NEW ZEALAND RAILWAYS

ENGINEDRIVERS CORRESPONDENCE COURSE

Ab CLASS STEAM LOCOMOTIVES

LESSON NO.3

LUBRICATION OF THE ENGINE MOTION (DRIVING GEAR)

The oil consumption in the working of our locomotives is large and costly. The closest supervision is necessary to ensure its most economical use - just as there is regarding the consumption of coal. By the proper attention to trimmings, lubrication of bearings and pin holes at the proper time; by giving consideration of the atmospheric conditions; by removing of trimmings when standing for any appreciable time, and avoiding the flooding of axle boxes etc., with oil, it is obvious that many gallons of valuable oil can be saved over a period of time.

THE MOVEMENT OR LACK OF MOVEMENT in the part to be lubricated determines to a certain extent the method of lubrication. Connecting rod ends, side-rods and eccentric rods, for instance, where the movement is sufficiently pronounced, are lubricated by the agitation of the oil in the cups when the locomotive is working, plug trimmings being placed inside the central oil tube of the oil cup so as to regulate the flow to the bearings.

Those portions of the locomotive having no throw are generally lubricated by the use of tail trimmings, which syphon the oil from the axle boxes, marine boxes or oil cups, as in the case of piston rods, slide bars, valve spindles, etc.

Much depends on the manner in which the trimmings, are made. By carefully adjusting the number of woollen strands to suit the climatic conditions, the class of oil used or the part to be lubricated, oil can be fed so as to give the correct supply to the bearings.

TRIMMINGS

When oiling the locomotive, the Enginedriver should examine the trimmings, and if they are found to be unsuitable, either from being too thick or too thin, dirty, or the wrong class of trimming he should adjust them or make new ones as required. As indicated in the previous paragraph, there are two classes of trimming used on locomotives, viz., plug and tail trimmings.

The following is a good method of making a "plug" trimming:

Cut a piece of thin copper or galvanised wire (about eight inches long). Double the wire. Begin to twist it at about one inch from the doubled end, continue twisting up to about one inch from the loose ends, which should be left open in a "V" shape. Take a single strand of clean worsted about five feet long, draw it through the wire loop, hold it and the wire with the left hand, while with the other hand wind the worsted over between the tail ends and back through the loop. Continue to cover the twisted part of the wire with the worsted until there are twenty or thirty strands according to the size of the syphon pipe. To complete the trimming, bind both ends of the worsted at the loop, and continue twisting the wire until there is about three-eighths of an inch of neck between the worsted and the loop end. The loop should now be ring-shaped and it will prevent the trimming from dropping down to the crank pin or bearings. The tail ends of the wire should be twisted sufficiently to keep the worsted in position. Any surplus wire should be cut off neatly, so that it will not rest on the bearing parts. The trimming should be made thick enough to just rub the sides of the syphon-pipe and at the same time be moved freely up and down the pipe with the finger and thumb. This class of "ring-top" trimming is easily withdrawn and replaced.

The "tail" trimming is made with a piece of wire about eight inches long (according to the length of the syphon-pipe to be trimmed) bent in the middle, both ends being brought opposite to each other. The worsted strands should be cut in lengths of, say, fourteen inches and placed in the bent centre of the wire. The wire should then be twisted tightly along the ends, and the middle of the worsted strands will be secured. Place the trimmings down the syphon pipe about two or three inches as required, then bend the wire over and make a neat little coil to the ends, so that the trimming can be easily handled.

"SWABS" are made to various shapes, but they are usually circular, particularly used on the piston rod of the air compressor.

The Ab class locomotives have grease cups on their coupling rods and big ends of the connecting rods. To fill these cups, release the locking nut on the cap portion and unscrew the cap anti-clockwise. Replenish with soft grease and replace the cap, then by screwing the cap clockwise the grease will be forced through to the bearings, then screw the locking nut down onto the base of the grease cup. Normally the Enginedriver during his preparation duties will only be required to release the locking nut, screw down the cap, and then retighten the locking nut, unless the grease cup requires replenishing. It is the practice at main depots to allocate all greasing to members regularly employed on this work.

THE ENGINE

Previous lessons in this course were devoted to a study of the locomotive boiler and its attachments, together with a detailed analysis of the duties and responsibilities covering the operation, functions, care and maintenance of this part of the locomotive.

The purpose of this lesson is to give the student a full description of the engine.

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The diagram (Fig. 1) issued with the first lesson, together with the attached diagram (Fig. 11) will be of considerable assistance to the student in checking the names and location of the various parts as they are described.

Coupling rods (56) are necessary so that the adhesion required in utilising the tractive force of the engines may be distributed or divided among the six or eight driving wheels, depending on the class of engine in question. The force exerted by a locomotive in moving a given load is known as the tractive effort, and the conversion of this force into motion is immediately dependent upon the adhesion or friction of the wheels on the rails, this adhesion in turn being governed by the weight of the engine and the climatic conditions. The force exerted in moving most of the modern heavy trains is so great that the necessary adhesion could not be obtained through a single pair of drivers without a considerable amount of slip, which would soon destroy the tyres and rails, hence the advantage of dividing the adhesion among the several wheels by coupling them up.

Many sudden and varying stresses are set up in the coupling rods by the slipping of the wheels, inertia, sanding, and the side bending due to the curvature of the road. They are, therefore, made from one piece of the best forged steel to avoid the risks of welding, and afterwards machined to the required shape, which is a fluted H section.

The "Ab", "Ww" and similar classes of locomotives have the coupling rods fitted with a cotter and block, so that the length of the rod can be adjusted with the brasses without altering the forged part of the rod, and the wear taken up by closing the joints of the brasses, which are made in halves.

For the engine with four driving wheels, a single rod on each side is a satisfactory coupling for the wheels. For six or eight coupled wheels, a joint in the rods is a necessity for giving the required vertical flexibility. A fork is formed in the end of the trailing coupling rod and connected to an eye in the end of the leading coupling rod by a strong coupling pin. The work done by the coupling rods is transmitted through the driving crank pins and they are accordingly made the stronger, being of a larger diameter than the leading and trailing crank pins (57).

Connecting rods (51) transmit the movements of the crossheads to the crankpins. Like the coupling rods, the connecting rods of "Ab", "Ww" and similar classes of locomotives have a cotter and block with split brasses at the crank pin end of the rod.

The cylinder (41), made of cast iron, is cast with the valve-chest (39) in which the valve works. It is bolted to the main engine frames, and is prevented from moving along the frames by a spigot cast on to the cylinder. Both ends of the cylinder are provided with covers. The front cylinder cover (36) is a dished casting shaped to suit the piston head (42). The back cylinder cover (43) is also dished to suit.

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The lap and lead rod (46) or combination lever, as it is sometimes called, is the part of the gear which combines the motion of the link with that obtained from the main crosshead and transfers this combined motion to the valve spindle. The motion produced by the crosshead during one stroke is reduced to such an extent by proportioning the two arms of the lap lead lever that when the link block is in the centre of the link, the lap and lead lever will move the valve a distance, equal to twice the lap of the valve, plus twice the lead. Hence the name "lap and lead lever". During this motion the lap and lead rod swings about the radius rod connection as a pivot.

The union link (47) connects the bottom of the lap and lead rod with the crosshead arm, which is bolted to the bottom of the crosshead (48). The crosshead arm is merely an extension to the crosshead to provide a means for connecting the union link to the crosshead and lap and lead lever, so that the union link will be in horizontal position when the crosshead is in either the middle or the ends of its stroke. The length of the union link must be such that when the crosshead is in the middle of its stroke, the lap and lead lever stands in a vertical position.

The weighbar shaft (24) or reversing shaft is the part of the gear which connects the reach rod and radius rod in such a way that when the reverse lever is moved back and forth, the die block is raised or lowered in the expansion link. It extends across the engine to connect the right and left motions with one reach rod being supported at each end by bearings attached to the engine frame. It is provided with arms for the attachment to the radius rod on each side and one arm at about right angles to these for the reach rod connection of the right-hand side. A balance weight is added to each side of the motion to make the changeover from forward to back gear easier to perform, as the weight of the moving parts is then counter balanced.

The lifting links (23) connect the arms on the weighbar shaft with the radius rods on each side of the engine, and serve to lift the radius rod and the die-block from the full forward gear position at the bottom of the expansion link to the full back gear position at the top of the expansion link.

The reach rod is the part of the gear which connects the weighbar shaft with the reverse lever. It consists of a long rod, forked at both ends, and prevented from sideways movement by slotted brackets placed along the running board of the locomotive.

The reversing lever is the part of the gear whereby the Enginedriver reverses the engine and varies the amount of cut-off in the cylinders. A trigger on the handle operates a trigger block having teeth on it which engage with teeth upon a sector plate, thereby ensuring that the lever remains in any one given position.

Valve Gear

The mechanism by means of which motion is imparted to the valves is termed the valve-gear. It is the mechanism employed for actuating the valve. The gear most generally used in this country is that known as the "Walschaerts Valve Gear" and is shown in Fig. 1. This is the invention of a Belgian Engineer, Egide Walschaerts.

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The eccentric crank arm (53) is connected to an extension of the big end pin. (54) It is fastened rigidly to the big end pin by means of two bolts, one on either side of the pin, while the crank arm itself is split so that it can be drawn to a tight joint on the square end of the big end pin by means of the two binding bolts. On the "Ab" locomotives the crank arm is a forging with a case hardened eccentric crank pin pressed in.

The length of the eccentric crank arm is such that, with the centre of the eccentric crank pin set the proper distance away from the centre of the axle to produce the required throw, the centre of the eccentric crankpin will be slightly more than one quarter of a turn, or 90 degrees, away from the centre of the big end pin.

The purpose of the eccentric crank is to give the valve, with the locomotive in full gear, a movement equal to the specified valve travel. It also serves as a collar to hold the connecting rod on the main crank-pin. The eccentric crank consists of a short arm rigidly secured to the outer end of the main crank pin from which it obtains its movement. It is set in such a position that the end moves in a path having a diameter smaller than that of the main pin. Due largely to the fact that the swing of the link is much less than the swing of the link foot, the eccentric crank has to be designed with a throw greater even than the total valve travel, so as to obtain, with the locomotive in full gear, the valve travel specified in the design.

The eccentric rod (52) connects the eccentric crank pin with the expansion link. Since the connection to the eccentric crank pin must provide for turning through a complete revolution, this is made in the form of a split bush and cotter, similar to that on the connecting and coupling rods. The end which is attached to the expansion link turns through a small angle and here a case-hardened pin is used.

The purpose of the eccentric rod is to transmit the movement of the eccentric to the expansion link.

The expansion link (21) is made of mild steel in two parts which are bolted together after the wearing parts have been case-hardened. The link is supported by means of a bridle which is riveted in position on the link. The radius of the link is equal to the length between the centres of the pin holes in the radius rod and is measured from the centre of the link slot.

The purpose of the expansion link is to transmit the movement of the eccentric crank and the eccentric rod to the radius rod. It also permits the locomotive to be reversed and the cut-off changed.

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The die block (22) slides in the expansion link slot. It is attached to and is held in position by the radius rod and is made of mild steel, and case-hardened. If the die block is in the centre of the link, it will receive no motion from the link, and if moved away from the centre of the link, its travel will be increased proportionately. With a direct motion engine, full forward gear, the die block is at the bottom of the expansion link, and in full back gear, it is at the top.

The radius rod (25) transmits the motion of the expansion link to the valve spindle (44).

Steam is led down to the cylinders from the superheater header by cast iron steam pipes. One steam pipe (28) leads from the header to the side of the smokebox, and the other steam pipe (35) leads from the side of the smokebox to the top of the valve chest (39). Covers are provided for each end of the valve chest. The front cover serves as an outlet for the exhaust steam to pass from the valve chest to the blast pipe. The back cover, in addition to serving as an outlet for the exhaust steam, also acts as a guide for the valve spindle (44).

To allow for wear inside the cylinder, a cast-iron liner is pressed in so that the wearing surfaces may be renewed without the necessity for the renewal of the whole cylinder block. The piston head (42) is an iron casting, dished for greater strength, and made slightly smaller than the inside diameter (the bore) of the cylinder. Around its outer circumference grooves are cut, into which the piston rings fit. These rings are made so as to be an easy fit with regard to the width, and about 1/8" larger in diameter than the cylinder. They are turned so as to present a smooth outer surface, and a piece about 1/4" long is then cut out of the ring before placing it in the groove. This allows the ring to be compressed when the piston is being placed in the cylinder. Once inside they spring outwards, and thus form a steam-tight joint with the smooth bore of the cylinder. This prevents steam working past the piston and being wasted. The piston rod passes through the piston head and is secured by means of a nut. That portion which rests within the body of the piston is tapered, as also is the hole which receives it. It is thus held rigidly and securely. The crosshead (48) is attached to the piston rod in a similar manner, except that a tapered cotter is used instead of a nut. Steam is prevented from passing through the back cylinder cover past the piston rod by means of metallic piston packing (Fig. 10) which is a neat fit upon the piston rod.

The piston valve (40) governs the admission and distribution of steam to the cylinders and the release of the steam to the atmosphere after it has completed its work in the cylinders. It has several advantages over the flat or D pattern slide valve. One is that it lessons the resistance due to friction caused by the constant rubbing of one surface against another; also there are no large surfaces exposed to steam, and it is more easily moved. The piston valve is so constructed that for all positions of the valve; live steam is permitted to escape from the steam chest directly to the exhaust port. However, it does not allow the steam to escape from the cylinder until it has propelled the piston for the greater part of its stroke.

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The central portion of the piston valve is made of a piece of solid drawn seamless steel tubing. At each end is welded a piece of boiler plate, which has previously been formed into the desired shape in a press. The ends of this valve are made of cast steel and are held together by means of two bolts. These ends are keyed to the valve spindle and carry the distance rings, which are made of cast-iron and are turned to an outside diameter 1/32" less than the bore of the bushing, so that the valve rings above bear against the wall of the bushing.

The piston valves used on the "Ab" locomotives, as was all the main classes of locomotives on the N.Z.R. are of the "inside" admission type. This means that the steam is admitted to the inside of the valve, or in other words, in between the sets of rings which make up the two ends of the valve. In this valve, the inside edges of the valve, and the inside edges of the steam ports control the admission of live steam into the cylinders and are known as steam edges (Fig. 11). In this case the live steam entirely envelopes the central portion of the valve. The outside edges of the valve and the outside edges of the steam ports are the "exhaust edges" because they control the exit of the exhaust steam from the cylinders. The ends of the valve are in communication with each other from the fact that the piston valve is hollow.

The valve seat for the piston valve is cylindrical in shape. It is made in the form of a cast-iron bushing which is pressed into each end of the steam chest. Openings are left in the bushings to form the steam ports and communicate with the steam passages extending entirely around the bushings. The parts of the bushing left between the openings are called the bridges and are designed to give sufficient bearing surface to prevent the valve rings from springing out and catching in the port.

The "steam edges" and "exhaust edges" are formed by means of valve rings to maintain a steam-tight joint between the ends of the valve and the valve bushing. They are the only parts of the valve that touch the bushing all the way round and consequently the edges of the rings control the distribution of the steam. The inner edges or the inside valve rings form the steam edges of the valve, while the outer edges of the outside valve rings form the exhaust edges of the valve.

As the valve moves back and forth over the valve seat throughout its travel, the various events or changes produced (in the distribution and control of the steam during each stroke of the piston) are designated by the following terms, each of which is taken up and explained in the order in which it occurs.

(a) Admission.

(b) Cut-off.

(c) Expansion.

(d) Release or Exhaust.

(e) Exhaust closure.

(f) Compression.

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(a) Period of Admission.

Admission begins when the steam edge of the valve uncovers the steam edge of the port and continues until the valve has reached the end of its stroke, and returning again, passes over the steam edge of the port. It is during admission that steam is taken into the cylinder.

(b) Point of Cut-Off.

Cut-off occurs when the steam edge of the valve closes the steam port, and thereby prevents the steam from entering the cylinder. After cut-off takes place, the piston must travel the remainder of its uncompleted stroke without receiving steam from the boiler.

(c) Period of Expansion.

Expansion takes place from the time cut-off occurs until the valve opens to exhaust. During expansion the steam follows the piston and occupies a larger space and consequently drops in pressure. If no expansion took place the steam would be blown into the exhaust at practically the boiler pressure. During expansion the flow of live steam ceases. Therefore, the earlier the cut-off, the larger the expansion and the longer will the live steam be held back and remain stored for the next stroke.

(d) Point of Release or Exhaust.

Release or exhaust occurs when the exhaust edge of the valve uncovers the exhaust edge of the port and discharges the steam into the exhaust port. When the steam has propelled the piston to nearly the end of its stroke, its duty is done. It is then important to get rid of it as quickly as possible, as otherwise it will hold back or retard the travel of the piston on its return stroke.

(e) Point of Exhaust Closure.

Exhaust closure takes place when the exhaust edge of the valve covers the exhaust edge of the steam port and prevents the steam remaining in the cylinder from escaping into the exhaust port.

(f) Period of Compression.

After the exhaust port closes, the steam remaining in the cylinder is confined for a short period and must be forced or "compressed" into the clearance volume (space left in cylinder and port when piston is at the end of its stroke). This causes resistance and is known as compression. It forms a cushion for the piston to strike against and prevents a certain amount of shock. At the time it causes the piston to rebound, giving it speed at the beginning of the stroke when it most requires it.

The above is the whole cycle of events and this occurs both sides of the piston alternately.

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There are eight positions of the crank in one revolution of the driving wheels, namely:-

Front Dead Centre, Front Bottom Eighth, Bottom Quarter, Back Bottom Eighth, Back Dead Centre, Back Top Eighth, Top Quarter, and Front Top Eighth.

The student meanwhile should set himself the task of becoming familiar with the names of all parts of the motion gear and rods so that he will be able to visualise the whole cycle of events as they occur when the locomotive is in motion.

The engine and boiler of a locomotive are carried upon frames supported by wheels and axles. These frames are made of steel plates 15/16" in thickness (for "Ab" locomotives), their outline depending very largely upon the type of engine for which they are intended. The drawing, Fig. 1, shows (in outline only) the frame of an "Ab" locomotive. Holes are cut in the bottom of the frames to take the wheels and axleboxes, and the horn blocks (steel castings with machined faces) upon which the axleboxes may slide up and down according to the effect produced by the unevenness of the rails upon the springs. The forward end of the frames are made narrow to clear the tops of the leading bogie frames, and the deeper portion in between is made deeper to provide bearing surfaces to which the cylinders may be bolted.

The frames are placed about 3 feet apart, and are stayed together at different points. The front headstock, formed from steel plate 1-1/8" thick, acts as a stay at the extreme end. The frame stay, in position between the two cylinders, in addition to securing the frames together, supports the front of the boiler and provides the bogie centre for the leading bogie. There is a stay plate above the crosshead bogie axle, and a stay plate above each of the driving wheels. The two main frames terminate just behind the trailing coupled wheels, and two smaller and thicker frame plates, suitably stayed by plates, form the rear of the engine frame, being attached by rivets to the main frame plates. The trailing headstock completes the staying of the engine frame. (It must be borne in mind that the above description applies only to the "Ab" locomotive, and that other classes of locomotive will differ in some respects).

A coupled wheel axlebox is made of cast steel. A crown brass is pressed into the box. A brass side liner is riveted to the outside face. The top of the box is shaped to form an oil well from which the oil is fed by trimmings to the axle journal. The box is provided with a cellar which contains an oily packing in contact with the lower side of the journal. This retains the oil fed onto the journal from above and assists lubrication.

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A pair of coupled wheels consists of several parts, namely, the centre (which include the spokes and rim, the tyre, the axle, and the crankpin). The wheel-centre is made of cast steel, and the tyre is shrunk on to it whilst hot.

The action of the reciprocating parts (that is, pistons with rods, etc.) and the revolving parts (wheels, cranks, and rods) of the engine is such as to cause a very irregular motion at any but a slow speed, and therefore balance weights are provided to counteract this effect.

The wheels are pressed on to the axles in a hydraulic press and keyways are cut, half in the axle and half in the wheel and steel keys driven in. The crank pins are pressed into the wheels also.

The leading bogie carries the leading end of the engine. It is a separate carriage altogether, and is free to move independently of the main portion of the locomotive. The bogie is located by a top centre fixed to the main frame and the bottom centre fastened to the bogie. A large central pin, known as the "king pin" passes through both centres. The bottom centre is swung between the bogie frame by means of four swing links. These enable the bogie to move sideways and enables the bogie to guide the locomotive around curves.

The trailing bogie, or cab bogie, carries the trailing end of the engine. Its function is similar to that of the leading bogie. The bogie framework is attached to the main engine frames by means of two horizontal swing links. The sideways movement of the bogie is regulated by control springs between the two main engine frames.

Springs are used to connect the wheels and axles of a locomotive to the main frames of the engine, so that shocks may be lessened. The usual type used for the engine springs is the "laminated" or "plate" type, and consists of several plates or leaves of spring steel bound together at their centre with a buckle.

The front end of the leading coupled wheel spring is attached directly to the engine frame. The back end of it is attached by means of a hanger to one end of an equalising beam. The equalising beam is pivoted on the engine frame.

The other end of the equalising beam is attached to the front end of the coupled wheel spring by a similar hanger. The back end of the spring is attached to the front end of the next equalising beam and so on. The back end of the trailing coupled wheel spring is attached to one end of a compensating beam which is pivoted on the main engine frame.

The other end of the compensating beam is attached directly to the engine frame. This spring arrangement aids in distributing the weight upon each wheel, so that no spring will get an excess of weight. Any excess that would otherwise go on to any one particular spring is distributed so that part of it is taken by the springs on each side of the particular spring in question.

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CYLINDERS AND CYLINDER COCKS

Condensation due to the cooling effect of the cylinder walls would be responsible for serious losses of steam if the cylinders were not well protected. Outside cylinders, owing to their exposed position, are particularly liable to cause excessive losses, due to condensation. For this reason, they are protected by asbestos lagging covered with mild steel sheets. This protection, however, does not prevent a certain amount of condensation when steam is first admitted to the cylinders after an engine has been standing. Seeing that water is practically incompressible, if it is present in the cylinder either from priming or condensation, there is a danger of knocking out the cylinder ends when the piston approaches the end of its stroke. The cylinder cocks (37), which are fitted to the lowest part of the cylinders, therefore have a very important duty to perform and are controlled by means of an air cylinder just in front of the L.H. cylinder. This air cylinder operates a rod (38) which moves to and from under the cylinder cocks, opening or closing them according to the operation of an air valve in cab.

When air is admitted to the air cylinder the piston is forced against and compresses the return spring and it moves the attached cock rod so that the cylinder cocks are lifted off their seats by the high side of the rod and therefore opened When air is cut off and exhausted from the cylinder the return spring returns the piston to its normal position carrying the cylinder cock rod so that the cylinder cocks drop into the recessed portion of the cock rod and become seated and closed.

When a locomotive is put away and stabled after service the steel wire stirrup attached to the cock rod must be flipped over to prevent the return spring in the air cylinder from placing the cock rods on both cylinders in the closed position after all air pressure has been lost. Conversely placing the wire stirrup back to the running position when sufficient air pressure has been raised to hold the cylinder cocks open when the locomotive is again taken into service.

The snifting valve is fitted to the main pipe leading to the cylinders, just above each steam chest. When a locomotive is standing in steam a certain amount of steam passes to the cylinders from the lubricator, or from a regulator valve, or from a drifting valve, that is leaking slightly. So that this steam can be released to the atmosphere to prevent it accumulating in the cylinders and thus remove the possibility of the locomotive moving, snifting valves are provided. When an engine is running after the regulator has been closed a pumping action is set up by the pistons in the cylinders, so that the air is withdrawn and a vacuum formed in the steam chest. The energy exerted by the pistons in creating this vacuum tends to slow up the engine. This vacuum will draw floating particles of ash and grit in the smokebox down the blast pipe and into the valve chests and cylinders thus causing damage. The snifting valve is maintained upon its seat by the pressure in the steam chest, so that when steam is shut off, and the pressure in the steam chest falls below that which will keep the valve up on its seat, the valve drops down off its seat, and allows air to be drawn in through the main steam pipe to the steam chest. As soon as steam is admitted again to the cylinders the valve lifts again on to its seat. The action to be taken in the case of defects with shifter valves is as follows:-

> If only the stem of the valve is broken and the valve is stuck open, the casing of the valve should be turned over if possible and the valve will then probably seat itself.
>
> If the valve will not seat or the valve becomes otherwise unfit for service, the valve and body complete should be removed from the steam pipe, and the snifting-valve stop, which is included in the breakdown equipment, should be inserted in its place.

The Sand dome (26), placed on top of the boiler in front of the steam dome, is secured in position by means of studs in the boiler barrel. On each side of the sand dome is a sand trap from which pipes convey sand to the rails. When the air sander valve in the cab is opened, air blows through a nipple in the sand traps, agitating the sand to carry it across the bridges on the traps, thence to the sand pipes and to the rails.

WALSCHAERTS' MOTION GEAR

Walschaerts' motion gear is widely used on our locomotives. Its principal advantages are:-

(a) Good steam distributing qualities.

(b) Simplicity, lightness, suitability for plain or piston valves having either inside or outside admission.

(c) Easy operation, (the reversing gear having only to shift the comparatively lightradius rods instead of the whole mass of the links and four eccentric rods of the Stephenson Link motion).

(d) Applicability to the best position for the valves, i.e. outside and above the cylinders and the centre lines of the valve spindle and piston rod parallel.

Description of Walschaert Valve Gear:

In the Walschaert motion the valve travel is derived from two separate points. Movement amounting to twice the lap and twice the lead is obtained from the piston-rod crosshead, giving a constant lead for all positions of the gear, and the remainder of the valve travel, amounting to twice the port opening, is obtained from the eccentric crank by way of the eccentric-rod, expansion link die-block and radius-rod. These two movements are added together at the valve spindle pin on the lap and lead rod, thereby producing the total travel of the valve when the reversing lever is in full gear position.

Adjustment of the valve travel is controlled from the reversing lever by raising or lowering the die-block in the expansion link, which regulates the amount of drive passed forward to the valve spindle from the eccentric. When the die-block is central in the expansion link, it is in line with the link trunnion pins, and consequently no movement will be imparted to the radius-rod, the reversing lever then being in mid-gear position. In this case the valve travel is confined to the lap and lead movement obtained from the crosshead driver, the ports being opened to the extent of the lead only at each end of the cylinder.

With an inside admission valve, foregear drive for the valve is obtained by lowering the die-block in the expansion link, and drive for backward gear by raising the die-block above the expansion link centre.

Setting of the Eccentric in relation to the Crank:

In the Walschaert motion the eccentric crank is set at 90 degrees in relation to the main crank, though sometimes the position is varied by one or two degrees in order to counteract the effects of angularity when the motion rods are short. For inside admission, the eccentric follows the crank and with outside admission valves it will lead the crank by the above amount. This change of position is necessary in order to keep the foregear position of the die-block within the lower half of the expansion link. In addition where inside admission valves are used, the radius rod will be coupled to the top of the lap and lead rod, while with outside admission valves, the valve spindle will be coupled to the top of the lap and lead rod.

The Radius-rods vary least of any motion details. The most common form as fitted to the "Ab" class locomotive has one end pinned to the die block and the other end pinned to the top of the lap and lead rod, and an intermediate pin is provided for attachment to the lifting links.

A piston valve consists of a pair of small piston heads fitted to the valve spindle, and which slide inside cylindrical sleeves or liners pressed into the steam chest casting. The cylinder ports lead from a series of openings cut around the circumference of the valve liners in such positions that the valve heads will cover and uncover them as the valve and spindle is moved to and fro.

There are two kinds of piston valves in use, and these are known respectively as "the inside" and "outside" admission type. The majority of our locomotives use the "inside" admission type, and with this type of piston valve the steam is fed to the central portion of the steam chest between the two valve heads, whilst the exhaust is led away from the two ends.

STEAM AND EXHAUST EDGES OF A VALVE:

The "steam edges" of a valve are the edges which control the admission and cut-off of live steam to the cylinder ports, and the "exhaust edges" are the edges which control the escape of the exhaust from the cylinder ports.

In the case of an inside admission piston valve, the steam edges correspond to the inside edges of the two heads and the exhaust edges to the outside edges of the valve.

LESSON NO.3

LAP AND LEAD:

Lap is the amount by which the steam edges of a valve overlap the inside edges of the cylinder steam ports with an inside admission piston valve, when the valve is in its central position.

The purpose of lap is to obtain a rather earlier cut off than could be obtained without its use, thereby making better use of the steam's expansive powers. The amount of lap given to a valve is generally sufficient to provide a cut-off at about 75% of the stroke in full gear.

Lead is the amount of width of steam port opening when the piston is at the extreme ends of the cylinder. Lead is provided to ensure that the steam pressure is built up in the steam port and clearance space between the cylinder covers and piston heads right at the commencement of the stroke, a factor of the utmost importance for high speed, running with heavy loads.

The lead steam also serves to cushion the piston and attached moving parts at the end of the stroke, thereby reducing the tendancy to knock in the big and little ends as well as the axle boxes.

CONTROL OF VALVE GEAR:

The Enginedriver has full control of the valve gear within the limits set by the valve gear itself. As he moves the reversing lever from full forward or full backward position towards mid-gear the valve travel will be progressively reduced until when, in full mid-gear it will correspond to twice the lap, plus twice the lead only.

As the valve travel is shortened, entry of live steam to the cylinder is cut off progressively earlier in the stroke so that the steam is forced to do a greater portion of its work by expansion, which consequently cuts down the amount of steam used per stroke, thereby resulting in economical use of the steam.

To use steam economically, the cut-off should be adjusted to take place not later than one third of the piston stroke and wherever possible should be kept earlier than this.

CONVERSION OF RECIPROCATING MOTION TO A ROTARY MOTION:

The drive from the piston rod is conveyed to the driving wheels per medium of the piston-rod, crosshead, little end, connecting rod, big end and the crank. The connecting-rod and crank convert the back and forward movement of the piston into the rotary movement of the axle and wheel.

In forward gear the pistons push the crank pins under the axle and pull them forward over it, while in back gear the crank pins are pushed over the axle and pulled forward under it. For this reason the thrust of the piston-rod crosshead is against the top slide bar when running forwards and against the bottom bar when running backwards.

LESSON NO. 3

POSITIONS OF CRANK:

The forward and backward crank positions in which the crank webs, connecting-rod and piston-rod are all in one straight line, is known as the front and back dead centres. When the crank stands vertically upwards or down, it is said to be on the top and bottom quarter respectively. The four intermediate settings which lie mid-way between the front and back dead centres and the top and bottom quarters are known respectively as the front and back top-eighths and the front and back bottom-eighths.

By reference to the eight crank positions described above, it is quite easy to visualise the position of the piston within the cylinder. For instance, when the crank is on front or back deal centre, the piston will be at the end of its stroke at the front or back of the cylinder. When the crank is on the top or bottom quarter, the piston will be approximately at mid-stroke. With the crank on the top or bottom front-eighth, the piston will be rather less than a quarter stroke from the front of the cylinder, and it will be a similar distance from the back cover when the crank is on either of the two back-eighths.

CYCLE OF VALVE EVENTS:

The following description details a typical steam cycle in the front end of the cylinder during one revolution of the driving wheels, the reverse lever being in a position giving about 30% cut off:-

Commencing from the front dead centre, the piston will travel about 30% of its stroke before the valve closes the front port to steam and cut off occurs. Expansion will occupy a further 45% of the stroke at which point the exhaust edge of the valve will uncover the front port to exhaust, giving the point of release, and the piston completes the remaining 25% of the backward stroke with the front port opening to exhaust. The piston will now make about 72% of the return stroke before the exhaust edge of the valve again closes the front port starting the period of compression. This will occupy about 25% of the stroke at which point the steam edge of the valve clears the front port once more, opening it to lead. This is the period of pre-admission which occupies the remaining 3% of the return stroke until the piston reaches front dead centre position in readiness for the commencement of the next cycle.

During the period the events just described are occurring, the following events at the back end of the cylinder are taking place at the same time. Starting from front dead centre, the valve already has the back port open to exhaust, which period continues until the piston has covered about 72% of the backward stroke, when the valve closes the back port and compression starts. This occupies a further 25% of the stroke when the steam edge of the valve will uncover the back port to lead and the period of pre-admission sets in to occupy the remaining 3% of the backward stroke. The piston now returns from back dead centre and will cover about 30% of the return stroke before cut off occurs at the back port. Expansion then follows for a further 45% of the stroke after which the back port is again opened to exhaust and release occurs, lasting over the remaining 25% of the stroke until the piston has reached front dead centre.

LESSON NO.3

STEAM ACTION IN RELATION TO CRANKS:

The steam action in the cylinder in relation to the piston movement has been explained in the previous chapter. The following chapter expalins its relation to the crank positions.

In forward gear the front side of the piston is exposed to live steam of the admission and expansion periods, and the back side is exhausting as the crank moves under the axle from front dead centre to back dead centre. After the crank passes back dead centre position, the back of the piston takes admission steam followed by expansion and the front side enters upon the exhaust and compression periods.

The exhaust beat from the front of the cylinder will therefore be heard as the big end passes from dead centre.

In backwards gear, steam acts in front of the piston as the crank passes back over the axle and behind the piston as the crank moves forward under it.

Clearance:

Clearance has been described as the distance between the piston and the covers of the cylinders, but when referring to steam, its action within the cylinders, and its effect upon the working of the locomotive as shown by the indicator, the term includes the ports and, in fact, all the spaces filled with steam between the valve space and the piston when at its extreme position. It is not possible in practice to do without clearance as it allows for wear etc., but the losses due to it may be decreased by closing the port to exhaust, and compressing a portion of the enclosed steam before the piston has reached the end of its stroke. The steam so compressed into the clearance spaces by the advancing piston forms a cushion useful in bringing it to rest without shock. The amount that can be allowed varies with the class and type of locomotive.

If all the working joints of the locomotive affected by the reciprocating motion of the piston, particularly the little and big ends of the connecting rods and driving axle-boxes, could be made a perfect fit, so that when the crank passed the dead centre no slackness was observable, it would not be altogether necessary to open the port to live steam before the piston reached its extreme point, or allow lead; but inasmuch as it is impossible to do this with a locomotive, as there will always be a certain amount of slack; in fact it is purposely provided in the first instance, and this increases as wear takes place, until a "knock" is given as the cranks pass their dead centres, due to the momentum of the connecting rod, etc., being suddenly arrested when these are checked preparatory to commencing the return stroke. By admitting steam to the end of the cylinder towards which the piston is travelling before it reaches its extreme position, its velocity is arrested as the steam forms a cushion for it to strike upon, thus relieving the moving parts of severe shock.

LESSON NO.3

The closing of the port to exhaust, as above described, before all the steam has escaped in front of the advancing piston, and consequently compression of the imprisoned steam, also assists in cushioning; but it has been proved that the compression alone, without assistance from live steam, admitted by prematurely opening the port by lead, is not sufficient to entirely eliminate "knock". The exact amount of lead necessary is determined by practice, and will vary from 1/16" in most favourable cases to 1/4" in others.

Another reason for allowing lead is that it causes the ports to be opened for the admission of steam well before the piston commences its stroke; it is thus enabled to enter at greater pressure and fill the cylinder better than would be the case if the valve only opened just as the piston reached the dead centre and commenced to return, this benefit being specially felt in fast running.

Besides allowing steam to enter the cylinder before the return stroke of the piston commences, it is also necessary to release the steam upon the other side of the piston as much as possible. The cavity of the valve, therefore, opens to exhaust upon the steam side of the piston before completion of the stroke, so that the port openings, small at the commencement of the valve strokes, shall provide an outlet large enough for the free escape of the steam when the piston commences to return, also helps to reduce back pressure, which is the name given to the retarding pressure upon the piston, and has to be overcome by the steam upon its other side.

The size of the blast pipe is also an important consideration, as if contracted too much, the back pressure is greatly increased, but as the forcing of the fire depends very much upon it, it cannot be too large otherwise the boiler would not steam so freely as was necessary.

Wiredrawing:

If obliged to pass through passages too contracted for it, the steam will be reduced in pressure or be "wiredrawn". The most common causes of this are small ports, insufficient port openings, especially when the locomotive is notched up too close to the centre and cutting off too early, either in the steam pipes or by having the regulator partially closed.

It is not, as a rule, advantageous to cut off steam at less than 25% of the stroke of the piston, owing to the fact that the steam is "wiredrawn" by being forced into the cylinder through so small a port opening. The cushioning, also becomes very great at this travel of the valve and if the latter is arranged so that the cushioning is lessened, the comparative low temperature of the exhaust steam would cool the ports etc., so that the entering steam for the next stroke would be further reduced in pressure by coming in contact with them.

LESSON NO.3

DIRECT AND INDIRECT MOTION:

The motion of a valve gear is said to be DIRECT when the eccentric rod moves in the same general direction as the valve. The motion is INDIRECT when these parts move in opposite directions. The Walschaert valve gear is direct with the locomotive moving forward with the die-block in the lower half of the expansion link because the movement of the eccentric rod can then be delivered directly to the radius rod and the valve. The gear is indirect with the die-block in the upper half of the expansion link, because, as the expansion link is pivoted at the middle, the movement of the eccentric rod is necessarily in a direction opposite to that of the upper end of expansion link and the radius rod.

TYPES OF RADIUS ROD HANGERS:

There are two general ways of connecting the back end of the radius rod to the reverse shaft crank. The drawing of the Ab class locomotive clearly shows the arrangement which is mostly used on our locomotives. The lifting links connect the arms on the weighbar shaft with the radius rod on each side of the locomotive, and serve to lift the radius rod and the die-block from the full forward position at the bottom of the expansion link to the full back gear position at the top of the expansion link. The reverse shaft has a balance weight attached to each side of the motion to assist in reversing from forward to back gear. This system of reversing varies from that where a counter balance spring is used.

The valve motion is provided with means for operation from the cab of the locomotive, so that the enginedriver can at will not only reverse the locomotive, but regulate the expansion of steam admitted to the cylinders by adjusting the cut off to any point of the stroke as the circumstances require. The details of the appliances for this purpose vary considerably, but it is uniformly situated in approximately the same place in the cab to permit of easy manipulation by the Enginedriver.

The ordinary type of reversing lever used on the Ab class locomotive is familiar to most students but the following description will enable students to understand the general principle of its operation.

The reversing lever has a handle and trigger at one end and works on a pin passing through a plate and bracket at the other. The trigger is coupled to a rod passing down the lever to a catch sliding in a guide; when down this engages in slots or notches at the top of the plate or sector, which is cut to a radius equal to the distance from the pivot or the lever, the catch being broad enough to engage both sectors, thus holding the lever firmly. When the catch is in the central notch the locomotive is in mid-gear or the valve is in its central position. Raising the catch by the trigger and pushing the lever over, towards the front, puts the motion into foregear and pulling it back the reverse, the intermediate notches giving varying degrees of expansion of the steam admitted to the cylinder. A boss is provided at a point in the length of the lever and has a pinhole for the attachment of the forked end of the reach rod, while at the other end it is coupled to the reversing shaft arm.

ENGINEDRIVERS CORRESPONDENCE COURSE

Ab CLASS STEAM LOCOMOTIVES

LESSON NO. 3 LIST OF QUESTIONS

1. (a) How can lubricating oil consumption in the engine motion (driving gear) be controlled to ensure its most economical use?

   (b) State in what parts of the engine motion (driving gear) of the locomotive would "Plug" or "Tail" trimmings be used.

2. Explain how to make (a) a tail trimming; (b) a plug trimming.

3. Describe the method of lubricating the coupling rod bearings and the big end bearings of the connecting rods on "Ab" class locomotives. State the procedure required to replenish the grease cups.

4. What is the function of the connecting rod and why are side rods necessary on a locomotive?

5. Describe the valve events occurring in a complete revolution of the driving wheel of a locomotive.

6. Describe a piston valve.

7. What is meant by the "tractive effort" of a locomotive?

8. (a) What is the purpose of the snifting valve on a locomotive, and how does it operate?

   (b) What would you do if a snifting valve was damaged?

9. What are the chief advantages to be gained by using Walschaert motion?

10. Name the parts of the Walschaert valve gear.

11. What is the purpose of the eccentric rod?

12. What is the purpose of the radius rod?

13. what is the purpose of the lifting links?

14. At what point is the radius rod connected to the lap and lead rod with inside admission valves?

15. What is the position of the eccentric crank in relation to the main crank pin with an inside admission valve and direct motion as fitted to an Ab class locomotive?

16. What method is used to connect the radius rod to the reverse shaft crank on an Ab class locomotive?

17. What is meant by the term "Piston Clearance" and what is its purpose?

18. What is the purpose of the lap and lead rod?

19. Name the eight positions of the crank in one revolution of the driving wheels.

20. What is the purpose of cylinder cocks and how are they blocked open?

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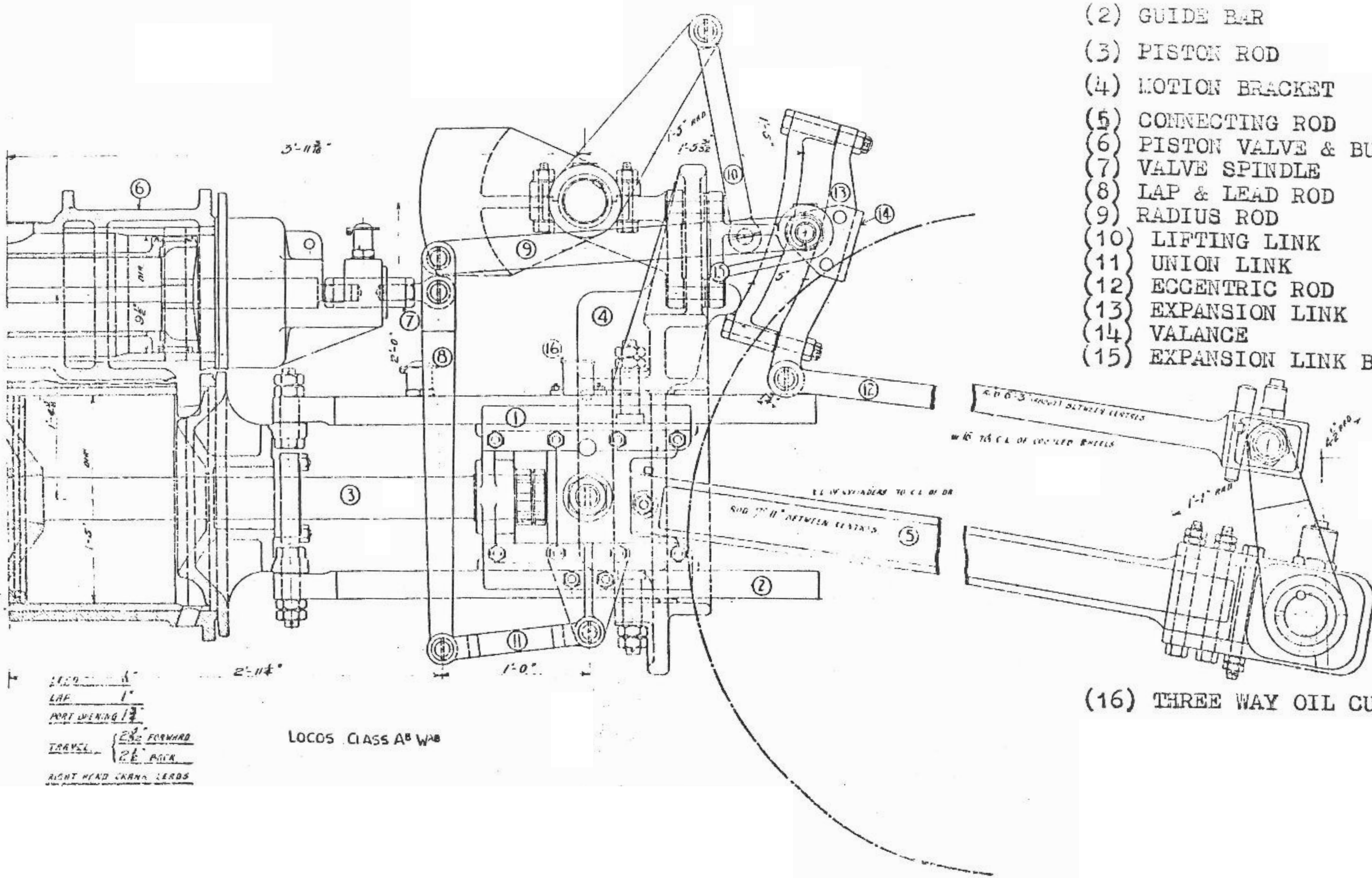
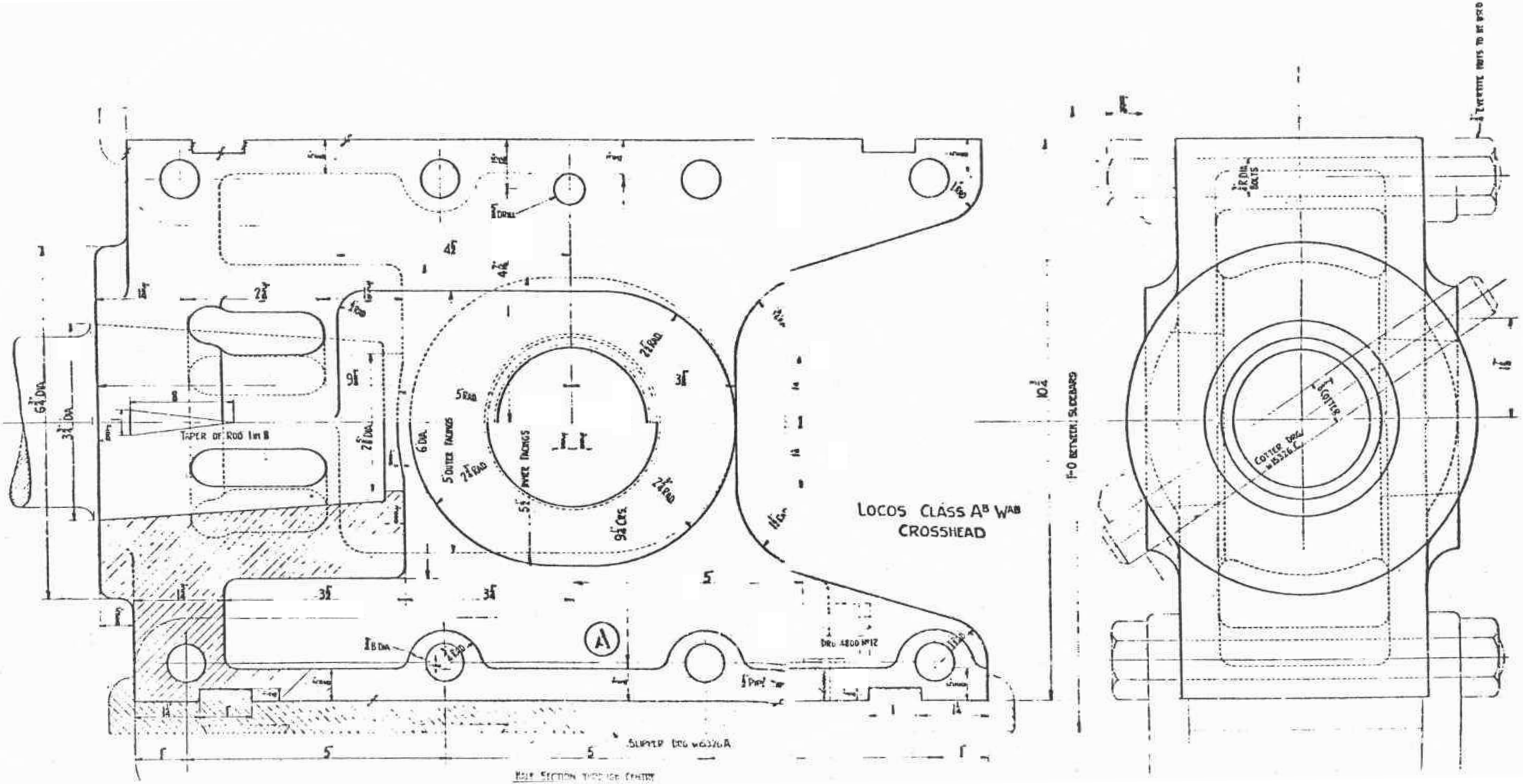
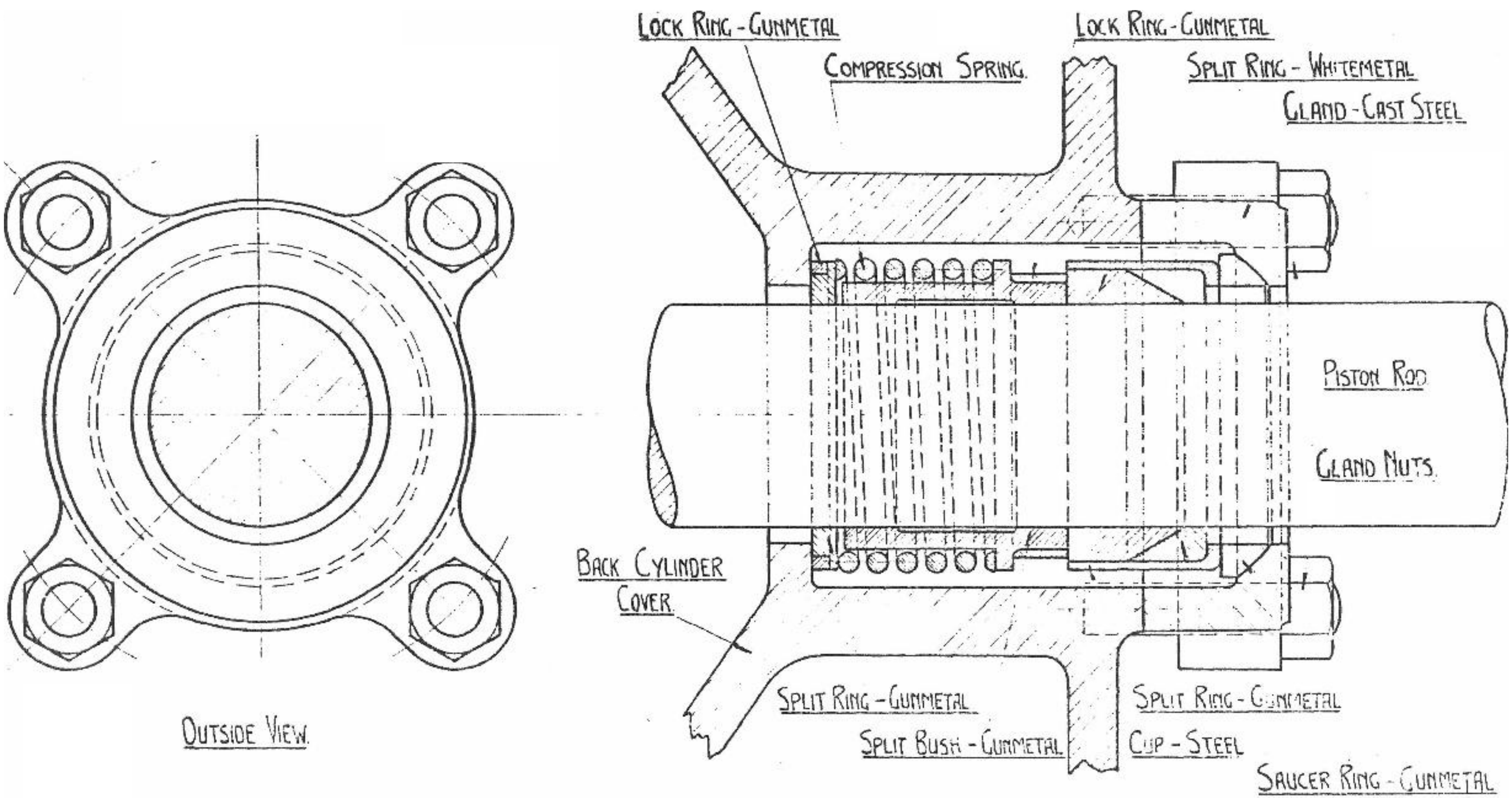


(1) CROSSHEAD
(2) GUIDE BAR
(3) PISTON ROD
(4) MOTION BRACKET
(5) CONNECTING ROD
(6) PISTON VALVE & BUSH
(7) VALVE SPINDLE
(8) LAP & LEAD ROD
(9) RADIUS ROD
(10) LIFTING LINK
(11) UNION LINK
(12) ECCENTRIC ROD
(13) EXPANSION LINK
(14) VALANCE
(15) EXPANSION LINK BEARING BRACKET
(16) THREE WAY OIL CUP


LOCOS CLASS A^B W^{AB}
CROSSHEAD
TAPER OF ROD 1 IN 8
5 OUTER FACINGS
INNER FACINGS
1'-0 BETWEEN SLIDEBARS
A



A^{B} Locomotive Piston Rod Packing.

Fig 10

FIG. 11 (a)

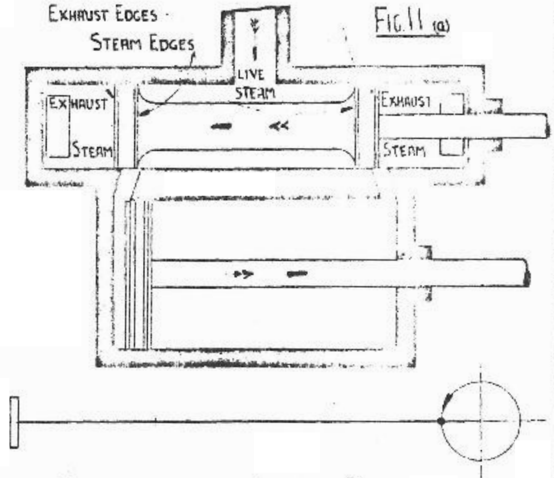
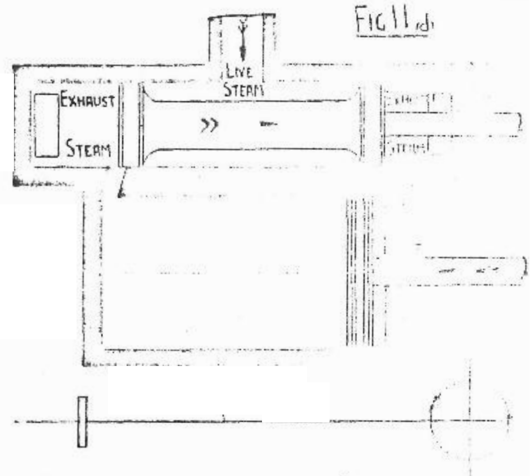


FIG. 11 (d)



FRONT
BEGINNING OF STROKE
FRONT PORT OPENING TO STEAM
STEAM FLOWING IN

BACK
EXHAUST
BACK PORT OPENING TO EXHAUST
STEAM EXHAUSTING.

FRONT
EXHAUST
FRONT PORT OPENING TO EXHAUST
STEAM EXHAUSTING

BACK
BEGINNING OF STROKE
BACK PORT OPENING TO STEAM
STEAM FLOWING IN

FIG. 11 (b)

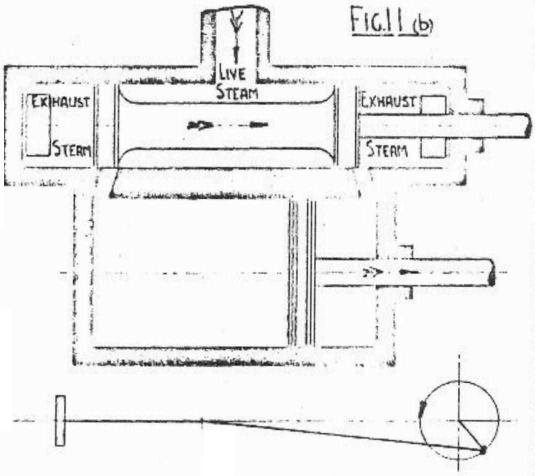
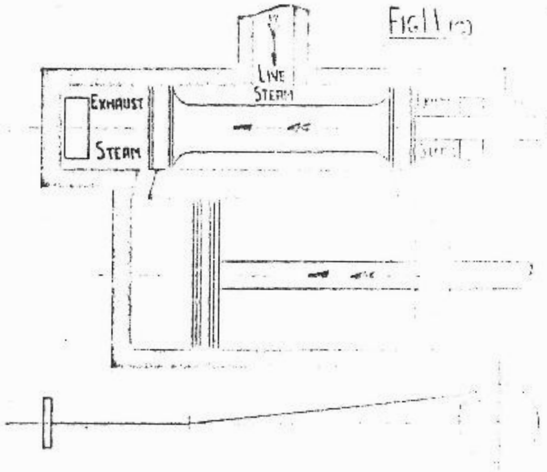


FIG. 11 (e)



FRONT
POINT OF CUT-OFF
FRONT PORT CLOSED TO STEAM
STEAM ABOUT TO EXPAND

BACK
EXHAUST
BACK PORT CLOSING TO EXHAUST
STEAM EXHAUSTING.

FRONT
EXHAUST
FRONT PORT CLOSING TO EXHAUST
STEAM EXHAUSTING

BACK
POINT OF CUT-OFF
BACK PORT CLOSED TO STEAM
STEAM ABOUT TO EXPAND

FIG. 11 (c)

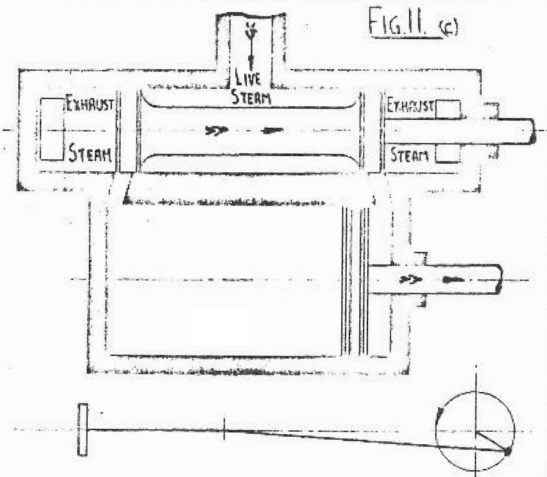
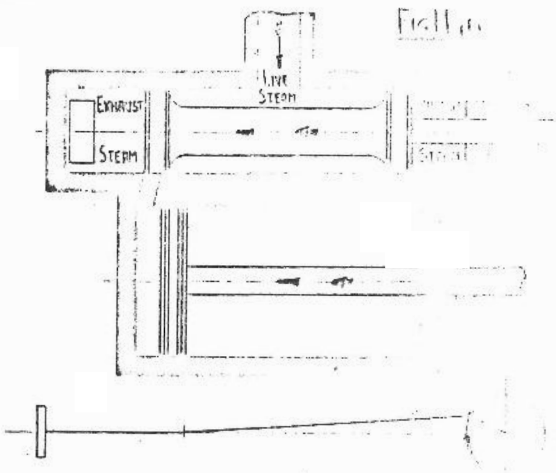


FIG. 11 (f)



FRONT
POINT OF RELEASE
FRONT PORT OPENING TO EXHAUST
STEAM ABOUT TO EXHAUST.

BACK
POINT OF EXHAUST CLOSURE
BACK PORT CLOSING TO EXHAUST
STEAM ABOUT TO BE COMPRESSED

FRONT
POINT OF EXHAUST CLOSURE
FRONT PORT CLOSING TO EXHAUST
STEAM ABOUT TO BE COMPRESSED

BACK
POINT OF RELEASE
BACK PORT OPENING TO EXHAUST
STEAM ABOUT TO EXHAUST