

Hints for Drivers and  
Notes on Maintenance.

**“Sentinel”  
Double  
Geared  
Steam  
Waggon  
32 D.G.**

**The “Sentinel” Waggon Works, Ltd.,  
10 HAYMARKET, LONDON, S.W.1.  
Works: SHREWSBURY.**

*Price 2/6.*

*January, 1938.*

**Hints for Drivers of  
"Sentinel" D.G. Waggon  
including eight, six and  
four wheeled models  
and some notes on  
Maintenance.**



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Works : Shrewsbury.*

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# Hints for Drivers of "Sentinel" D.G. Waggon.

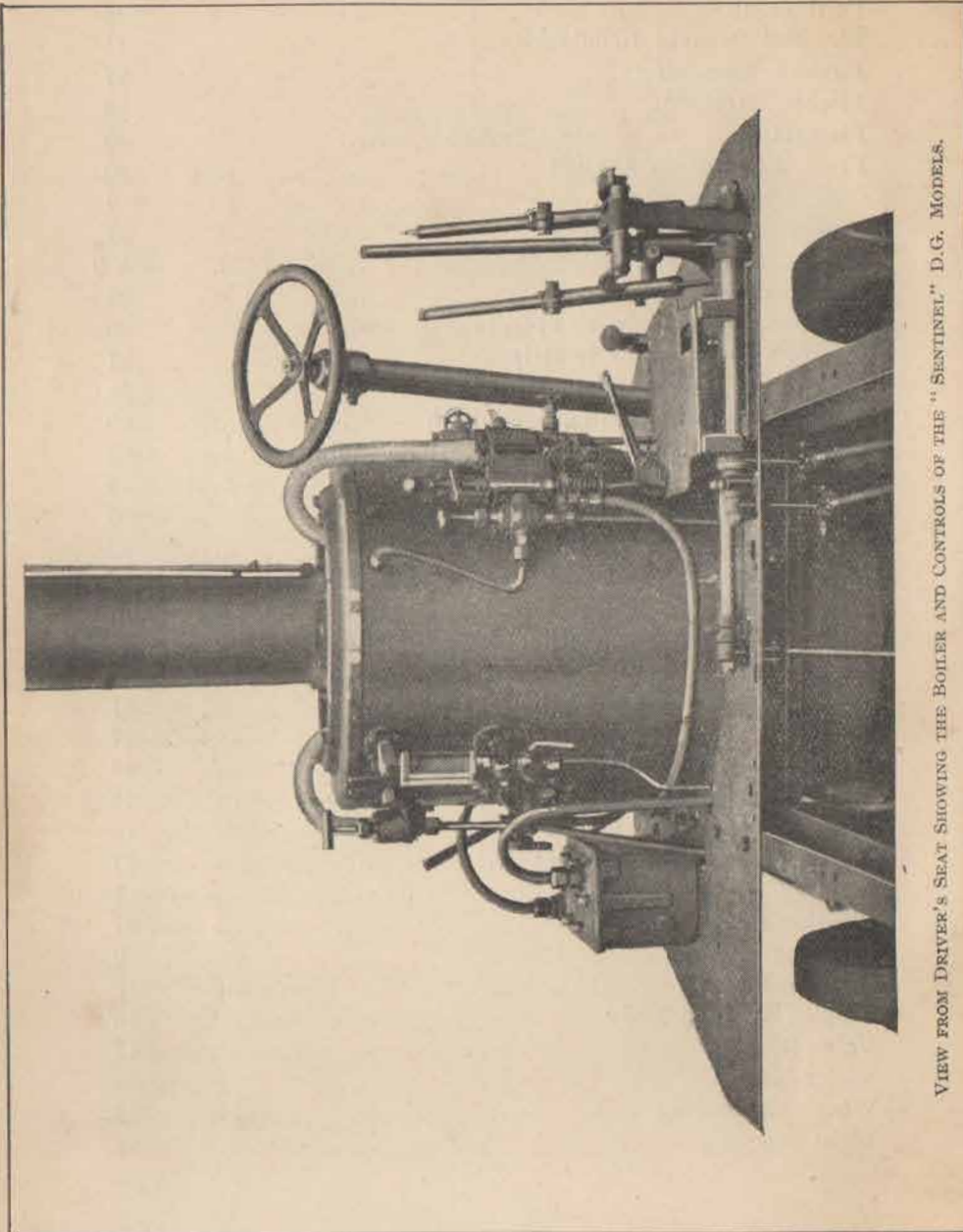
## BEFORE STARTING :—

- 1 Remember your driving license.
- 2 Examine Waggon to make certain all nuts and bolts are tight and secure, particularly chain link bolts, steering and brake connections, buckle bolts on spring pads and spring eye pins, pins in reversing lever and controls right through to cambox and gear shifter connections.
- 3 All grease nipples charged with grease gun.
- 4 Boiler water level about 2 inches in the glass.
- 5 Clean bright fire.
- 6 Bunker filled.
- 7 Water tank filled.
- 8 Mechanical lubricator filled and reserve oil in flask.
- 9 Crankchamber oil level correct and spare supply if long distance journey is contemplated.
- 10 All lamps in order.

Where electric equipment is fitted, full instructions for testing and maintenance are given in the booklet issued by the electrical manufacturers, a copy of which accompanies each waggon.

## CONTROLS.

- 1 Throttle on Stop Valve, cranked handle above stop valve chest.
- 2 Blower valve, mounted on stop valve chest to right of throttle.
- 3 Injector steam control valves on stop valve chest and boiler respectively to left of throttle.
- 4 Foot release valve, pedal on footplate, below stop valve chest.



VIEW FROM DRIVER'S SEAT SHOWING THE BOILER AND CONTROLS OF THE "SENTINEL" D.G. MODELS.

- 5 Cylinder drain valve lever on Bunker front.
- 6 Brake pedal (D.G.4) or Steam brake plunger (D.G.6) at foot of steering column.
- 7 Hand brake lever, nearest to driver's right hand.
- 8 Camshaft control lever (reversing lever) 2nd lever on right of driver.
- 9 Gear change lever, outside lever on driver's right hand.
- 10 Safety tipping lever on front of driver's seat. (D.G.6. and D.G.8. Tipping models only).
- 11 Boiler feed pump control lever on bunker front.
- 12 Injector water regulator on right at rear of driver's seat.
- 13 Cylinder lubricator test cock on stop valve chest to right of blower valve.

Foot release valve, No. 4 above, when depressed, short circuits the main steam supply to the exhaust and facilitates manoeuvring as it enables the driver to control the waggon when his hands are fully occupied, and, by relieving the pressure on the engine valves reduces the effort needed to slide the camshaft over when varying the cut off or reversing. It is only intended for temporary use for the above purposes as steam is passed direct up the funnel and wasted.

The foot release must never be used as a brake with the engine in reverse as was common practice on the early type "Sentinel," as the pressures developed are sufficient to wreck the engine, and in addition particles of soot and ash are drawn from the funnel right through the engine with disastrous results to the cylinders, pistons and valves.

The only justification for the use of the engine as a brake is where a collision would otherwise be

inevitable or life endangered, when the pedal may be depressed and the reversing lever thrown right back and the pedal released, with the throttle open, as gradually as the emergency will admit. When at a standstill reversing lever should be placed in "Drain" position and throttle closed. The operation of the other controls is described in the general instructions and special instructions for handling Injectors are given on pages 24 to 31.

**STARTING.**—As all the engine valves are held open when the reversing lever is in "Drain" position, no cylinder drain cocks are necessary, and warming up of cylinders can be carried out by placing reversing lever in that position, opening engine drain valve on exhaust pipe by means of the drain valve handle fitted on the bunker front, to which it is connected by a flexible steel cable, then opening the stop valve gently and blowing through cylinders for two minutes.

Place reversing lever in start position (right forward) and open stop valve slightly—when waggon is under way, pull lever into half way position which gives an earlier cut-off and when a speed of 8 to 10 m.p.h. is reached pull lever into the third position (forward fast). The best throttle position will very readily be found—excessive opening will only waste steam and draw the fire into holes, cause the emission of sparks and leave no head of steam when a hill is encountered. Only just sufficient opening for the load and road conditions is the ideal.

**CHANGING GEAR.**—Owing to the enormous power output of a Steam Engine at low speeds, it is impracticable to fit a clutch and, as the low gear is

provided for emergencies, *the gear box has not been designed for changing gear while running*, consequently the waggon must be brought to a standstill when a change is necessary, and under no circumstances should this be attempted when under way. After stopping to change, the hand brake should be pulled on to its full extent whatever the road, hilly or level, and if this habit be formed there is less likelihood of its omission when it is vitally necessary on a steep hill.

It is preferable to change at the foot of a steep hill or before negotiating soft ground, but, in strange country if an unexpectedly stiff rise is encountered on an already severe gradient, then apply both brakes and, as a precaution, the mate should stand by with a scotch.

After bringing the waggon to a standstill the gear lever should be slipped into neutral and the required gear engaged, if any difficulty is experienced the lever should be held in neutral and the stop valve opened momentarily to turn the engine slightly. The gear should then slide home, but if it does not, movement of the reverse lever into reverse position will enable this to be done—the whole process occupies no more than a few seconds.

**CLIMBING HILLS.**—A Petrol Driver will invariably rush a hill, depending upon the momentum of the vehicle to keep up the engine revs. ; this is useless and unnecessary in the case of a steam waggon, as excessive throttle opening will merely reduce the head of steam and probably spoil the fire. When approaching a long hill the boiler should be on the point of blowing off with a full glass of water and a

moderately thick clear fire, and if the hill can be climbed without the use of the feed pump, so much the better. The throttle should be regulated in order that the pressure does not fall below 250 lbs., and at the first sign of labouring the reverse lever should be pushed forward into medium cut-off, and if still further power is needed, into late cut-off (forward start), but owing to the heavy consumption of steam in this position, it should only be used for as short a period as possible. If further power is required resort should be had to the low gear.

The Waggon should reach the crest of the hill with not less than an inch of water in the glass and the pump should then be put into action and the fire made up; this will prevent the safety valve blowing off and will enable the water level to be brought up to normal.

**DESCENDING STEEP HILLS.**—With engine in high gear, close stop valve and apply hand brake sufficiently hard to check the vehicle but not to stop it, then control the speed with the foot brake, if the hill becomes steeper, calling for greater pressure on the foot brake, the hand brake should be pulled on harder. It is important to remember that *it is dangerous to coast down a hill with the engine in neutral and this must not be attempted.*

**STOPPING.**—When approaching a loading or unloading point the following preparations will save annoyance to the customer :—

Arrive with a clear fire to avoid smothering the place with smoke.

Top up boiler before arriving, to avoid dripping from the overflow of the injector.

Turn off chain lubricators to prevent loss of oil and consequent mess when stopped.

Do not clean the fire when standing in a customer's yard.

**LOADING.**—Wherever possible, loads should be evenly distributed over the platform, but where a concentrated load is to be carried, this should be placed in such a manner that the centre of the load rests slightly forward of the rear bogie or axle. Overhanging loads must be avoided at all costs.

**TIPPING WAGGONS.**—Where practicable the loads should be evenly distributed, as in the case of a platform waggon, and although waggons can be designed to tip a portion of the load at a time, it is preferable, where possible, to discharge the whole of the load in one operation, as it will be appreciated when a portion of the load is left at the forward end when rear tipping an extra strain is set up in the tipping gear mechanism when discharging the remainder of the load, as it has to carry a dead weight unbalanced by any load at the rear end.

**TIPPING THE WAGGON BODY**—"SENTINEL" D.G.4.T.

This type of waggon is fitted with a tipping Injector on the off or driver's side of the waggon beneath the feed tank, illustrated on page 29, full instructions for its working are given on page 30.

When facing the Injector the left hand handle operates the Injector on the suction side to the Feed Tank, the right one is the return from the tipping cylinder to the feed tank. When tipping the latter handle must be closed and the former open.

When lowering the body after discharging the load, the left hand handle should be closed and the right hand handle opened gradually and closed

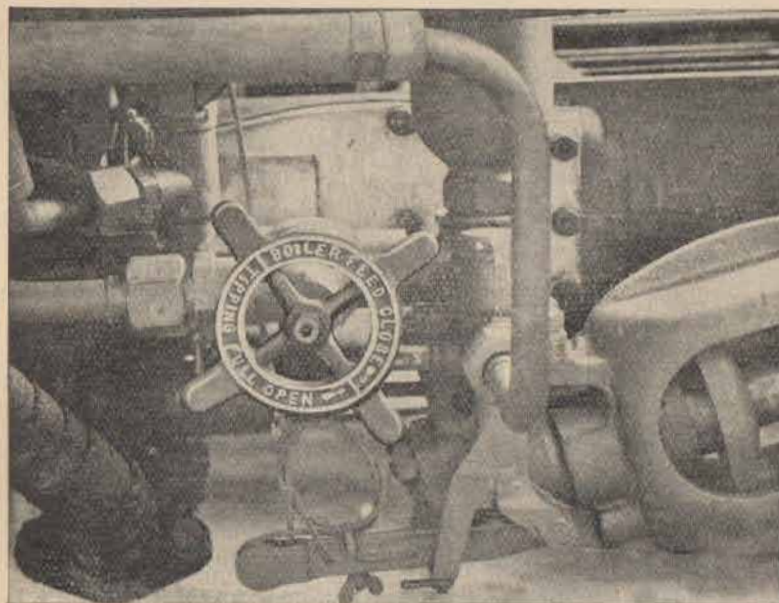
when the body is back in position.

When lowering the body it may be retained in any position desired by closing the right hand water cock. Both handles should be vertically downwards in the closed position.

"SENTINEL" D.G.6. AND D.G.8. TIPPERS.

The Tipping mechanism of the "Sentinel" D.G.6. and D.G.8. tippers is operated by means of the boiler feed pump and is carried out as follows:—

With brakes hard on and engine out of gear, the two-forward body clamp pins on the right and left hand side of the frame should be withdrawn for end tipping or, if desired to side tip on the near side both offside pins should be withdrawn and vice versa.



The control valve shown above should then be

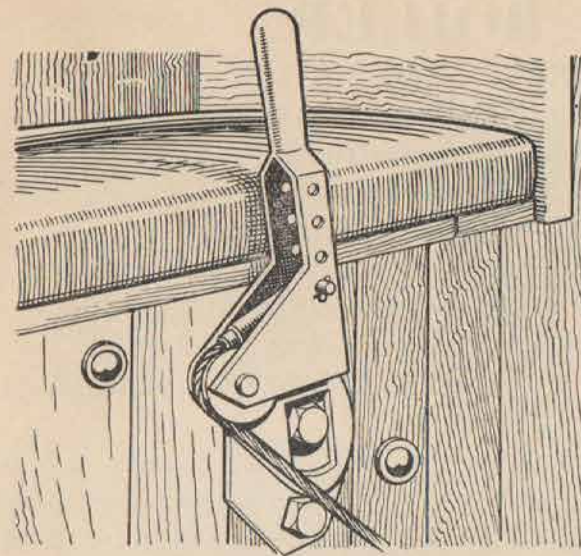
opened, anti-clockwise, the engine stop valve opened and the engine speed controlled to give even tipping action. If the engine is running too slowly the body will rise in a series of jerks due to the intermittent action of the pump. If too fast, water hammer will be set up, but an intermediate speed can readily be found by an efficient operator which will avoid both these extremes.

To lower the body after tipping, the two-way valve referred to should be turned as far as it will go in a clockwise direction, the body may then be eased down by means of the pump release valve.

A common fault is to lower the body with a run until nearly on the stops, and then to check it by suddenly closing the three-way cock. This sets up a very heavy strain on all the connecting pipes and serves no useful purpose. The body can be allowed to return right down on the stops on the waggon frame without any check as the stops are designed to take this load and the springs of the vehicle are effective cushions to prevent damage.

It is impossible to over-run the tipping mechanism as there is a relief valve on the delivery pipe which prevents any possibility of damage.

A safety device has been incorporated on later D.G.6.T. models and on the D.G.8.T. as on several occasions damage to the frame of a D.G.6. tipping waggon had been reported to us. On investigation we found that this was due to the fact that the driver had forgotten to close the control valve after tipping his load and before starting his waggon. The result was that water under pressure was able to pass from the feed pump to the underside of the tipping cylinder ram and thus an excessive strain was thrown upon the chassis frame.



SAFETY DEVICE ON BUNKER FRONT OF "SENTINEL"  
D.G.6. AND 8. TIPPERS.

To guard against this an improved form of relief valve is now fitted on the delivery pipe connecting the feed pump with the tipping cylinder. This valve is controlled by a wire cable and a lever, the latter attached to the bunker casing in front of the driver's seat (see above). When it is required to tip the body this lever has to be moved into the vertical position, with the result that the driver cannot sit in the driving seat, and is reminded before he starts the waggon he should push the lever down into the horizontal position. When so placed no pressure can accumulate in the tipping cylinder whilst the feed pump is working if the control valve is left in the tipping position, and no damage to the frame or parts of the tipping gear is possible. The attention of the driver will be drawn to his omission to close the control valve, by the pump failing to feed the boiler next time he uses the pump control lever on the bunker front panel. (The few additional parts required to make the alteration can be fitted easily to existing D.G.6. tippers and to any owner who is interested we shall be pleased to send a blue print showing how this is done, and a quotation for the parts required.)



# BOILER.

**FIRE AND DRAFT REGULATION.**—To enable a steam waggon to be licensed as a Heavy Motor Car the boiler must be so constructed as to consume its own smoke. This is accomplished in the "Sentinel" models by the following provisions:—

Air admission by means of ashpan regulation.

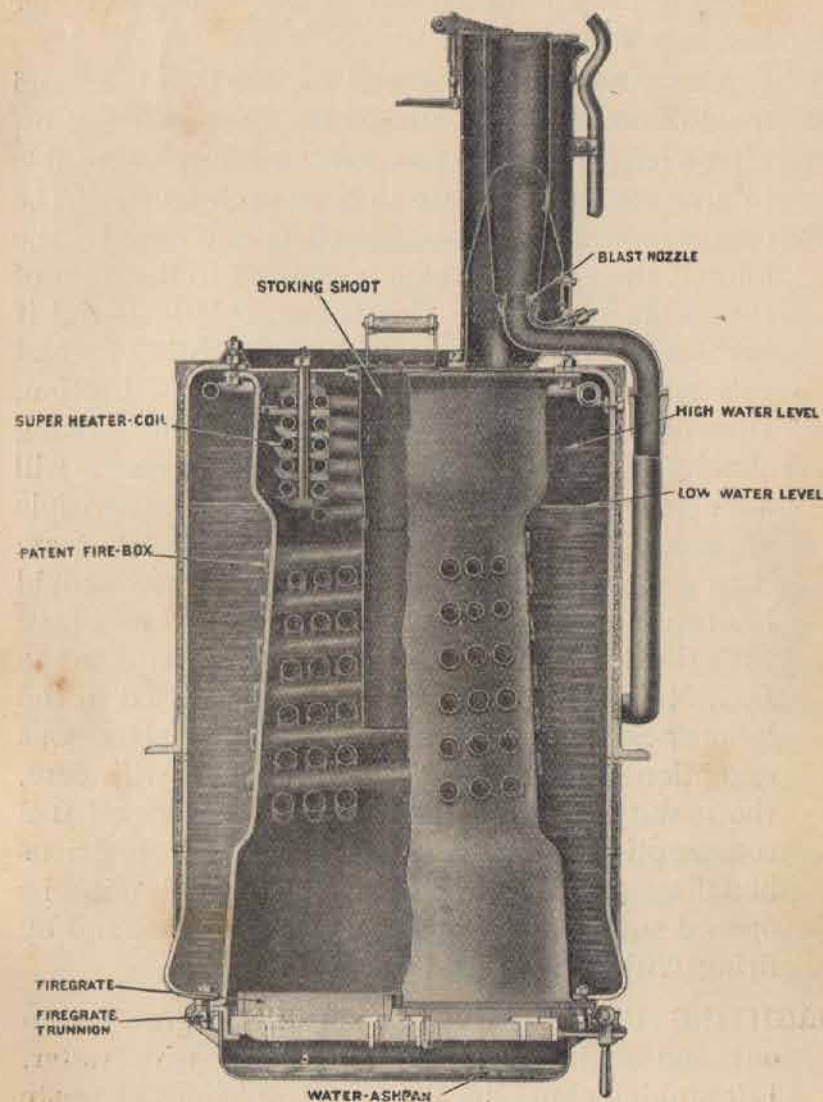
Exhaust Blast through nozzle at funnel base.

Blower combined with blast nozzle.

Top air admission by way of the stoking chute lid.

Smoke is unburnt fuel: indicates waste, and is the result of insufficient air, but it is possible under all conditions to obtain perfect combustion by using any one, or a combination of, the foregoing devices. Occasional and temporary emission of smoke is not illegal, and is very difficult to avoid, as, for instance, when stoking up before the correct adjustment of air and blast has been found, and for this reason it is advisable to fire up before reaching the outskirts of a town or populated area, to enable the fire to burn brightly before traffic and compulsory stops are encountered.

When running normally the exhaust from the engine creates the necessary blast for drawing air through the firebars, and this is automatically adjusted by the engine demand. When running at maximum speed and the engine requires full steam the blast is strongest and the fire hottest; when travelling slowly the engine is using less steam and the exhaust blast being weaker, less draught is exerted on the fire. The intensity of the blast may be varied by the size of the blast nozzle, the smaller the nozzle the keener the blast, but a small



SECTION OF BOILER FITTED TO "SENTINEL" D.G. MODELS.

nozzle may set up considerable back pressure on the engine, therefore, the waggons are passed out from test with the largest nozzle which will give the required blast.

A very keen blast will pull the fire into holes and for this reason it is advisable, when starting off after a lengthy halt to proceed as steadily as possible to give the fire a chance to burn up brightly. The engine exhaust may be assisted at any time by the blower, the valve of which is situated to the right of the steam regulator; this is particularly useful if the waggon is stopped in traffic after firing up and will induce extra air to give smokeless combustion. If smoke still persists, the opening of the stoking chute Air Shutter to a greater or less extent, will admit the "top air" necessary to give an invisible vapour. If when starting off with a dull fire steam commences to fall steadily, the blower valve should be opened and kept so until the boiler is keeping pace with the demand. The type of blower fitted to the D.G. Models is quite different to that fitted to the "Super-Sentinel," and whereas the latter was exceptionally fierce and had to be used with care, the new type cannot be abused. Water and fuel consumption can be kept down by judicious handling of the throttle, which should only be opened sufficiently for actual requirements, and by firing "little but often."

**LIGHTING UP.**—Unhook Ashpan, tilt firegrate, clean out and replace, half filling ashpan with water. Lift stoking chute lid, light some shavings or waste soaked in paraffin and throw down on to grate, follow up with ample firewood until there is a thick fire. Spread a layer of coke or coal on top when

the wood is well alight and when red hot add more coal or coke slowly, spreading it as evenly as possible.

Water level should be maintained at 2in. from the bottom of the gauge glass, above this there may be a tendency to prime, which, apart from its unpleasantness, is injurious to the engine, the wet steam frequently carrying solids through and causing excessive wear on the cylinder walls, piston rings, rods and packings.

To ensure a correct water level reading, the following drill should be carried out daily. Shut off both top and bottom water gauge cocks, open drain, then open and close top and bottom cocks in succession, close drain, open top and bottom cocks, water will then show at its true level.

With a little practice a steady water level of 2in. and 250 lbs. steam pressure are easily maintained for average running. The fire must be kept clear, bright and evenly spread, a shovelful once every 7 or 8 minutes is sufficient for normal running, but firing will be necessary more frequently when the going is bad. The Ashpan should be kept closed as much as possible when running.

Test Safety Valve daily by blowing off at 275 lbs. pressure. If steam pressure rises, raise the water level and close the ashpan, and if it still continues to rise, admit top air through the stoking chute.

Bad steaming is probably due to any or a combination of the following:—

Clinker on firegrate.

Accumulated dust and soot on tubes.

Excessive scale in boiler.

Air leaks through top plate.  
Too keen a blast, pulling fire into holes.  
Blast nozzle not in line with funnel.  
Unsuitable fuel.  
Excessive consumption of steam.

Each defect suggests its own remedy, but if impossible to rectify immediately, use of the blower will frequently get the waggon to its destination.

If any difficulty is experienced in obtaining a satisfactory fuel, our Service Department will be pleased to give advice.

Obscure steaming difficulties have occasionally been traced to a blocked or "made-up" collector pipe, the small holes in which were found to be heavily built up with scale, but this should not occur with proper boiler attention. In tracing apparent steaming defects a careful check should be made of the water consumption, if excessive, this definitely indicates engine fault.

**FAILURE OF PUMP AND INJECTOR.**—In the unlikely event of such an occurrence and a reading cannot be obtained on the water gauge glass, the waggon should be stopped immediately, clear of traffic, and damper and ashpan closed. If steam continues to rise damp fire with coke or coal dust, sand or earth, but do not draw the fire, and when satisfied that the pressure is falling, trace and rectify the pump and injector defect. (See maintenance notes on Feed Pump and Injector, pages 46 and 56).

**PERIODICAL ATTENTION.**—The Boiler should be blown down as frequently as possible to remove sediment from the bottom of the boiler. First fill boiler by means of the injector and with a low steam

pressure open blow-off cock and blow down until the water level reaches the bottom of the glass, then close blow-off cock and raise water level to normal. Regular attention to this will reduce work in washing out each week-end.

**WASHING OUT BOILER.**—Draw the fire, taking care to close the damper to prevent cold air being drawn into the firebox while the ashpan is down and the grate tilted, and when the boiler is cold remove the wash out plugs round the base, the hand-hole door and filling plug in the side of the boiler shell.

Remove stoking chute, and firegrates, flush out the water space with a strong jet of clean water, inserting the end of the hose in all plug holes and apertures top and bottom.

A piece of steel cable, bound about 3 in. from the end, will make an effective brush to assist in removal of sludge.

*Note.*—On every occasion when hand-hole door is removed the fusible plug should be examined.

**CLEANING BY STEAM JET.**—A flexible tube boiler cleaner is supplied with each waggon and can be attached to either of two unions for cleaning the firebox from above, through the stoking chute and below through the opened firegrates.

This provides an effective means of removing soot from the fire side of the tubes and firebox plates and should be used regularly each week to maintain steaming efficiency.

**SUPERHEATER COIL.**—This is suspended from the top plate by long bolts with distance pieces to prevent vibration. These bolts must be kept tight to avoid the risk of the coils chafing, which would reduce the thickness of the tube and might cause a burst.

**WATER TANK.**—Remove the manhole door and wash-out plugs in bottom at intervals according to the quality of water used, and wash out all deposit with a hose.

#### **PRECAUTIONS AGAINST FROST.**

All motor vehicles, Steam as well as Petrol, are liable to damage by frost, unless precautions are taken. In the case of "Sentinel" D.G. models this risk is now limited to the fracture of the feed pump casing safety flange.

When frost may be expected, the steps given below should be taken when "Sentinel" Waggon are kept in a building where heating apparatus is not provided.

- 1 Drain the engine by placing reversing lever in stop position, leaving drain valve open and taking out plug from end of steam pipe.
- 2 Drain feed pump and line of parts by closing the shut-off valve on the boiler check valve chest and removing the check valve, also removing both delivery and suction valves from pump chest and opening drain cocks. Then close shut-off valve of water filter on side of tank and remove the plug from bottom of the filter itself.
- 3 The Boiler should be emptied if a waggon is to be left out in the open all night unless the fire can be kept in. In the case of Tipping Waggon, the tipping cylinder should be carefully drained by opening all drain cocks.

Given careful attention to the above points there should be no trouble whatever due to frost, but our experience has been that, when a frost has come unexpectedly, the result has been quite a number of

broken pump casings.

Now, while it was possible for us a few years ago to stock sufficient pump casings to meet any demand, it is quite impossible for us to do this to-day, as will be readily understood when one considers the very large number of "Sentinel" D.G. Waggon there are now in service.

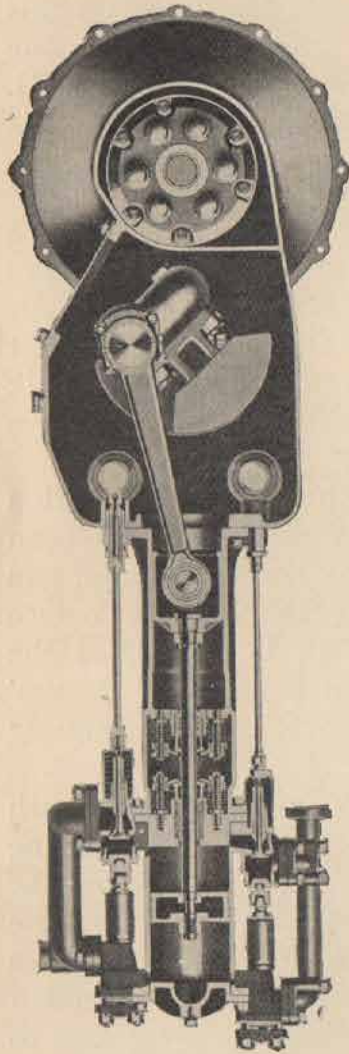
## **ENGINE.**

**GENERAL.**—Drain all the oil from the crankcase of a new engine when warm, after the first 500 miles running and re-fill to the level shown on the gauge with 9 gallons of "Sentinel" crankcase oil, the last half gallon should not be introduced until the bulk has found its level, otherwise it is possible to have an unnecessary excess of oil.

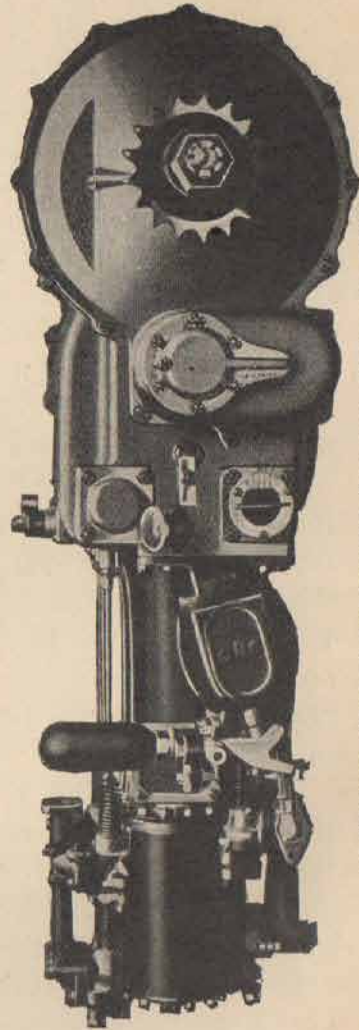
In several isolated cases of heavy oil consumption it has been found that the crankcase had been replenished when standing on unlevel ground, and whereas 100 miles' running should only reduce the correct level by  $\frac{1}{4}$ " to  $\frac{3}{8}$ ", if over filled the correct level may be reached during a few miles' running, the excess being merely wasted, resulting in a heavy oil bill.

The cam follower guides are provided with packing glands and are lightly adjusted when leaving the Works. If oil loss occurs at these points the gland nuts should be tightened, but great care exercised to ensure the cam followers are quite free otherwise uneven running may be caused and a knock set up which may wrongly be attributed to a defective big-end.

During the first week's running ascertain that all other packing glands are not leaking, and where necessary tighten up, applying only slight pressure :



A VERTICAL CROSS SECTION THROUGH THE "SENTINEL" D.G. ENGINE.



AN OUTSIDE VIEW OF THE TOTALLY ENCLOSED "SENTINEL" D.G. ENGINE.

actually the oil packing glands may usually be slackened back slightly after the first 500 miles as the packing material swells with the absorption of oil.

**ENGINE KNOCK** may be caused by:—

- 1 Big end slackness.
- 2 Main bearing slackness.
- 3 Piston loose on rod.
- 4 Piston rod slack in crosshead.
- 5 Slack wrist pin.
- 6 Sticking valve.
- 7 Sticking cam followers.
- 8 Loose chain pinion.
- 9 Engine suspension plate loose on chassis side members.

Of the foregoing Nos. 6 and 7 are by far the most likely causes, and cases have occurred where an engine has been opened up for suspected big end slackness, when the cause has eventually been traced to a sticking valve and it is here that it is so important to realise the vital necessity to ensure that suitable oil is used. An engine using superheated steam has to run under conditions entirely different to those encountered when using saturated steam, and we have in our customers' interests gone to considerable expense to obtain a lubricant suitably blended for the engine. If for any reason a "Sentinel" owner wishes to use an oil not hitherto recommended, we will be very pleased to test a sample and advise as to its suitability.

**JERKY MOTION OF ENGINE** is probably caused by 6 or 7, excessive clearance on push rods or defective timing.

**LACK OF POWER.**—Valves may require re-grinding, piston ring replacement, leaking glands, defective

timing, insufficient or excessive push rod clearances or insufficient steam. A false reading on the boiler pressure gauge was actually responsible for a complaint on this score in one instance!

**DIFFERENTIAL LOCK.**—All D.G. Waggon are fitted with a differential lock. This is actuated by the small hand wheel protruding from the lay shaft on the near side of the vehicle. To lock the differential this hand wheel should be pushed in as far as it will go, when it is pulled out (*i.e.*, towards you when standing on the near side of the vehicle) the differential is free. To prevent tampering with the differential lock, as the hand wheel is in a somewhat accessible position, a safety ferrule is fitted behind the small hand wheel. This positively prevents the lock being actuated until the nut and hand wheel are removed and the ferrule taken off the shaft. After using the differential lock always make sure that the ferrule is replaced.

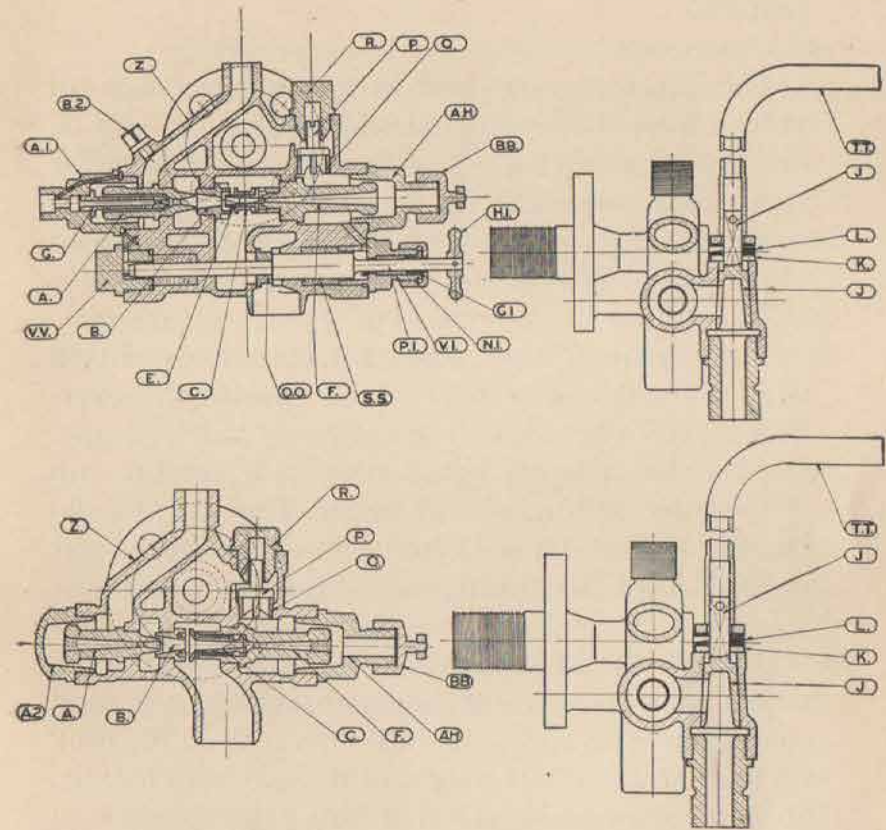
The differential lock is so arranged that it can be put in, no matter what position the engine happens to stop. If after removing the ferrule and pushing on the lock it will not go, rotate the hand wheel in either direction until it can be pushed home.

On D.G. Waggon, especially the six and eight wheeled models, it will be found that the differential lock will rarely be needed. Only in cases where the vehicle gets badly bogged in a place where neither of the driving wheels on the same side can get a grip, will it be necessary to put it into operation.

## INJECTORS.

**GENERAL.**—The injector fitted to "Sentinel" D.G. Waggon prior to No. 8401 is of the hot water

lifting pattern, illustrated below; it is fitted on the off-side of the vehicle under the foot plate in a position where it can keep as cool as possible.



A.	Steam Nozzle.	A.1.*	Steam End Cap.
B.	Lifting Tube.	A.2.*	Steam End Cap.
C.	Sliding Thimble.	BB.	Delivery End Cap.
E.	Combining Nozzle.	AH.	Delivery End Nipple.
F.	Delivery Nozzle.	VV.	Overflow Valve Cap (Steam end).
G.	Auxiliary Steam Nozzle.	OO.	Overflow Valve.
J.	Watercock Plug.	P1.	Overflow Valve Piston.
K.	Watercock Stop Washer.	V1.	Overflow Valve Stuffing Box.
L.	Watercock Spring Washer.	H1.	Overflow Valve Handle.
TT.	Watercock Operating Rod.	G1.	Overflow Valve Gland.
P.	Delivery Back Pressure Valve.	N1.	Overflow Valve Gland Nut.
Q.	Delivery Back Pressure Valve Seat.	SS.	Lead Moss Packing.
R.	Delivery Back Pressure Valve Cap.	B2.	Oil Plug.
Z.	Injector Body.		

\*On Waggon 8401 and later ones, the Auxiliary Steam Nozzle G. is dispensed with and the steam end cap A.1. is replaced by A.2.

Waggons bearing a later number than 8400 are fitted with the injector illustrated on page 25, but generally the following remarks apply to both patterns.

The injector is provided with a separate shut-off valve on the boiler so that, if necessary, it can be dismantled and cleaned whilst the boiler is under steam. It is operated by an extended handle which comes through the floor of the cab and reaches to a convenient position for the driver's right hand.

The "Sentinel" hot water injector is also fitted with a small handle H.I. which enables the overflow valve to be released in the event of it sticking. It has also a small oiling plug B.2. on the top of the injector towards the rear. This plug should be removed once a week and a few drops of oil put in to prevent the shuttle valve from sticking.

Care should be taken to see that the spring L. which holds the shut-off cock up to its seat is in good condition. This spring has not only to hold the cock up but also the whole weight of the extended handle. If it becomes weak through any cause there is a tendency for the weight of the handle and the cock to cause the latter to drop away from its seat, in which case the injector sucks air and will not function correctly.

#### TO OPERATE "SENTINEL" BOILER INJECTORS.

See that the delivery stop valve is full open.

Open the water cock full.

Open the steam valve slightly and wait for the injector to pick up water, then open the valve full.

If the overflow is not "dry," gradually close the water cock until it becomes "dry," ; the injector is then at work.

If the injector should for any reason "throw off" when working, it will automatically restart without attention, although it may at times be necessary for the water cock to be opened full until it picks up its water again, after which the water cock can be partially closed to its previous position.

To shut off the injector, simply shut the steam valve. It is important that when the injector is not working the water cock should be kept shut so that any leakage through the steam and delivery stop valves will drain through the overflow. With the water cock left open, this leakage reaches and heats up the suction pipe and makes starting difficult.

#### STRIPPING THE INJECTOR.

GENERAL INSTRUCTIONS.—When stripping and re-assembling injectors, treat all parts with the greatest care—especially the nozzles—as the slightest knock, dent or strain may quite well stop the efficient working of the injector. Before putting back nozzles, examine the shoulders and collars on the injector body and nozzles, and wipe them perfectly clean. When screwing up, do not use any jointing; a little vaseline on the threads is recommended.

Drivers are advised not to attempt any but the simplest overhauls such as periodic cleaning of the injector when this is required.

### SPECIAL INSTRUCTIONS.

**NOZZLES. ETC.**—The auxiliary steam nozzle G\* comes away with the steam end cap AI, and can be removed entirely from this cap by means of one of the special keys supplied with each injector. The main steam nozzle A can be removed by an ordinary key; similarly the delivery nozzle F and, with it, the combining nozzle E can be removed by an ordinary key, the lifting tube B can then be removed by one of the special keys supplied. The delivery back-pressure valve P can be ground in by removing the cap R. No tool is provided for removing the renewable seat Q; this seat is pressed into position and, should renewal by any chance be necessary, the injector should be sent back to us.

\* See Note under reference List on page 25.

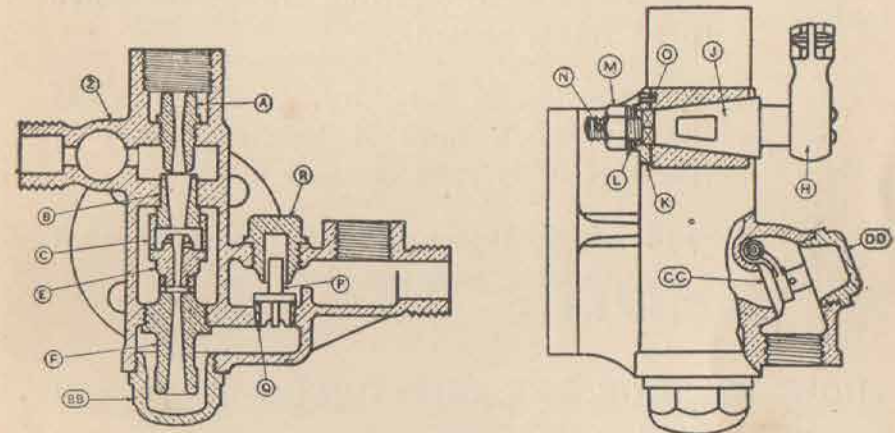
**OVERFLOW VALVE.**—Unscrew overflow cap VV of hot water injector and overflow valve cap guide VI, hold hand under the overflow branch, and push out the overflow valve piston PI from left to right; the overflow valve OO will drop into the hand through the overflow branch. In replacing see that the lead moss packing SS is undisturbed; failing which, repack carefully. Care must always be taken to ensure that the piston is free after packing.

### WASHING DOWN WITH INJECTOR.

By removing the delivery end cap BB and attaching a rubber hose to the screwed nipple AH a powerful stream of water for washing down the waggon can be obtained when the injector is set to work in exactly the same manner as if it were being used for feeding the boiler.

### TIPPING INJECTORS.

(Fitted to Sentinel D.G.4.T. only).



A.	Steam Nozzle.	CC.	Overflow Valve (complete).	
B.	Lifting Tube	DD.	Overflow Valve Cap.	
C.	Sliding Thimble.	H.	Watercock Handle.	} Complete Water-Cock.
E.	Combining Nozzle.	J.	Watercock Plug.	
F.	Delivery Nozzle.	K.	Watercock Stop Washer.	
P.	Delivery Back Pressure Valve.	L.	Watercock Spring Washer.	
Q.	Delivery Back Pressure Valve Seat	M.	Watercock Nut.	
R.	Delivery Back Pressure Valve Cap.	N.	Watercock Split Pin.	
Z.	Injector Body	O.	Watercock Stop Pin.	
BB.	Delivery End Cap.			

This injector is specially designed to give a very high pressure on the tipping ram. The pressure being steady and continuous, wear and tear on the



tipping mechanism is reduced to a minimum. No lubrication or packing of glands is required. It is easy to operate, the tipping action is smooth and quick, and time is saved on each tip.

#### HOW TO OPERATE THE TIPPING INJECTOR.

Admit water from the tank by opening full the left-hand watercock

Immediately, so as not to waste any water, admit steam by opening the steam valve to its fullest extent.

If the overflow is not "dry," gradually close the watercock until it becomes "dry"; the injector is then at work.

To shut off the injector simply shut the steam valve and the watercock.

#### HOW TO STRIP THE INJECTOR (see also General Instructions on page 27).

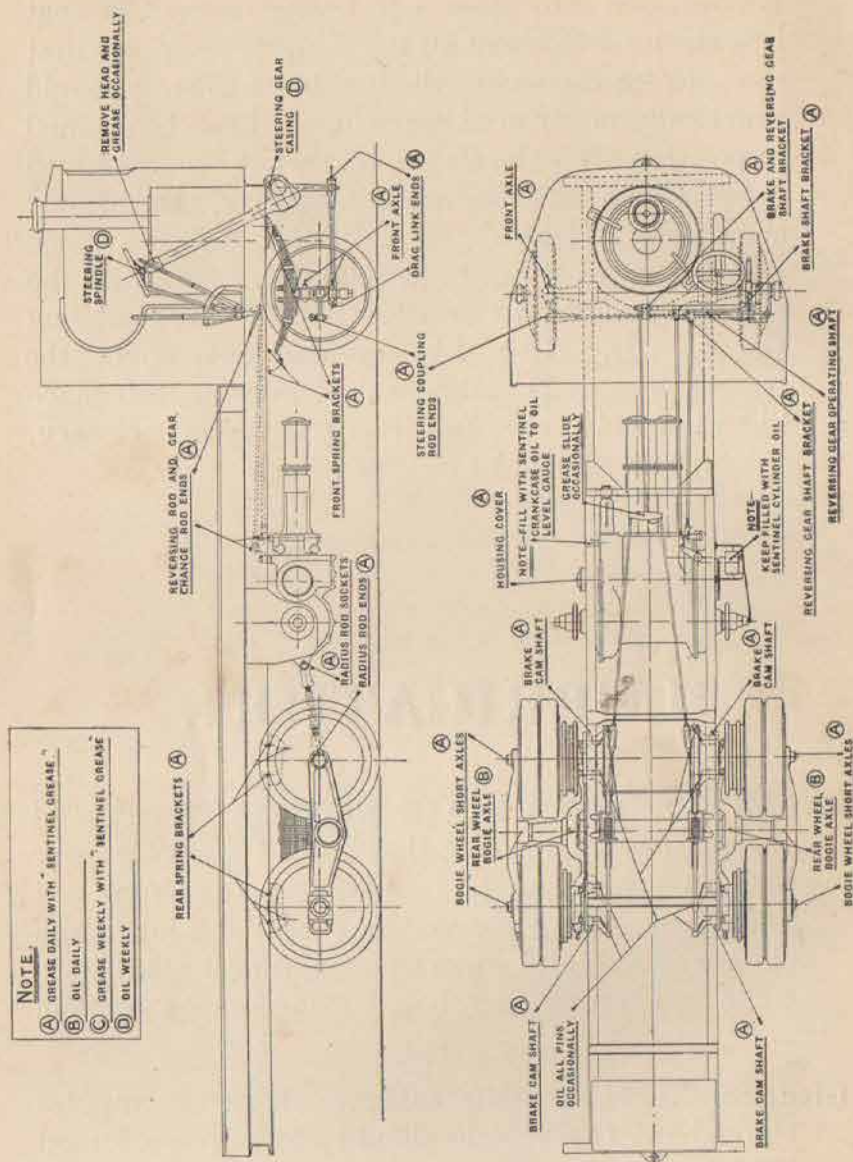
There being no pressure on the delivery side of the injector when the waggon body is in normal running position, the injector can be stripped while the boiler is under steam by shutting the filter cock, the right and left-hand watercocks and the steam valve. By detaching the latter the steam nozzle A can be removed by the special box-key supplied; by unscrewing the end cap BB delivery nozzle F and combining nozzle E can be removed (in one piece) by an ordinary spanner, and with them will

come away the sliding thimble C. The lifting tube B is pressed into place, and owing to the fact that it is the least liable of all the parts to wear and that the injector is comparatively seldom used, it should practically never need renewing. It can be cleaned in position after the steam nozzle has been removed if by any chance renewal is necessary, the injector should be returned to us. The delivery back pressure valve P can be ground in by removing the cap R; similarly the overflow valve CC by removing the cap DD. No tool is provided for removing the renewable seat Q; this seat is pressed into place like the lifting tube, and if its renewal is necessary, the injector should be returned to us.

## LUBRICATION.

**CLEAN OIL AND GREASE NECESSARY.**—It is of the utmost importance that for all purposes your oil and grease should be perfectly free from grit and chips. Keep the vessels containing lubricants closely sealed, and when drawing off oil allow it to run through a strainer before using on the waggon.

**GREASE NIPPLES AND CUPS.**—All grease nipples throughout the vehicle should have grease forced into them daily by means of grease gun and tops of cups should be given a turn and refilled as soon as empty.



LUBRICATION CHART FOR "SENTINEL" D.G.6.

**CHAINS.**—Keep well oiled and clean. Chain lubricators on side of chassis should be filled daily or oftener if necessary. The drip feeds on these should be adjusted to give from one to two drips per minute. It is also good practice to brush the chains daily with a stiff brush soaked in oil.

Chains should be removed at least once a month, thoroughly cleaned in paraffin, and carefully lubricated by being soaked in hot grease. A mixture of grease and graphite is even better.

It is a great advantage to keep a spare pair of chains, so that one can be thoroughly cleaned and oiled when the other is in use. This adds much to their life.

**CRANK CASE.**—Examine *daily* and pour new Crankcase Oil through crankcase filler until oil level is up to red line on sight glass which is fitted over the near side end of the lower camshaft. Great care should be taken to see that only oil marked "Sentinel" Crankcase Oil is used here.

**CYLINDER LUBRICATOR.**—This is on the offside of the Engine Crankcase. It is driven direct from the Crankshaft and is not adjustable, the rate of feed being determined before leaving the Works to provide effective lubrication on a minimum consumption of oil. When an Engine is new it may be advisable to give the hand feed handle a few turns whenever stopping to pick up water. A cylinder

lubricator test cock, through which the oil is fed into the main steam supply pipe, is fitted on the control valve chest in the Boiler. This Test Cock should be opened each morning and the hand feed handle on the lubricator operated to ensure that oil is flowing through freely. If any obstruction is present it is probably at one of the three non-return valves on the system.

The earlier series of D.G. Models are provided with lubricators operated by an actuating rod from the Differential Shaft, on which adjustment can be made. Moving the actuating rod towards the pivot on the lubricator increases the oil supply and moving it away from the pivot reduces.

**FRONT WHEEL JOURNALS.**—These are fed with grease through flexible leads from the duplex lubricator on the footplate under control of the stoker, who should give the handle one turn about every half-hour after the waggon has been run-in. This lubricator is charged with the service grease-gun and holds sufficient grease to last for one week's ordinary running. When a waggon is new it is advisable to feed grease through more frequently during the early running-in stage. A soft grease should be used about the consistency of mineral jelly.

**REAR WHEEL BUSHES.**—These should be greased daily. On models D.G.4. and D.G.4.T. Nipples will

be found on the Rear Wheel Hub Caps. On models D.G.6. and D.G.8. the Nipples will be found on the ends of the Stub Shafts which project through the outer bogie arms. The right quantity is about half a gun-full in each hub per day, in three doses. The grease should not be too stiff.

**STEERING GEAR.**—The oil box at base of steering column should be kept filled with Crankcase oil. From time to time extra oil should be added through the lubricator on top of the steering wheel. A plug is also provided in front channel for the same purpose.

# Maintenance of "Sentinel" D.G. Waggon.

WHEN REFERRING TO THE ENGINE THE FOLLOWING  
TERMS ARE USED.

RIGHT-HAND side of Engine, when sitting in Cab. Off-side. High Gear side.	LEFT-HAND side when sitting in Cab. Near-side. Pump Side. Low Gear Side.
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## CRANKSHAFT POSITIONS.

Inner dead centre. Crank away from cylinders. Piston towards Stuffing Box.	Outer dead centre. Crank towards cylinders. Piston towards outside end cover.
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## DIRECTION OF ROTATION.

When looking at Engine from Pump side, for forward running, engine turns over clockwise driving the differential shaft and chain pinions in an anti-clock direction.

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## Boiler.

Trouble-free service can be ensured by careful selection of water pick-up supplies, and when it is realised that in an average year's working as much as 16 cwts. of solids may pass into the boiler with the water, too much attention cannot be paid to this point. Too frequently the driver throws his hose into a pool or stream with the suction end resting on,

or partially buried in, the muddy bottom, and puts on his water lifter before the disturbed sediment has settled. The best method is to place a coal shovel in the water-bed, on which to rest the rose, and wait until the water is clear before commencing to pick up.

**BLAST NOZZLE.**—Standard sizes run from  $1\frac{1}{16}$ " to  $1\frac{3}{8}$ ", but as a guide the following dimensions represent general practice. Measurements taken at outlet:—

Best qualities Welsh Coal	..	$1\frac{3}{8}$ " to $1\frac{7}{16}$ "
Industrial Hard Coal	.. ..	$1\frac{3}{16}$ " to $1\frac{1}{4}$ "
Coke	.. .. .	$1\frac{1}{16}$ " to $1\frac{1}{8}$ "

Several cases of bad steaming have been traced to lack of alignment of the blast nozzle. This should be correctly centred by inserting a good fitting round rod or even a broom handle in the nozzle of sufficient length to protrude above the funnel, and with the flange bolts slack the rod should be moved about until central in the funnel when the bolts can be tightened. The flanges are dowelled to ensure alignment, but in the event of the dowels being lost the foregoing precaution is recommended.

Back pressure will be set up if carbon deposit is allowed to form inside the blast nozzle. This should be examined and cleaned out every two months, as also the blast nozzle bend, which can be removed without dismantling the funnel. If waggon is fitted with a windscreen the one half will have to be removed to obtain access to the blast nozzle bend.

**FIREBOX—REMOVING.**—Before commencing this work it is advisable to have in hand a pair of top and bottom joints, two or three dozen copper washers, a dozen boiler joint studs, long and short, with nuts

and a supply of boiler mounting set pins. The firebox is marked with an arrow shewing its register with the boiler shell. A similar mark also appears on the front of the shell beneath the funnel, but if this is obscured by scale or dirt the operator may prefer to make his own marks in order to ensure the correct replacement of the box.

The stud cover at the top of the boiler should be removed for inspection every three months and all the parts cleaned and oiled. The reason for this will be obvious the first time it is removed.

To remove the Firebox for annual inspection, scaling or re-tubing, the waggon should be run over a pit which must be of sufficient width to admit the widest portion of the firebox, namely the lower flange, and of sufficient depth to enable the box to clear the bottom studs of the boiler shell when resting on the bottom of the pit. A suitable size for the pit is 3' 3" wide by 3' 3" deep.

In the absence of a pit the front of the waggon should be jacked up 3' 6", and if the machine is a D.G.6 or D.G.8, the leading bogie wheels should be first of all raised on 6 inch blocks, to avoid having to disconnect the brake rods. If the front of the machine is jacked up by means of the side members or any portion of the frame, a chain should first of all be passed through the spokes of the wheels and over the foot plate to prevent the weight of the axle hanging on the springs. Then proceed to remove the funnel after disconnecting the blast nozzle connection to the exhaust pipe, followed by the stud cover (the boiler top plate and superheater coil may be removed as one unit), then remove ashpan and firegrate.

Remove all cap nuts from boiler flange studs, top and bottom, leaving four nuts to support the firebox until tackle is rigged for lowering.

If an overhead crane or girder is available a one-ton chain block should be slung immediately above the centre of the firebox and a sling passed through and round a stout cross bar sufficiently long to span the bottom flange of the box. Under no circumstances should any attempt be made to sling the firebox by means of the cross tubes. In the absence of a crane a similar bar to that below the firebox should span the top of the boiler shell, supported on timbering sufficiently high to allow of a chain block slung to the top cross bar being operated. Remove the remaining cap nuts and copper washers and ease away the chain block. It may be necessary to start the joints by flogging around the inside top radius of the box with a 14 lb. hammer interposing a hardwood block to avoid damage, or, if this is insufficient, half a dozen thin steel wedges 1½" wide and 3" long, tapering from ¾" to nothing, may be equally spaced round the flange and driven in tightly between the joint faces exercising every care to avoid distorting either of the flanges. When free the box may be lowered, but if the front of the waggon is jacked up as suggested it will be necessary to manipulate the top flange through the bottom aperture of the boiler.

**FIREBOX—RE-TUBING.**—Plain Tubes are best removed by means of a hammer and blunt set, crushing inwards one of the projecting ends of the tubes from four directions, approximately at 90° to each other; the end of the tube will then assume a cruciform appearance and can be driven out using a flat ended circular punch as near as possible to

but not exceeding the diameter of the tube hole in the firebox. The edge of the punch should be slightly rounded to avoid damaging the aperture. When all plain tubes have been removed the stay tubes should be cut off short from the inside, using a long chisel bar, and the end of each tube split lengthways, taking care to avoid damaging the thread in the firebox, a cape or round nose chisel being best for this purpose. One side of the tube may now be driven in towards the centre, which will allow it to fall clear of the thread.

Before re-tubing, all mill scale must be removed from the outside of the tubes where they bear in the plate and from the bore of the holes in the firebox, the sharp edges of which should be faired, and when expanding great care must be exercised to hold the tool perfectly in line with the tube.

Stay tubes should be screwed in by means of a stud box engaging about 3 threads of the large end.

When closing up the boiler it is advisable to use new copper washers, but in any case distorted ones are useless, and a frequent source of external corrosion is slight leakage past the top joint or round the studs. Where this is apparent the cap nut or nuts should be slackened off and a grummet placed over the stud under the copper washer before re-tightening, otherwise a deep groove of corrosion may be formed at the radius which may eventually develop into a fracture owing to the expansion and contraction or "breathing" of the box at this point.

**FIREGRATES.**—The most durable firegrates are made from cold blast iron, but ordinary grade will stand up to a reasonable amount of service providing an ample supply of water is kept in the ashpan.

Some operators have obtained very good results from sprinkling the bars with broken firebrick or limestone, about walnut size before lighting up; this is claimed to prevent clinkering on the bars.

The following spacings are recommended for firegrates :—

Welsh Coal,  $\frac{3}{8}$ " spacing.

Industrial Hard Coal,  $\frac{5}{8}$ " spacing.

Inferior Soft Coal, 1" spacing.

**STUDS—BOILER.**—Should it be necessary to replace any broken or corroded flange studs, these should be cut off flush with the joint face and centre punched as accurately as possible, then followed up with a  $\frac{1}{2}$ " drill not deeper than  $\frac{1}{4}$ ", when the stud can be removed by detaching the cap nut and using a pipe wrench or two thin lock nuts on the projecting stud. The new stud should be pulled well home and after the cap nut is hard up, the joint face side should be caulked up round the stud.

In addition to the usual inspection the steam collector ring immediately below the top flange of the boiler shell should receive particular attention, and should be scaled and the small holes cleared. A new or refilled Fusible Plug should be fitted whether the original one appears to be sound or not. If the Firebox Joints are undamaged they may possibly be used a second time, but as the expense of new Joints is moderate, it is probably safer not to attempt this questionable economy. All the metal faces must be very carefully cleaned and graphite compound applied freely to assist in subsequent removal. This compound should also be applied to the studs and cap nuts.

## Engine.

**COMPLETE DISMANTLING.**—Drain oil from crank-case, preferably when Engine is warm, then slacken off chain pinion nuts—to avoid transmitting any strain through the differential, the chain should be removed and a stout hard-wood balk of timber or prop jammed between one of the chain pinion teeth and the ground to take the shock when slackening the nut. The Chain Pinions may be removed at this stage by means of the special extractor included in the tool kit or it can be done after the engine is taken out of the chassis.

*Note.*—Much unnecessary trouble will be avoided, particularly on the Engine, if all nuts are replaced on their respective studs or bolts, especially where castellated nuts are used.

**REMOVING ENGINE FROM FRAME.**—In the case of the platform model access to the Engine is through the hatch provided.

In the tipping models, the body should be fully tipped and firmly supported with packing or shores, and, in the absence of overhead tackle, lifting gear can be slung from the sub-frame of the tipping body.

As the point of balance of the engine is situated about mid-way between the centres of the camshafts and the crankshaft, the sling should be rigged at this point.

Remove driving chains, valve push rods, pipe connections, cables and the control rods at the engine end, and take the weight of the engine on the tackle.

Remove engine suspension plate bolts from the side members and wedge out the suspension plates

until the lips are free from the top of side members, disconnect front suspension link and lower engine on to a low truck or a couple of planks resting on the floor.

Slide engine clear of the chassis and turn over to bring crank chamber inspection door upwards, support gear box end on wood blocks, sleepers or suitable packing of sufficient height for convenient working and pack up under the crosshead guides to bring engine into horizontal position.

Remove cylinder covers. Bar engine round until one piston is at the outer end of the stroke—remove piston rod nut cotter pin and nut—box wrench with tommy bar not longer than 24" should be used, as excessive force will distort connecting rod—if the nut is fast with carbonized oil and cannot be removed with this leverage, the nut should be split with a chisel. Draw piston by means of the two  $\frac{3}{8}$ " tapped draw holes. Fit the gun metal pilot or thimble on the thread end of piston rod to prevent damage to the metallic packing, the gland of which should be slackened back slightly, and remove all big end cotter pins, nuts, cap, packing pieces and shims, leaving the bolts and inner half of the bearing on the connecting rod. Rotate crank pin free of big end bolts to the lowest position and draw the assembly.

**BIG END BEARINGS.**—The shims, three thousandths of an inch thick, are forced together under pressure into a pack and when taking up bearings in position it is advisable to take a "lead" of the clearance before removing any laminations. This is done by inserting a shred or shaving of sheet lead, or thin lead wire (fuse wire is too hard) between the pin and

the cap and nutting up hard—assuming the extruded lead then measures 12 thousandths of an inch in thickness the removal of three shims of three thousandths of an inch thick will probably be sufficient to take up the clearance, as some allowance must be made for expansion of the lead test strip.

**CLEARANCES.**—*Piston rings.* Gap when in cylinder, minimum 6 thousandths, maximum one-tenth of an inch. Float in grooves one to two thousandths.

*Piston.* Minimum clearance in cylinder, one hundredth of an inch.

*Engine valves.* Cold two thousandths, hot one hundredth of an inch. Set cold until push rods are just free to rotate between finger and thumb. Clearances cannot be checked by a feeler gauge owing to the ball formation of the push rod ends where they fit into the tappet and valve stem sockets.

*Pump valves and boiler check valve.* Lift should not be permitted to exceed  $3/32$ ",  $1/16$ " lift being the standard setting.

**CYLINDER LUBRICATOR.**—Commencing with Waggon No. 8271, the lubricator body is cast integral with the outer cover on the off side of the crank-chamber, and the lubricator pump driven direct by a worm extension on the engine crankshaft. Earlier models have an independent lubricator driven by a coupling rod from the differential shaft.

**CAMSHAFTS—RE-TIMING.**—Turn engine until the crank on the pump side is on the inner dead centre and with the camshaft end covers removed and camshaft pinions out of mesh or removed, rotate both camshafts until the arrow marks on the shaft

ends are pointing upwards in a true vertical direction. Then slide the camshaft pinions into mesh with the intermediate timing wheel and replace cover.

The camshafts are provided with two keyways, only one of which is sufficiently deep to engage the pinion key, the other being provided for manufacturing purposes only, therefore it is impossible to assemble incorrectly. If, on checking over the valve opening positions, these are found to be incorrect the camshaft should be drawn out for examination (see note under heading "Low-Gear Cover—Dismantling") after removing the push rods, wear of the cams could be the only cause.

NOTE.—Exhaust Camshaft can be withdrawn with engine in position, but to draw steam camshaft the engine must be lowered from cylinder end, after dismantling pipes, controls and brake gear.

**DIFFERENTIAL—REMOVING.**—Dismantle both suspension plates, replacing each split housing on its plate to avoid confusion. Then remove high-gear side cover door, withdraw high-gear sliding pinion together with the shifter gear, which is freed by moving round the shifter gear lever to a suitable position. Note that pinions and splined shafts are marked and must be so reassembled. Draw chain pinions by means of the special extractor issued in the kit, and remove oil gland and spring. Place wood packing or jack below the end of the differential shaft and after removing all cover nuts start the joint by means of three small wedges, this is necessary as the cover is closely spigotted to the crank chamber casing, space the wedges equally round the circumference and tap gently, avoiding bruising or damaging the joint faces. When free, the cover



should be drawn away as far as the packing or jack will admit, when fresh packing should be rigged to support the shaft and the original removed to allow the cover to be taken off. Remove high-gear spur ring. If the fitted bolts turn, the heads are accessible from a small door on the normal top of the crankcase or underneath when the engine is inverted. When reassembling note the gear ring is marked to the flange on the differential sleeve.

**FEED PUMP.**—Irregular action or even failure may be caused by the bypass valve not seating correctly. Waggon as despatched from the Works are provided with a *flexible* steel cable, but cases have been found where these have been replaced by heavy stiff cable which overcomes the return spring on the bypass valve, thus preventing it falling on to its seat. Excessive lift on suction and delivery valves will also cause erratic working of the pump at high speeds, lift should be checked from time to time, and should not exceed  $3/32$ nd's of an inch. This also applies to the boiler check valve. Air leaks on the suction side from the feed tank will also prevent proper working of the feed pump. Choked Water Filter should be suspected if all other details appear correct.

**LOW GEAR COVER—DISMANTLING.**—Remove crankshaft end nut, and the nuts around small cover carrying the locating ball race, prise off cover, which will at the same time draw the distance piece and ball race. When the distance piece is free draw off and remove key to avoid fouling ball race. The ball race may be left in the small cover unless a replacement is required. Then undo all main cover

nuts and break joint by means of fine 'wedges, support differential shaft end, as before, and draw cover. The differential assembly can then be lowered to rest inside the casing and can be drawn out from the low gear side. Remove the low gear pinion and shifter lever. To draw crankshaft the steam camshaft must first be removed, this is done by removing the camshaft control lever cover (underneath when engine is inverted), without disconnecting the lever, and allowing the control shaft to drop to its fullest extent, this will disengage the fingers from the recess in the camshaft. Draw timing pinion and camshaft, then remove the intermediate timing wheel axis and allow the wheel, with pump eccentric, to rest on the bottom of the casing.

The Crankshaft complete with its roller races and timing pinion may be driven out from high gear side by removing the bolts in the large end cover of the crank chamber, high gear side.

If the crankshaft timing pinion requires replacement this can be removed without drawing the shaft from the crank chamber, and should be forced off by means of wedges driven in at the back of the pinion between it and the inner roller race securing nut.

Re-assembling is carried out in the reverse order to the above.

**PACKING—OIL GLAND.**—Beldam Packing is recommended and where necessary to re-pack every precaution must be taken to remove the last vestige of the old packing before inserting the new. The gland must not be pulled up too tightly and the locking springs are essential to prevent the nuts slackening back. If any difficulty is experienced in

starting the nuts against the spring pressure, a flat strip of say  $\frac{1}{16}$ " steel sufficiently wide to force the gland down against the springs to expose the stud ends, and bent "U" fashion to pass above and below the piston rod will simplify assembly, but must be removed on completion of the job.

**PACKING—METALLIC.**—Each steam stuffing box carries three rings of special metallic packing with three ground steel discs separated by three distance pieces, and one copper washer. The method of assembling is as follows:—

When fitting new packing (cast iron type) to old rods, provided the latter are not scored, the rings should be ground to the rods, holding each set of packing between two of the steel discs, using a fine grinding compound which should be very carefully washed out with petrol when finished. Test the bearing on the rod with marking, such as Prussian blue, from time to time. (Grinding Compound must not be used with white metal type of packing rings).

Place copper ring at the back of the stuffing box, followed by a ground steel disc and distance piece, then insert one ring of metallic packing with the radial slots towards the cylinder and follow up with the second disc and so on; the gland beds on the last distance piece, etc., and should be pulled up just hard and no more. Additional pressure will do no good as the various components of the packing are incompressible end-ways. Ascertain with the finger before threading the piston rod that each ring of packing is just free to float between its discs.

**PISTON AND CROSSHEAD.**—After removing cotter pin and nut the piston rod can be driven out of the crosshead, the latter being placed on a flat surface.

When re-assembling, care must be taken to ensure the key registers with the keyway. When fitting new piston rods, unless the original nut is usable, particular care must be taken to see that when pulled home the nut does not distort the rod. This can be checked between centres or marking smeared on the crosshead face to show if the nut is bearing hard on one side, when it should be filed or scraped until true.

**VALVE SETTING.**—Before attempting to check over the valve settings all valve clearances should be adjusted cold to about two thousandths of an inch, with the push rods just free to rotate between the finger and thumb when the valve is seating and the cam in the closed position.

Remove the off-side trunk cover door, giving access to the piston rod packing glands and turn crankshaft as for forward running until the off-side crank is nearly on the inner dead centre position and place camshaft control lever in forward start the gear lever remaining in neutral. While the assistant turns the engine very slowly, by means of the nut on the out-end of the crank-shaft on the near side, in a direction tending to tighten the nut, take the nearest steam valve push rod (above the engine off-side) between finger and thumb and semi-rotate it until the rising cam takes up all clearance. At this point a fine pencil mark should be made on the piston rod, using the steam packing gland as a register, then turn the crankshaft to and fro to find the inner dead centre which should be marked in the same way. The distance on the rod between these two points should not exceed  $\frac{1}{8}$ , the nominal steam admission setting being on dead centre. This

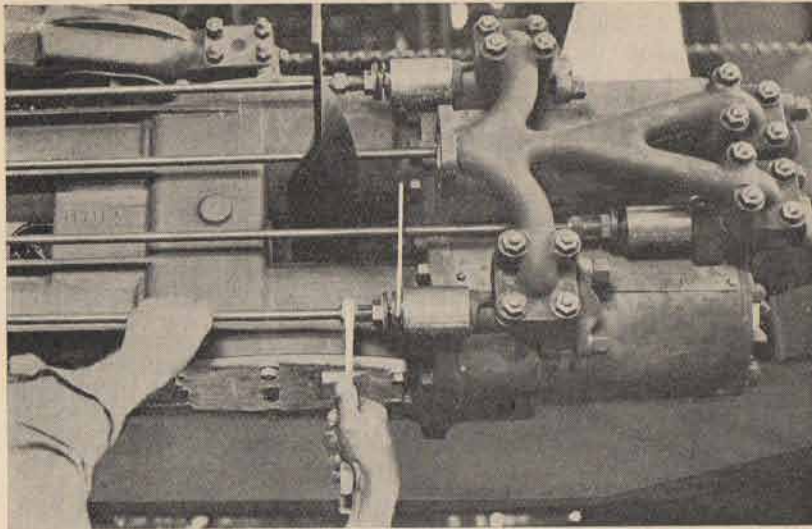


Fig. 1.

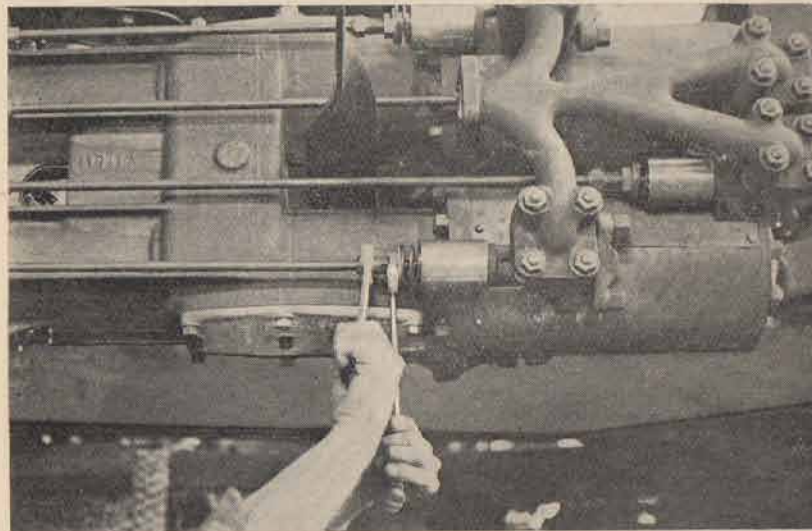


Fig. 2.  
VALVE CLEARANCE.

The push rod is semi-rotated between finger and thumb of the left hand whilst the split taper adjuster is being screwed in or out as may be required by means of the spanner held in the right hand. The thin spanner on the flat on stem of valve prevents the latter from rotating whilst the adjustment is being made. In Fig. 2, the method of tightening the adjuster locknut after the correct clearance has been obtained is shown.

operation should be repeated with the control lever in reverse, the engine being rotated in the opposite direction. If there is any great discrepancy in the valve opening positions, the error may be corrected by re-meshing the camshaft pinion with the intermediate spur wheel, so that the steam admission points for forward start and reverse are identical.

**WRIST PIN.**—Unscrew the set pin on the outside of the crosshead and tap wrist pin out from the opposite side. The small-end bush has an oil slot cut on each upper side where it projects from the connecting rod end and is held in position by a lug through which passes a cheese headed pin secured by a cotter at the opposite side. This cotter should be on the same side as the wrist pin set pin in the crosshead when assembling.

## General

**AXLE—FRONT.**—D.G. Waggon, commencing with No. 8264, have re-designed front axle pivots, Bushes and Journals. The Journal is increased in diameter by  $\frac{1}{2}$ " and in length by 1" and has a thrust shoulder on the inner end in place of the earlier lock nut, and is sealed against dust and grit, or loss of oil, by a brass cap. These Journals are lubricated by a duplex grease gun fitted in the cab, under the control of the stoker, connected by flexible pipes, and can be lubricated when the waggon is running.

The wheel is only removable from the taper and the greatest care must be exercised in ensuring that this nut is *locked up solid* after removal for re-tyring or other purposes.

All waggons fitted with the new type axle are equipped with extractors for the removal of the wheels, which are interchangeable with old style.

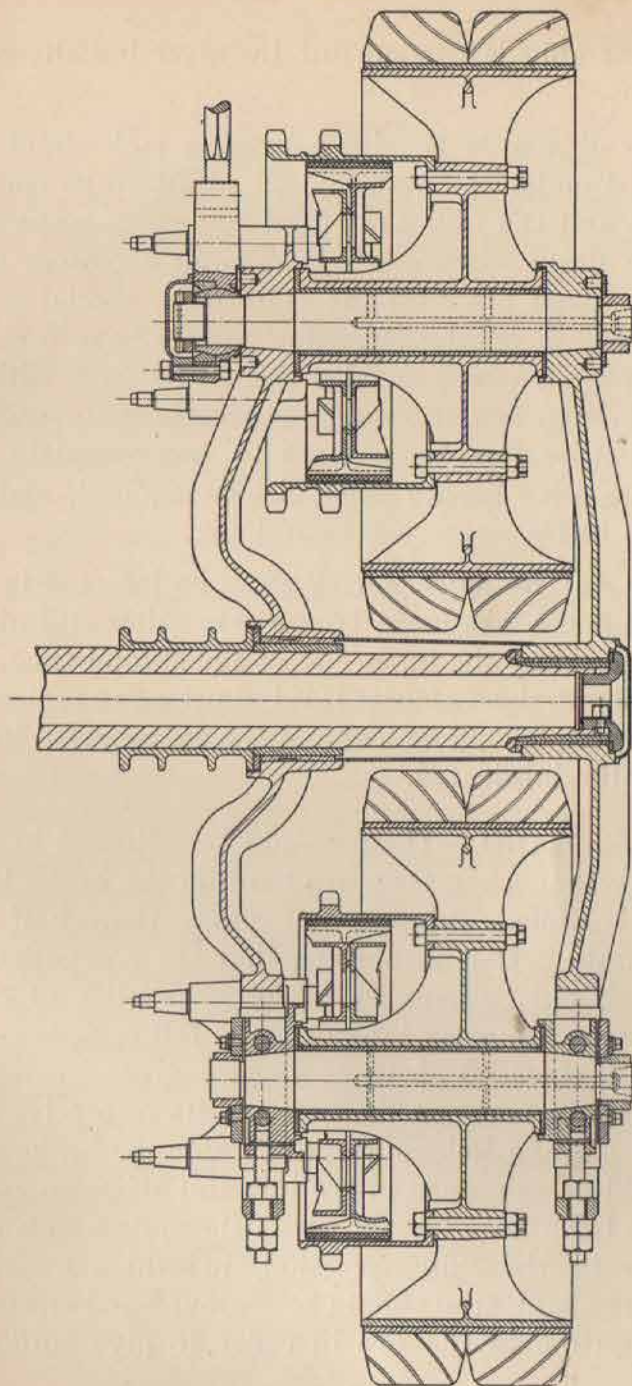
**AXLE—REAR.**—(Four-wheel Bogie of "Sentinel" D.G.6 and D.G.8).

To remove outer Bogie arms for tyre or brake attention, first disconnect all driving chains, jack up the inner bogie arm directly beneath main axle, leaving wheels just clear of ground. Remove main axle cap provided on later models, take off hexagon lock nut from centre of large main axle nut and remove the hexagonal locking piece with the square broached hole, which fits on the shank of the tee headed locking bolt. The position of all nuts should be marked before slacking. Remove main axle nut (special hexagon bar key provided), together with the tee headed bolt. Later types have a main axle nut with larger hexagon shaped bore with 6 tapped holes for a set pin to register with any one of 5 slots in the bore of the main axle—this is readily removed, after withdrawing the set pin, by means of the hexagon key supplied in the tool kit.

Take off Lock Plates from both outside stub axle nuts, and remove nuts. Two  $\frac{7}{8}$ " tapped holes are provided on the bogie arm facings surrounding the stub axles and corresponding studs in the tool kit together with extractor plates, by means of which the outside arm may be drawn off the stubs. Where an oil casing shrouding the main axle between the inner and outer arms is provided, it may come away with the outer arm, but this is unimportant so long as it is replaced in the same position.

The wheels may now be drawn off, making certain that the brakes are released, and where brake drums are deeply worn it may be necessary to disconnect the brake rods from the lever ends.

FRONT.



SECTIONAL PLAN OF OFFSIDE WHEELS, ETC., ON REAR BOGIE AXLE OF "SENTINEL" D.G.6. AND D.G.8.

Assembly is carried out by reversing the operations.

To dismantle the inner arm, a jack should be placed under the main axle, and all brake connections and the radius rod from the engine-suspension plate fixing disconnected. Should excessive wear have taken place on the main axle, special repair sleeves are obtainable, later models have a sleeve shrunk on, which enables this to be done without machining, but it would be necessary to machine the earlier type main axles to accommodate the sleeves. New bushes would also be required, and are listed in the spare parts catalogue.

An Oil Retainer Felt Washer is inserted in the inner bogie arm main bore at the outer end of the bush, sealing the inner end of the shroud tube. If this shows signs of wear it is important to replace it, otherwise oil will be lost and the axle journal insufficiently lubricated.

**BRAKES—HAND.**—These should be adjusted in such a way that when they are hard on the brake lever has travelled through not more than half the quadrant. It is important that the compensating link should be kept as nearly as possible at right angles to the main brake rod, as full compensation is not obtained if there is any great degree of angularity between the link and its respective rod.

The Brake Release Springs inside the brake shoe should be examined in both on and off positions, as cases have been known where the spring coils bind when in the "ON" position, in which case the square shank stud should be removed and stretched by heating in the fire in order to give sufficient

length, but usually if such a procedure is necessary it means the brake linings are worn too thin for safety, and should be renewed at the first opportunity. Brake linings are attached to the shoes by means of counter-sunk brass screws and nuts. These are more readily fitted than where rivets are employed.

The same general remarks apply to the steam operated brakes.

**BRAKES—STEAM.**—Drain valves are provided beneath the cylinders to carry off the condensed steam and consist of lightly spring loaded valves which automatically close under steam pressure.

These should be tested occasionally, and if steam is emitted after the brake is applied, the gun-metal portion of the drain valve should be unscrewed, whilst preventing the steel union from turning. The valve chest and valve should be cleaned and the valve re-ground to its seat, and the cylinder blown through thoroughly before re-assembly. The bronze spring fits in the gun-metal valve body beneath the valve normally preventing the valve from seating until pressure is applied. The exhaust release from foot valve in the cab is carried to the ashpan and a stopped pipe would cause sluggish return of the brakes after application. If this exhaust release pipe appears to be clear, lack of lubrication of the brake cams is most probably the cause, or a weak spring at the top of the brake lever beams.

**CHAINS—ADJUSTING.**—When Bogie chains require taking up, both outer and inner stub axle nuts must be slackened back and the bolts passing through the

rear end of the bogie arm in a vertical direction must be slackened, when the required adjustment can be effected by means of the adjustment set pins. Care should be taken to adjust each one equally, testing the wheels for alignment by a straight edge across the faces, adjustment pin lock nuts must be pulled up hard tight, and stub axle nuts screwed hard up and the vertical bolts tightened.

When adjusting driving chains Radius Rod Socket Ends should be same distance apart on each side.

### INJECTOR TROUBLE.

In the majority of cases Injector defects can be traced to air leaks most probably caused by defective couplings on suction line from tank. The remedy is to tighten up all couplings and if trouble still continues slack off and clean all metal surfaces to ensure air-tight seatings.

When the Injector is pulling Water correctly from tank but failing to deliver it to the boiler: this is most probably due to stoppage in sliding thimble. To remedy this, remove sliding thimble and clean out with a piece of thin wire.

Another cause may be sticking of overflow valve and in this case it is necessary to free Valve Piston by means of small handle at forward end, also ascertain that a supply of lubricant has been introduced through the small plug on the upper left hand or rear side of Injector. Cylinder oil is too heavy. "Double Purpose" oil is suitable.

Another cause of defective functioning of the Injector may be choked water filter. The remedy is obvious and should not occur where proper attention is given to the waggon.

### REVERSING LEVER—ADJUSTING IN RELATION TO CAMSHAFT.

Remove pin from fork end of control rod (engine end), force camshaft hard up against stop by means of the short lever and with the reversing lever in forward start notch, offer up the connecting pin, if the adjustment is correct the pin will slide in without effort, if it does not the fork end lock nut should be slackened and the fork end screwed on to or off the rod half a turn at a time until the pin will enter. This should be also checked with the camshaft in the opposite end direction and the lever in reverse notch. If any alteration is still required, it is advisable to readjust the fork end slightly in the forward start position to prevent the camshaft hitting on the stop when thrown hard over violently.

**STEERING GEAR.**—The only adjustment provided or necessary, is for end movement in a vertical direction of the spindle in the steering column. This is adjusted by means of the column cap nut, the clamping bolt of which should be slackened and the column cap nut screwed down until the spindle is just free in all positions. To test this it is advisable to disconnect the drag link from the drop arm. Steering stiffness may be due to any of the following causes:—

- (1) Mal-alignment of front wheels (out of line).
  - (2) Bent front axle.
  - (3) Front wheel bush seizure.
  - (4) Front wheel bush wear.
  - (5) Excessive end play.
- (1) To check alignment of front wheels two straight edges are recommended or a trammel, measurements

being taken at axle height before and behind the front axle. Best results are obtained with a toe-in of from nothing to  $\frac{1}{16}$ ".

- (2) If steering appears heavy after a minor accident or violent contact with the curb, the axle should be checked and if necessary straightened hot under a press.
- (3) If a front wheel shows signs of heat when running the wheel and journal should be drawn and the bush scraped and oilways cleared and before replacing the journal the greaser should be screwed down to make sure that lubrication is reaching this point.
- (4) If the bush is so badly worn as to allow the wheel to splay from the vertical it should be replaced.
- (5) Special Thrust Washers of anti-friction white metal are supplied in various thicknesses for taking up end play. These washers should only be fitted on the inside end of the journal.

**NOTE.**—Under no circumstances should a journal be removed from the wheel centre unless it is necessary to renew it (except on later models, see "Axle-Front"), in which case it must be carefully ground to the taper and the outside nut flogged home.

**WHEELS—REMOVING.**—When removing and replacing wheels (front or rear) fitted with white metal lined bushes, there is a risk of damage to the white metal by the thread on the end of the axle. A thimble or pilot can be supplied to thread over the end of the journal to eliminate any possibility of damage, or one can be made by machining the hexagon off a spare journal nut, to an external diameter about  $\frac{1}{64}$ " smaller than the journal with rounded off leading edge. This thimble should be highly polished.