipe because the snifting valves only opened when vacuum was formed in the steam chests. These gases may contain large quantities of smoke, soot, cinders or coal dust which caused carbon deposit in the cylinders, valve chests, steam pipes and superheater, causing undue wear of the valves and pistons.

The correct and best position for drifting (or coasting) was with lever in 45% cut-off (5th notch). When drifting with the gear in this position, whilst a certain quantity of air was drawn in through the snifting valves and there was also a light suction down the blast pipe, a mean position was obtained between the two undesirable extremes (See graph Fig.29.).

If, in addition to the lubricator combining valve, the regulator was opened slightly (i.e. not sufficient to provide power in the cylinders) the steam passing through the cylinders prevented smokebox gases being drawn in through the blast pipe and ensured a better distribution of the cylinder lubrication.



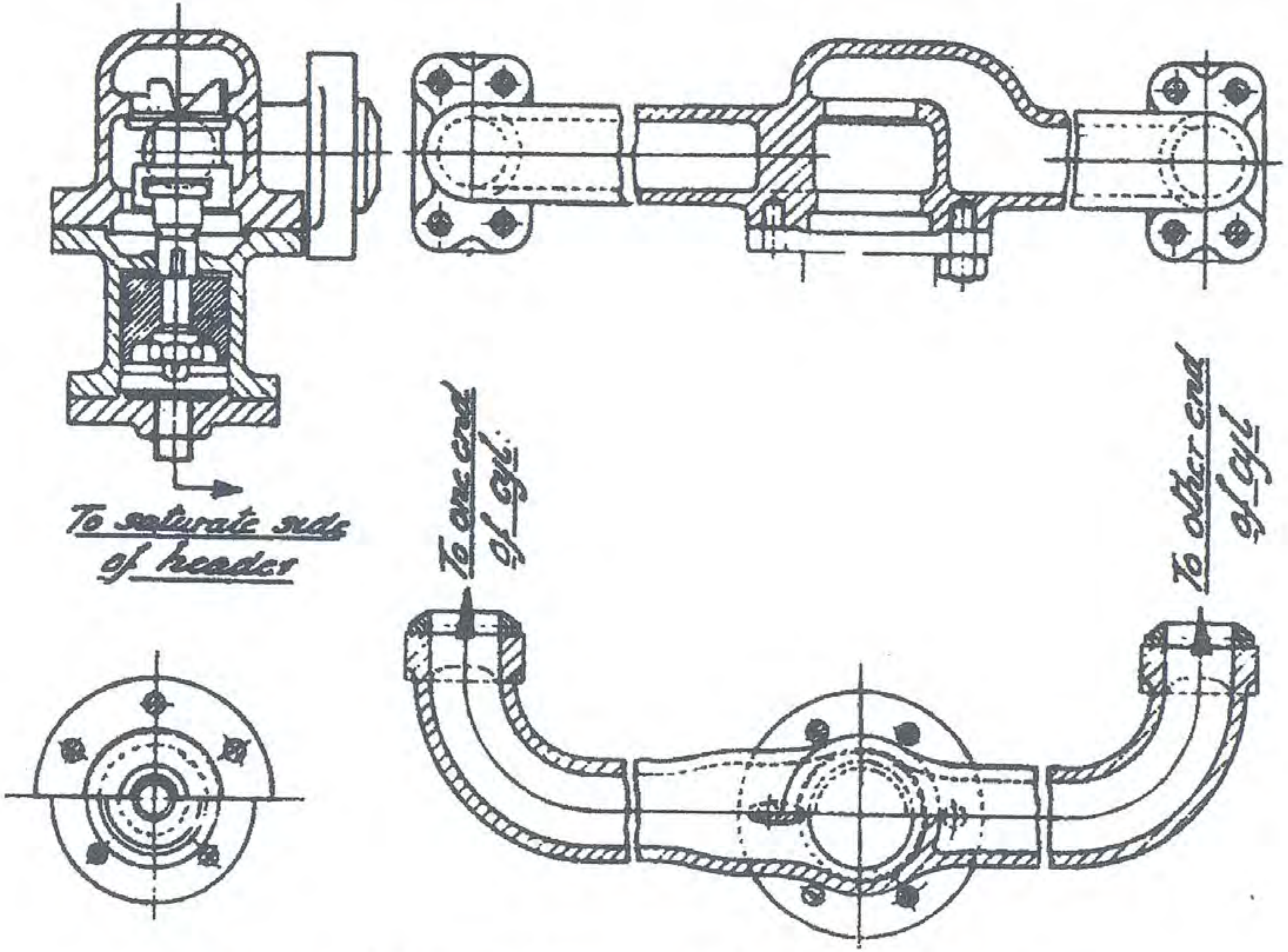


FIG. 7. FOWLER-ANDERSON BYE-PASS VALVE.

This interesting design of piston valve of Russian origin has the feature of providing an automatic bye-pass when the regulator is closed. Fig. 31 shows this valve for normal working and fig. 32 illustrates how the bye-pass is obtained. The valve consists of a spindle *A* with two stop discs *B* rigidly fixed to the spindle, between which are mounted the two slidable pistons *C*. When the regulator is open, steam enters between the two slidable pistons and forces them apart, and into contact with each stop disc. Thus, as the valve spindle is driven forward and backward the sliding pistons have the same movements, and the whole valve works as a solid unit. With the regulator closed, there is no pressure between the slidable pistons, so that when the spindle is reciprocated, the stop discs push them toward each other, where they remain stationary, as shown in fig. 32. It will be seen that a passage is provided through the slidable

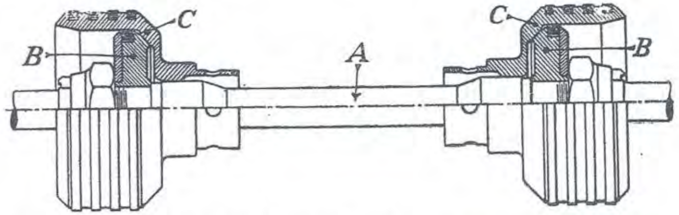


Fig. 31.—Trofinoff piston valve—normal position

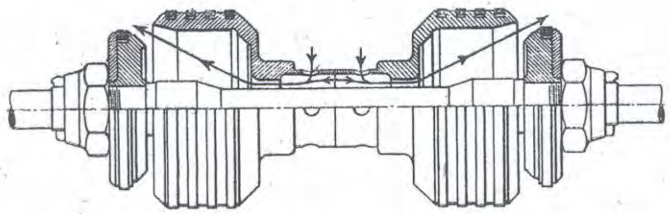
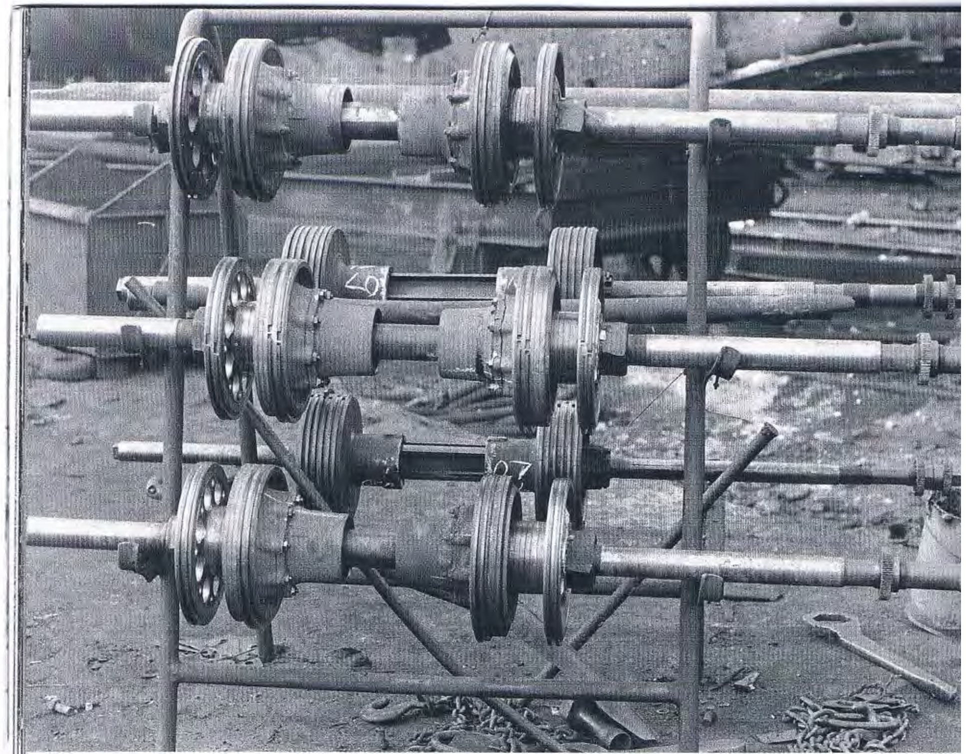


Fig. 32.—Trofinoff piston valve—bye-pass position

pistons, thus connecting both ends of the cylinder with each other and the atmosphere through the exhaust passages.



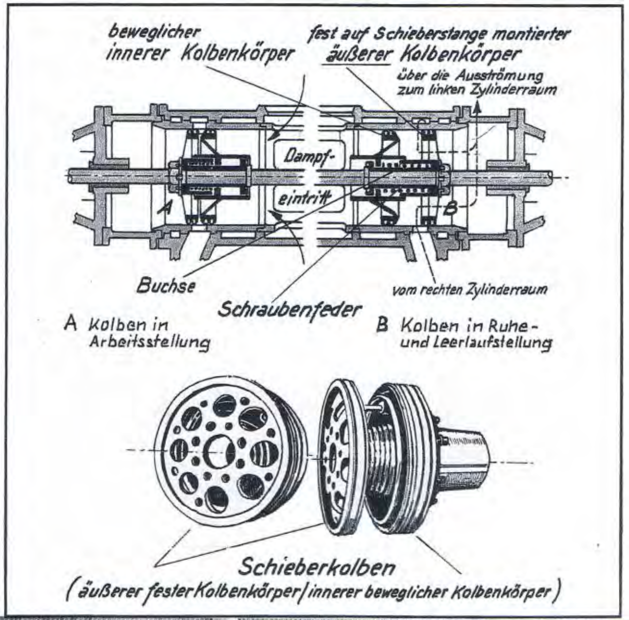
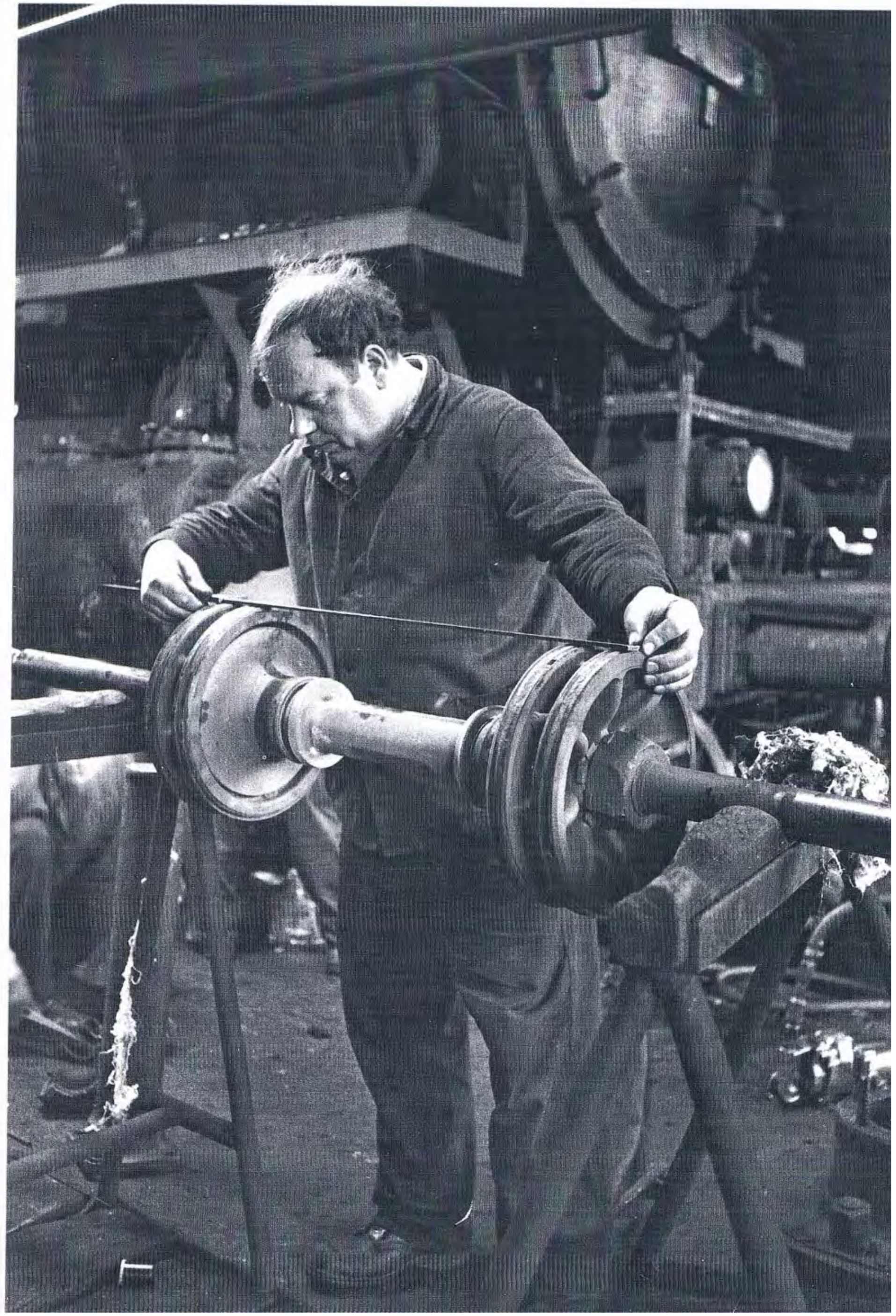


Bild 64: Unterschiedliche Kolbenschieber! Im vorder
Ständers Karl-Schulz-Schieber (mit den kreisförm
sparungen). Im hinteren Teil Trofimoff-Schieber.
Foto: M.

Bild 65: Schnittzeichnung eines Zylinders mit Kolbe
der Bauart Karl Schulz. **Zeichnung: R.**

Bild 66: Ausbohren des linken Dampfzylinders bei 01
auch erkennbar, wie der Zylinderblock mit dem Ra
schraubt ist. **Foto: M.**

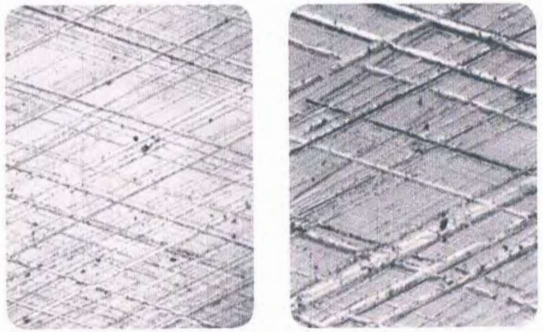
außen, wodurch sie stets an der Zy
lauffläche anliegen. Die Breite de
benringe beträgt 8 mm, die Höh
schen 12 und 16 mm. Die Stöße d
benringe sind gegeneinander um
versetzt, denn beim zufälligen Hin
anderliegen der Stöße könnte sic
Dampf einen Weg suchen.
Der Kolben ruht nicht auf den Kolb
gen. da dies zu einseitiger Abn
von Zylinderlauffläche und Kolben
führen würde. Er wird vielmehr v
Kolbenstange, die hinten vom Kreu
vorn von einer Kolbentragbuchse
führt, daß er im Zylinderraum "sch
Die Kolbenstange ist eines der am
sten beanspruchten Bauteile der D
lokomotive. Sie besteht deshalb a
sonders hochwertigem Stahl. Der D
kolben wird auf die Kolbenstange h
lisch aufgepreßt und mit einer verni
Mutter gesichert.
Bei den meisten Länderbahnlokom
sowie bei allen Einheits- und Neuba



Today most cylinder liners made of untreated cast iron are used as the counter running surface to the piston ring. For final machining of the running surface, clean plateau honing, also recommended by Federal-Mogul, has long since become the norm. Nitrided or laser hardened cylinder sleeves are therefore being used less frequently. Cylinder sleeves today have a service life of around 100,000 operating hours; the sleeve must be honed twice during this period.

In summary we can say that the introduction of the chrome ceramic coating in combination with the antipolishing ring marked a milestone in the development of the module piston ring and cylinder sleeve. The anti-polishing ring (also called fireband) is a ring inserted in the upper end of the cylinder sleeve in order to prevent carbon deposits forming on the piston above the top compression ring.

Rpk < 0.3 µm
Rk = 0.5..1.3 µm
Rvk = 1.0..3.0
(acc.ISO 13565)



Anti-polishing ring

Plateau honing