

Drivers Instructions
and Maintenance.

"Sentinel"
Model S
Steam
Waggons
D.L.S.L.

The "Sentinel" Waggon Works, Ltd.,
SHREWSBURY,
England.

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Driver's Instructions and Maintenance.

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Drivers Instructions and Maintenance—"Sentinel" Model S Steam Waggons.

Introduction.

The success or otherwise of the vehicle which has just been placed in your hands rests with you—the driver. This may sound a very sweeping assertion to make; yet it is literally true.

In the "Sentinel" Model "S" we claim by our long experience and by many original features in design to have produced a waggon unsurpassed in its class for lightness, durability, simplicity and economy.

Although every care has been taken in design, material, and workmanship, no piece of mechanism designed by man will stand constant neglect or abuse. We would therefore urge you to give special attention to the following points:—

- 1 Do not exceed a speed of 25 m.p.h. for the first 500 miles.
- 2 Do not neglect lubrication.
Many parts which will normally run 100,000 miles can be worn out in a few thousand miles, and may be the source of trouble and extensive repairs if lubrication is neglected.
- 3 Keep your vehicle clean to be a credit to yourself and a good advertisement to your business.
- 4 From time to time glance over all parts of the waggon and do not neglect or put off rectifying small defects, as by so doing you will probably cause considerable trouble later.

Before Lighting up.

- 1 See that boiler water level is about 2" in glass. If boiler

water has to be added the plug at the top of the boiler behind the driver's seat should be removed, and the boiler filled with a hose pipe direct into the hole or through the special filler funnel supplied.

- 2 See that the funnel damper is open.

Lighting up.

Unhook ashpan, tilt firegrate, clean out and replace, half filling ashpan with water. Lift stoking chute lid, light some shavings or a small piece of waste soaked in paraffin and throw down on to grate. Follow up with firewood (preferably without nails) until there is a thick fire. Spread a layer of coal or coke 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 2" 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 wear on the cylinder walls, piston rings, and engine valves.

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, and see that they blow through freely.

(Note: Cocks are shut when handles are horizontal; open when vertical). Close drain, open top and bottom cocks, and water will then show at its true level.

Before Starting.

- 1 Fill the Bunker. The bunkers are filled through the cab roof. If they cannot be filled by standing on the platform of the waggon a ladder is supplied for this

purpose. Hooks are provided on the side of the cab behind the doors, to which the ladder should be hooked.

Do not stand on the cab roof as it is not designed or intended to carry the weight of a man.

- 2 Fill the water tanks. A filling hole is provided on the tank on the stoker's side for filling by a hose pipe; or the tank may be filled by the water lifter and filling hose.

The two tanks are connected by a levelling pipe behind the boiler.

- 3 Remember your Driving Licence and Insurance Certificate.
- 4 See that you have a clean bright fire before starting.
- 5 Fill the cylinder lubricator with cylinder oil. "Sentinel" Treble Filtered Green Cylinder Oil is recommended. (Note: Compound oils must not be used).

- 6 *Crankcase Lubrication.*—On the bottom of the sump in the middle of the near side there is a drain cock. *This must be opened and water drained out* until oil begins to run. The cock should then be closed and the crankcase, pump case, and gearcase filled to their normal level with crankcase oil. "Sentinel" Crankcase Oil is recommended.

NOTE.—A good quality mineral oil which will separate from water must be used. Poor quality mineral oil or compound oil will not separate from water, and will form a sludge in the crankcase.

- 7 With the Tecalet Grease Gun supplied, a charge should be given daily to the front and rear spring slippers, and spring pins.
- 8 See that Disc Wheel Nuts are tight and check tyre pressures if there is the least doubt as to their being correct.
- 9 As regards the other Lubrication, see also "Twice Weekly Attention" on page 14.

Position of Main Controls.

- 1 *Throttle*, handle on Boiler Stop Valve. Foot control at left hand side of steering column.
- 2 *Foot Release Valve* on floorboards at left hand front corner of driver's seat.
- 3 *Hand Brake Lever*, nearest to driver's left hand.
- 4 *Camshaft Control Lever* (reversing lever) 2nd lever on driver's left hand.
- 5 *Gear Change Lever*. Outside lever on driver's left hand.
- 6 *Steam Brake Control* pedal on right hand side of steering column.

Position of Valves and Fittings.

- 1 *Blower Valve*, on stop valve chest, farthest away from driver.
- 2 *Steam to Brake*, on stop valve chest, nearest driver.
- 3 *Injector Steam Control Valve*, farthest from stoker on front of boiler.
- 4 *Injector Water Regulator* handle behind gear change lever.
- 5 *Engine Drain Valve Control*, handle fixed to right hand side of driver's seat.
- 6 *Steam to Boiler Cleaning Pipe*, valve nearest stoker on near side of front of boiler.
- 7 *Feed Pump Bypass Valve*, on bottom of tank behind driver.
- 8 *Boiler Gauge Glass Cocks*, on front centre line of boiler.
- 9 *Water Lifter Valve* on superheater elbow on stoker's side of boiler.
- 10 *Cylinder Lubricator Test Cock*, on underside of stop valve chest, also one on main steam pipe below cab.
- 11 *Engine $\frac{1}{2}$ -inch globe valve*. On main steam pipe below cab; this is used for running engine when standing, pumping tyres or operating tipping gear.

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 the feedheater, then opening the foot throttle valve gently and blowing through cylinders for two minutes.

Place reversing lever in start position (right forward) and open foot throttle 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.

Engine Oil Pressure.—The normal oil pressure is 10 lbs. per square inch. Oil pressure may fall to 2 lbs. per square inch when engine is hot on long runs.

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 only, 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.

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. Opening the foot release valve will also let the lower gear be engaged.

Climbing Hills.—A Petrol Lorry 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 220 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 made 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. In descending long steep hills, it is advisable to put engine into low gear. Speed should not exceed 8 miles per hour.

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

Arrive with a clear fire to avoid showing smoke.

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

Before leaving cab always put reverse lever in drain position and shut stop valve handle.

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

On no account must the waggon stand with the tyres on oil, as this very quickly causes the rubber to perish.

Loading.—Whenever 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.

Failure of Boiler Feed 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 or injector defect. (See pages 60, 63 and 64).

Picking Up Water.

A hose pipe is carried on the near side of the waggon. One end of this is fixed to the water tank on the stoker's side. The other end with strainer attached is for placing in the water. If shallow and muddy it is sometimes desirable to place the strainer on the stoker's shovel. By so doing less mud will be sucked up. The water lifter valve should then be opened and the tanks filled. An indicator is provided at the top of the tank to show when the tank is almost full. This should be watched to prevent overflowing. Always pick up the cleanest water possible.

As a guide to drivers the following shows approximately the mileage which can be run on a tank of water :—

4-Wheelers—50 to 60 miles.

6-Wheelers and Waggon and Trailers—40 to 50 miles.

Spark Arrester and Collector Box.

A Spark Arrester is provided in the base of the funnel. This comprises a series of baffles which deflect the sparks through a pipe into a box just behind the boiler. This box has a sliding lid at the bottom and should be emptied every 50 or 60 miles. On no account let this become choked up, as this renders it difficult to empty.

Fire and Draught 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 nozzle may set up considerable back pressure in 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. 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.

Periodical Attention.

A summary of the main points needing attention on the waggon is given below. These are summarised under the headings "Twice Weekly Attention," "Weekly Attention," and "Occasional Attention," and are based on the assumption that the average mileage is 500 to 700 miles per week.

Reasonable attention to the following will ensure the chances of trouble on the road being reduced to a minimum :—

Twice Weekly Attention.

- 1 Make sure that all disc-wheel nuts are tight and generally glance over nuts, glands, etc., on waggon.
- 2 With the Tecalet Grease Gun supplied a charge of oil or grease should be given to all the points mentioned opposite :—

		<i>Four-wheeled Six-wheeled</i>	
		<i>Waggon</i>	<i>Waggon.</i>
Front Wheels	1 on each	2	2
Front Pivots	" "	2	2
Track Rod	1 each end	2	2
Steering Drag Link	" "	2	2
Steering Casing	.. ..	1	1
Steering Column (top)	.. ..	1	1
Hand Brake Bkts. (on frame behind cab)	1 on each	2	2
Rear Wheels	" "	2	4
Hand Brake Cam Spindles	" "	2	4
Steam	" "	2	4
Hand Brake Shoe Spindles	" "	2	4
Steam	" "	2	4
Cardan Shaft (each end)	.. ..	2	4

- 3 About 12 strokes of the pump should be given to each nipple. Do not give so much grease that it is forced out and thrown on to brake drums.

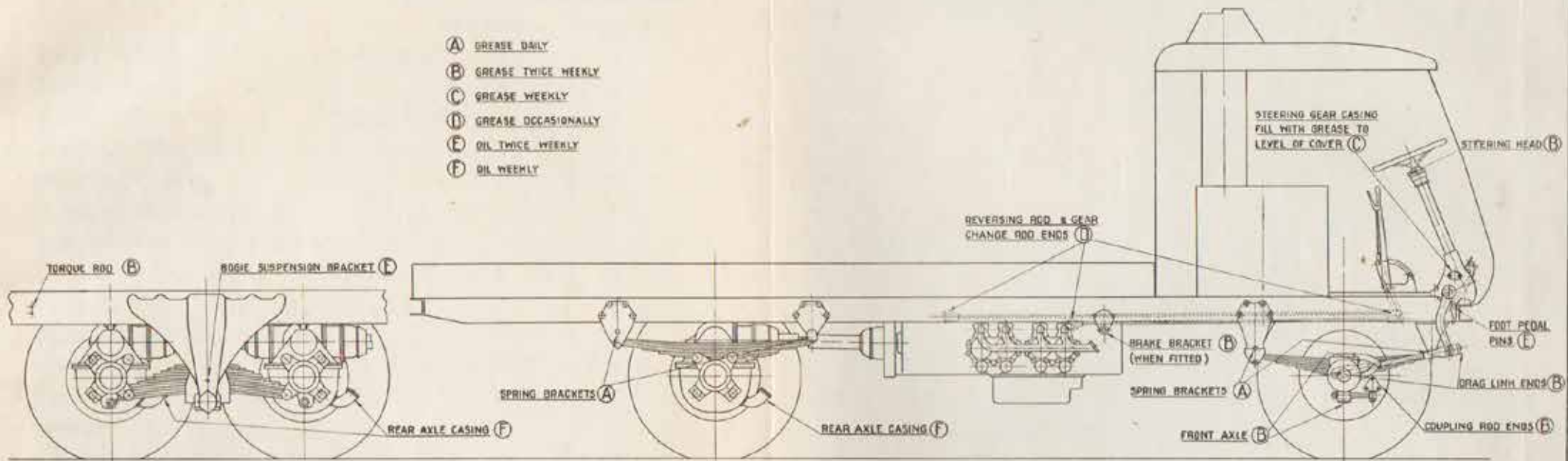
Six-wheeled waggon rear bogie trunnions. It is important that these receive ample lubrication. They are lubricated with oil through a plug on the outside of the bogie frame between the tyres. The plugs should be removed and about an eggcupful of oil put in each.

- 4 Check Tyre Pressures. The following pressures should be adhered to :—

Front	90 lbs. per sq. inch.
Rear (Inner)	85
Rear (Outer)	100

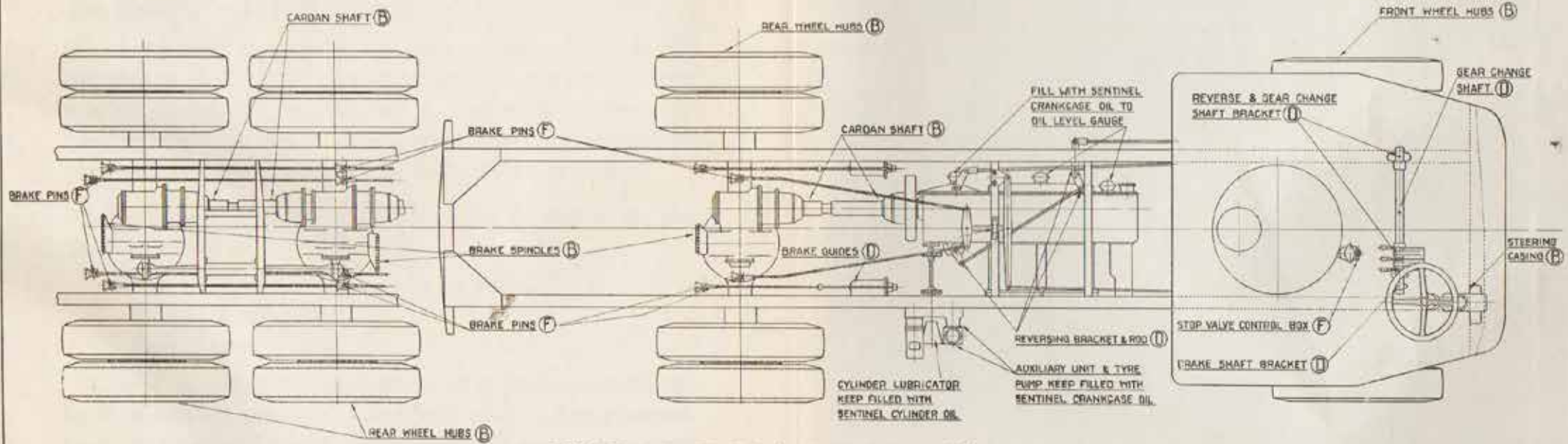
It is of the utmost importance that tyres be maintained at their correct pressure. Any reduction below pressure recommended will materially shorten life of tyre and may lead to overheating and bursts.

- (A) GREASE DAILY
- (B) GREASE TWICE WEEKLY
- (C) GREASE WEEKLY
- (D) GREASE OCCASIONALLY
- (E) OIL TWICE WEEKLY
- (F) OIL WEEKLY



MODEL 'S6' REAR BOGIE

MODEL 'S4'



LUBRICATION CHART FOR SENTINEL MODELS 'S'

NOTE.—When pumping tyres do not overrun the air compressor, as damage can be done to the driving gear if the engine is run at too high a speed. An engine speed of 300 r.p.m. equivalent to 12 m.p.h. is sufficient to run the compressor at its maximum rated output.

- 2 Examine tyres for cuts. Any deep cut should be vulcanised; otherwise tyre may be quickly ruined. Undue wear of front tyres is probably due to want of alignment of wheels (see page 61).
- 3 Blow down boiler. Water level in gauge glass should be raised to $\frac{1}{2}$ glass and blow down valve opened until water is just showing in glass. Blow down valve should be slowly and carefully opened.

Weekly or Shed-day Attention.

Every waggon should be given a shed-day once a week, when the following points should be given attention:—

- 1 Grease the steering casing. The casing should be filled to the level of the cover on the right hand side of the steering column.
- 2 Top up the accumulator with distilled water. The plates should be covered by $\frac{3}{8}$ " or $\frac{1}{2}$ " of water. The accumulator is under the stoker's seat.
- 3 Check the oil level in the auxiliary drive unit. The correct level is up to the filler plug.
- 4 Check the oil level in the rear axle casing. A filler is placed on the front of the axle. The correct level is $1\frac{1}{2}$ " below the filler opening.

- 5 Wash out boiler.

To do this 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, then, when the boiler is cold, remove the wash-out plugs round the base and the filling plug in the side of the boiler shell.

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 3in. from the end, will make an effective brush to assist in removal of sludge. Before replacing wash-out plugs, put some graphite grease on the thread, do not screw up too tight, or they will be difficult to remove again.

- 6 Give a few drops of oil to brake rod joints, and stop valve spindle screw.
- 7 Examine all packing, tightening up when necessary. NOTE.—When re-packing glands, it is advisable to remove all the old packing and replace with the requisite number of turns of new stuff.
- 8 Examine all joints, tightening up and renewing them where necessary. See that screwed valve caps are tight, also cylinder head nuts.
- 9 Clean all working parts of the engine which are open to the road.
- 10 *Cleaning boiler tubes 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. Remove the stoking chute and blow through the stoking chute opening, also from 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.

Occasional Attention.

- 1 The exhaust blast nozzle in funnel is liable in time to get a carbon deposit and choke the outlet. This should be examined every 5,000 miles or so, as also should be the

blower plate and blast bend. Choking up of the blast nozzle reduces the exhaust steam outlet, thus causing increased draught and fuel consumption, and possibly loss of power due to excessive back pressure in the exhaust pipe.

- 2 The engine oil filter should be cleaned every month for the first three months, and afterwards every three months.
- 3 Check steam and exhaust valve clearances—see page 52.
- 4 The superheater coil bolts should be kept tight to prevent the coils from chafing. These may be got at by removing the boiler top lagging plate. At the same time the top ring of nuts holding the firebox to the outer shell should be tightened if necessary.
- 5 Remove manhole doors and washout plugs from the water tank, and wash out any deposit with a hose. This should be done at intervals according to the quality of water used.
- 6 With the Tecalemit Grease Gun supplied a charge of grease or oil should be given to the following points:—

*Four-wheel Six-wheel
Waggon. Waggon.*

Gear Change Rod	1 each end	2	2
Control Shaft (in cab)	„ „	2	2
Front Reversing Rod	„ „	2	2
Back „ „	.. ..	1	1
Reversing Rod Bkt.	.. ..	1	1

- 7 Remove the screwed plug in boiler shell behind the driver's seat. This exposes the fusible plug, which should be removed with a box spanner and examined. If coated with scale this should be removed. If the whitemetal in plug is melted, the spare plug should be fitted.
- 8 Adjust brakes as required.

Lack of Power and Bad Steaming in Boiler.

If the working steam pressure takes longer than usual to attain, the fault is connected with the boiler. If steam cannot be maintained on the road, the fault *may* be connected with the boiler. It is hoped that the following list will help drivers to diagnose and remedy the particular trouble if either of the above takes place.

- 1 Clinker on firegrate.
- 2 Accumulated dust and soot on tubes.
- 3 Excessive scale in boiler.
- 4 Blocked steam collector pipe in boiler steam space.
- 5 Air leaks through boiler top-plate, or top-plate clamps not tight.
- 6 Too keen a blast, pulling fire into holes.
- 7 Blast nozzle not in line with funnel.
- 8 Unsuitable fuel, blast nozzle, or firegrate.
- 9 Bad driving or stoking.

Nos. 1, 2, 3 and 4 are obviously due to lack of boiler attention, and should be remedied as soon as possible.

No. 4 will cause loss of power and engine will not respond to wide throttle opening.

No. 5 can be tested for by running the engine with the waggon at a standstill and going over the boiler-top joints with a lighted taper, the cladding first being removed. If the light is extinguished or "drawn in" there is a leak at that spot. The boiler top dogs should be tightened up, and if the leak is round the superheater coils, the steady plates and their holding down bolts should be examined and tightened up or renewed as required.

No. 6 is caused by the blast nozzle or combined blast and blower pipe choking up (see "Occasional Attention," page 17).

No. 7 has caused bad steaming in the past. With the

blast and blower bend dowelled as in the 'S' Model, this trouble should not occur. If it does, owing to the dowels being lost, a good fitting round rod, or even a broom handle of sufficient length to protrude above the funnel, should be inserted in the nozzle and the nozzle centred with the flange nuts slackened back. A good approximate method of testing whether blast nozzle is in alignment is to run the engine and hold a piece of springy steel (cardboard or jointing will do) over the funnel top. Gradually lengthen the steel over the funnel until it is noted that the steel vibrates from the funnel blast. The distance in which the steel vibrates at opposite points will show whether the blast nozzle is central.

No. 8.—A list of fuels tested and found satisfactory by ourselves or our customers is given on page 75. If a customer wishes to use any fuel not mentioned, and is doubtful of its suitability, our Service Dept. will always give advice, and if desired, have it tested. It must be borne in mind that with a change of fuel a change of firegrate or blast nozzle may improve steaming. (See Boiler, page 36).

No. 9.—The driver and stoker should learn to work together, as indifferent results can be obtained by one not watching the other. Such points as adding fuel at the wrong time, turning on the feed pump on an incline, keeping too thin or thick a fire, and driving with the regulator too far open for long periods, should be avoided, as they cause excessive fuel and water consumption, and therefore inefficiency. A stoker will soon ascertain the best type of fire for his waggon, and its particular work.

Lack of Power In Engine.

If the boiler appears to be in good condition, and the

waggon appears to be losing power, if the beat of exhaust blast in funnel is uneven, or if there appears to be engine vibration, the engine should be examined for :—

- 1 Push rods out of adjustment.
- 2 Sticking Valve.
- 3 Sticking or worn cam follower.

Lack of power may also be caused by the valves requiring re-grinding, slack piston rings or scraper rings, defective timing (only if the engine has been stripped and re-assembled) and leaking joints.

A knock in the engine may be caused by :—

- 1 Big end slackness.
- 2 Main Bearing slackness.
- 3 Wrist Pin slack in piston.
- 4 Wrist Pin slack in connecting rod.
- 5 Sticking cam follower.
- 6 Sticking valve.

For information on stripping and re-assembling engine see pages 51 to 56.

Loss of power may also occur due to steam or exhaust pipes or exhaust pipe rubber connection being partly choked with carbon or deposit due to boiler priming. ▽

Engine Lubrication.—The engine lubrication is a dry sump system, that is, the main and connecting rod bearings do not dip into oil, but are dependent on a pressure supply of oil from the forced lubrication pump.

In the event of failure of the forced lubrication pump, the engine may be run with splash lubrication, by filling the crankcase with oil to a level of about $2\frac{1}{4}$ ins. below the filling cover.

The level can be tested with a dip stick through the centre crankcase filling cover.

Precautions against Frost.

When frost is expected the following precautions should be taken :—

- 1 Drain the engine by placing reversing lever in drain position, and leaving the drain valve on the feedheater open.
- 2 Drain the feed pump by opening all three cocks on the pump body, and by shutting both boiler check and tank filler valves.
- 3 Drain water tanks by removing plugs. If boiler is hot and cab closed up, water should not freeze in tanks under 12 to 14 hours.
- 4 In the case of tipping waggons, open cocks on the tipping cylinder.
- 5 If the waggon is to lie out for longer than 12 to 14 hours without the fire in, empty the boiler by opening blowdown cock at the bottom of the shell.
- 6 When a thermofeed is fitted, this should also be drained after the boiler has been emptied.
- 7 Drain out any accumulated water in engine sump. It is advisable to warm sump before engine is run, so that oil will be sufficiently fluid to flow to the forced lubrication pump.

THE "SENTINEL" DRIVERS' CLUB.

Now in its eleventh year of existence, the "Sentinel" Drivers' Club has done much towards making the job of driving a "Sentinel" Waggon a congenial one. The Club was founded with the object of helping the driver, and showing that the waggon makers are prepared to give him all the advice they can. How far these aims have been realised can be gauged from the fact that there are now many thousand Members of the Club, all of whom are either drivers or stokers of "Sentinel" Waggons of various models.

Every *bona-fide* driver or stoker of any "Sentinel" vehicle is entitled to Membership, and to wear the badge which is presented to him upon enrolment. The surety of help from any other Member of the Club when in trouble on the road, and advice given by our Service Department and visiting Inspectors, all help to make the Member of the "Sentinel" Drivers' Club more interested in his job.

If you are not already a Member, and would like to join the Club, ask for an enrolment card, addressing your letter to The "Sentinel" Drivers' Club, "Sentinel" Waggon Works, Ltd., Shrewsbury.

NOTES.

Descriptions, Repairs and Overhauls—“Sentinel” Model S Steam Waggons.

“By timely mending, save much spending.”

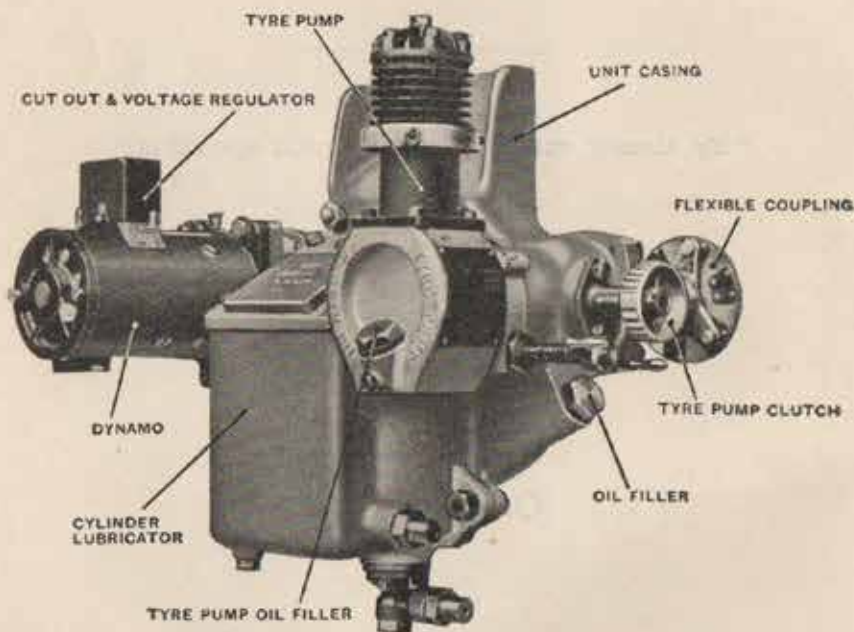
Old Proverb.

October, 1933.

The “Sentinel” Waggon Works Ltd.,
Shrewsbury, England.

Auxiliary Unit.

The dynamo, cylinder lubricator, and tyre pump are combined into one unit easily detachable from the engine. The drive is by spiral gearing in the engine, through a universally jointed shaft to a spur wheel in the unit itself. The main aluminium casting is rigidly bolted to the offside chassis frame channel. Gears and bearings are lubricated by splash. The casing is filled with oil up to the level of the oil filling plug.



Cylinder Lubricator.

The cylinder lubricator is driven by worm gearing, the worm being on the end of the unit driving spindle and the wheel mounted on a cross shaft running in gun metal bushes, one on either side of the lubricator box. A single cam, mounted on the hexagonal part of this shaft operates

a flat pawl which in its turn opens two spring-loaded plungers. The fulcrum of the pawl is so placed that one valve opening is twice that of the other. Separate pipes lead from these valves, the heavier feed to the engine steam manifold, and the lighter feed to the boiler stop valve. This arrangement considerably reduces the oil consumption. The cam can be operated either by the worm gearing already mentioned, or by the hand wheel on the left hand side of the oil box. In the former case rotation is transmitted by a coil spring, and in the latter, by directly rotating the spindle on which the cam is mounted. A fine mesh strainer fits into the oil box, and should be cleaned in paraffin when necessary. The outside feed connection on cylinder lubricator feeds into the engine steam pipe, the inner to the boiler stop valve.

The lubricator is set for an oil consumption of 450 to 550 miles per gallon, or 300 to 350 miles per filling of lubricator box.

DEFECTS.—If less than the necessary amount of cylinder oil is used, the following are likely causes:—

- Lubricator delivery valve sticking or leaking.
- Wear in cylinder or plunger allowing leakage.
- Wear of Cam or Rocker Arm.
- Breakage of drive spring.

If the valves are in good condition, and the wear on the plunger and cylinder is not bad, feed can be increased by reducing the thickness of the packing under the cylinder bodies.

NOTE.—Do not interfere with the packing unless it is absolutely necessary.

Dynamo Drive.—The dynamo is driven by a pinion which meshes with the main spur wheel. This gear is

keyed to a spindle and is centrally supported on two ball bearings. The drive is taken to the dynamo by a rubber bushed coupling. Between the drive and the dynamo a cored hole allows oil leakage from the bearings to escape and avoids any possibility of it reaching the dynamo.

Tyre Pump.—The tyre pump is driven by another pinion on the front end of the unit. This gear can be engaged when required by turning the small milled wheel on the side of the casing, at the same time pressing the spring-loaded catch. The positions "out" and "in" are clearly marked on this wheel. The single piston is driven by an overhung crank. Fins are cast on the sides and top of the cylinder to assist in cooling the compressed air. The suction is through a row of ports which are uncovered when the piston is at the bottom of its stroke. Delivery takes place through a spring-loaded valve on the cylinder head. This valve has holes drilled just above its seat in order to release air trapped behind it when open.

The correct oil level in the sump is up to that of the filling plug. This must be strictly adhered to in order to prevent excessive oil passing the bucket rings, and mixing with the air. The crankpin is lubricated by a dipper on the bearing cap. The piston and gudgeon pin are splash-lubricated.

The air receiver, bolted to the cylinder lubricator, acts as an air cooler and oil filter. The oil filter, contained in the back cover, should be re-packed at intervals with clean white stockinette. The drain plug should be removed, preferably while the compressor is in operation, after 8 to 10 hrs. running. This allows any condensed oil vapour to be blown out. To test the condition of the oil filter, a piece of clean white paper should be held, at intervals, to the discharge from it. Any trace of oil on

this paper will indicate the necessity for re-packing the filter.

Boiler.

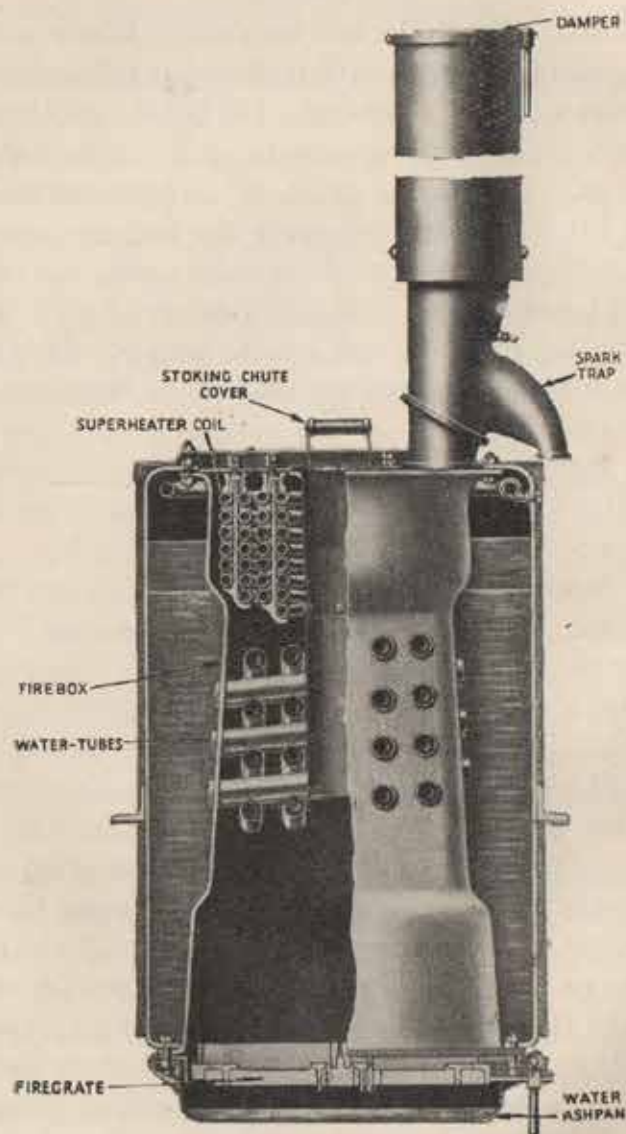
Description.—The Boiler is of the Vertical Water-tube type with square firebox, 2" outside diameter tubes and double superheater coils, 1" diameter. The boiler top of malleable cast iron carries the superheater coils by heat-resisting steel dogs. The stoking chute, in the centre of the boiler, can be lifted out after removing the furnace door. The firegrate trunnions are made in halves, only one of which need be lowered when "dropping the fire." The ashpan is controlled from the cab by the stoker. It is hinged so that it opens towards the rear of the front mudguard on the stoker's side.

The working pressure is 255 lbs. per square inch. The total heating surface of firebox and tubes is 42.8 sq. ft., and the total firegrate area 3.28 sq. ft.

The lagging is of corrugated asbestos covered with aluminium sheeting. The top plate cleading is easily detachable when the studs or top plate dogs require attention.

Mountings.—The Mountings are all grouped in the most accessible positions, both for controlling and for maintenance. The stop valve chest has superheated connections to the main engine steam pipe, the steam brake and the blower. There are separate saturated steam connections on the stoker's side of the boiler for the cleaning pipe, and the injector. The water gauge glass is placed centrally on the front of the boiler, and is easily seen from the driver's seat. The water lifter steam connection comes off the superheater coil elbow, and the safety valve is at the back of the boiler on the stoker's side.

Funnel and Spark Arrester.—The funnel base and spark arrester are combined together in a malleable casting bolted directly to the boiler top. The sparks are



Section of Model S Boiler.

thrown into a chamber and down through a pipe which leads to a round box behind the boiler on the near side of the waggon. The inner funnel is rivetted directly to the funnel base, and protrudes above the cab roof. The outer funnel is bolted to the inner by bolts and distance pieces. An aluminium funnel surround, bolted to the canopy, reduces the show of vapour at the top, and also acts as a ventilator. The combined blast and blower pipe, bolted directly to the funnel base, can be removed, complete with blast nozzle and blower ring, without dismantling any other part of the funnel.

DEFECTS IN BOILER AND FUNNEL.

BAD STEAMING.—See "Lack of Power and Bad Steaming of Boiler," page 19.

LEAKAGE.—This may take place either at the top joint or the bottom. If the top joint is at fault, remove the boiler top cladding and tighten stud nuts. The bottom cap-nuts can be tightened without any dismantling. Leakage taking place at the tubes indicates that the fire-box must be lowered and the tubes examined.

LEAKAGE PAST VALVES.—Grind in valves and examine packing.

LEAKAGE OF STOP VALVE GLAND.—Two square headed studs keep pressure on the stop valve gland packing. These should be kept tight.

SPARK VANES.—In the event of the spark arrester vanes burning away, these can be renewed by taking off the funnel complete with base, and removing the four bolts, two at either side, holding the vanes. The vanes can then be withdrawn.

THROTTLE VALVE.—In the event of the foot throttle valve not admitting full steam, the cam and roller at the foot of the spindle should be examined. Wear in this, due to shortage of oil, would cause a reduced opening of the stop valve.

GAUGE GLASS REPLACEMENT.—Remove top plug of the gauge mounting; and also the gland nuts and old packing. Pass new gauge glass down through top of mounting and thread on new packing and gland nuts. Push gauge glass as far down as it will go, and then lift about $\frac{1}{16}$ ". Tighten up gland nuts, top one first, but only a shade more than finger tight. Gland nuts will require following up from time to time. Always shut gauge cocks before tightening glands.

MAINTENANCE OF BOILER.

According to regulations, the boiler must be inspected annually for deposits of scale, etc. To do this the firebox has to be removed.

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 showing 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 before dropping the box in order to ensure correct replacement.

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 has to be raised sufficiently to clear the firebox when it is lowered. The best method to employ when doing this is as follows:—

- 1 Place a girder or heavy wooden beam (not less than 6" × 4") across the waggon underneath the side frame channels and just behind the front-spring brackets.
- 2 Cut two round holes in the cab floor boards suitably placed to pass chains through and round the beam.
- 3 Cut a hole in the canopy to allow both ends of the chain to pass through on to the crane hook.
- 4 When the waggon is lowered again, the holes can be covered by suitable pieces of steel plate.

By adopting the above method the waggon is firmly and safely held, thus subjecting men working below to the least possible danger.

NOTE.—Not less than a 4-ton crane must be used.

Then remove the funnel after disconnecting the blast nozzle connection to the exhaust pipe, (the boiler top plate and superheater coil may be removed as one unit), then remove ashpan and firegrate.

Remove the 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 $1\frac{1}{2}$ " wide by 3" long, tapering from $\frac{3}{8}$ " 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 lifted as suggested it will be necessary to manipulate the top of the firebox 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 the form of a cross 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 retubing, all scale must be removed from the outside of the new 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 around 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.

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 re-filled 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.

Firegrates—Removal.

- 1 Lower Ashpan to its full extent.
- 2 Remove bolts holding front half of firegrate.
- 3 Take out front half, and as rear half is not bolted down it can also be lifted out.

Boiler Mountings.—When the boiler is dismantled for annual inspection, all mountings should be examined, valves ground in and glands re-packed where necessary. Joints should also be examined and re-made where required.

Boiler—Removal of.—If, for any reason, the boiler has to be removed from the frame for shell inspection, etc., the following instructions should be carried out:—

- 1 Remove Cab. This is done by taking off the coping round the bottom and taking out the bolts which fix the cab to its support channels.
- 2 Remove bolts from boiler feet.
- 3 Remove water tanks from frame by taking out bolts joining the tank feet to the frame channels.
- 4 Sling boiler and lift out.

NOTE.—A crane or chain block capable of lifting *at least* 1 ton must be used.

Fuels.

Different fuels require different blast nozzles. The following list gives what are considered the most suitable sizes:—

	<i>Blast Nozzle.</i>
Welsh Steam Coal	1 $\frac{1}{4}$ " to 1 $\frac{5}{8}$ "
Poorer Grade Coal and Coke ..	1 $\frac{1}{8}$ "

Brakes.

Hand Brake.—The hand brake is operated by a lever conveniently placed at the driver's left hand. A straight rod connects the hand brake lever to a pivotted cross beam from the centre of which a guided short rod couples to the brake compensator. At either end of the compensator a brake rod couples up to each cam lever. Each brake rod can be adjusted by means of a wing nut at the cam lever end.

MAINTENANCE.—All brake joints should be kept clean and a few drops of oil applied at intervals.

Adjustment.—Brakes 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.

NOTE.—The brake rod adjustments are not sufficient to wear out the linings, and when this adjustment is fully taken up, the rods should be removed and the cam levers taken off and set back the requisite number of serrations on the cam spindle.

Re-lining.—The brake release springs inside the brake shoes should be examined in both "on" and "off" positions, as cases have been known where the spring coils bind when in the "on" position. This indicates that the brake linings are worn too thin for safety, and should be renewed at the first opportunity. To reline, brakes, wheels, and brake drums must be removed (see page 67, Rear Axle Maintenance). The linings are attached to the shoes by means of special hollow rivets.

Steam Brake.—The steam brake is operated by a pedal on the right hand side of the steering column, which, when depressed admits steam to the brake cylinders which are bolted to the chassis side-frame channels. When the pedal is released the steam is allowed to escape to the ashpan. Drain valves are provided beneath the cylinders to carry off the condensed steam and consist of lightly spring-loaded valves which automatically close under pressure.

DEFECTS.—If the brakes appear sluggish in coming off, the following should be examined:—

- 1 The exhaust release pipe to the ashpan. This may be choked, in which case it should be blown through.
- 2 Brake cams. Lack of lubrication will cause these to seize.

Steam may be emitted from drain valves after the brakes are applied. These valves should therefore be tested occasionally, and if steam is emitted after the brakes are 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.

If brakes are sluggish in going on and the linings are good, examine the foot-operated plunger. This may have become worn, allowing live steam to drain to the ashpan.

MAINTENANCE.—For *Adjustment* and *Re-lining*, see Hand Brake Maintenance, page 37.

Cardan Shaft.

The Cardan Shaft consists of a large diameter steel tube with universal couplings at either end. The coupling at the engine end slides on a spline on the main shaft. Each coupling consists of a flange yoke, a sleeve yoke and a journal which is mounted on two bushes in both yokes. The bushes are a driving fit in the yokes and must be driven out in order to split the coupling. The outer and inner casings on either coupling are oil-sealed by cork washers and springs. Lubricant is admitted by a Tecalet nipple at either end of the shaft, and opposite the nipple there is an overflow hole. When lubricating the couplings, grease should be pumped into the joint until it starts to come out of this hole.

MAINTENANCE.—REMOVAL OF CARDAN SHAFT.—To remove Cardan Shaft from chassis, take out bolts from both flanges and lift out shaft. Do not allow one end to fall, as this is liable to harm the oil retaining devices on both flanges.

To SPLIT THE COUPLING, unscrew the dust-cap from the sleeve yoke and remove the casing spring retaining lock. The outer and inner covers can then be removed, care being taken not to bend or distort them. The inner baffle, baffle spring, retainer and gasket can then be taken off. To disassemble the yokes and journal, the bushes must be driven out from the flange yoke, using a flat-nose punch and hammer. The flange yoke will then come apart and the sleeve yoke bushes can be driven out, thus separating the journal.

When re-assembling shaft complete, the arrows on the sleeve and tube must be opposite each other as they align the trunnions.

Lubrication.—Grease should be added every 1,000 miles for satisfactory results.

Electrical Equipment.

The compensated voltage control system is used on the Sentinel Model "S" for the lighting horn, etc.

The principles of this system are firstly to make the dynamo output entirely independent of the speed at which it is driven once this has passed the minimum value at which the full output can be produced, and secondly to maintain the voltage of the dynamo always slightly in excess of the back pressure or voltage of the battery, so that when the battery is connected with the dynamo a charging current will flow. This second principle is, however, elaborated to the extent that the excess voltage of the dynamo over the battery is made greater and greater as the battery becomes discharged, and less and less as the battery becomes more fully charged.

One result is that the charging current delivered to the battery depends upon the state of charge of the battery; when the battery is in a low state of charge and therefore offers a low back pressure it receives a comparatively high charging current, and as it becomes charged and offers a higher back pressure the charging current sinks. This action is so regulated that when the battery is in a very low state and badly needs a good charging, the initial rate is almost as high as the battery can safely withstand. This treatment, whilst being perfectly safe, is vigorous enough to remove rapidly the battery from the danger of sulphation. Then as the state of the battery improves, the charging current becomes less, until when the battery begins to gas the charging rate has dropped to a figure well below the limit at which any harm can possibly arise through too profuse bubbling.

Another result of the principles applied in the Compensated Voltage System is that the dynamo is called

upon to deliver, and does actually deliver, only sufficient current to meet the load adequately.

While this fact is not of much important in itself, since the dynamo is robust enough to carry any reasonable load continuously, yet it is a useful one to bear in mind during the running or maintenance of a voltage control set.

Dynamo.—The dynamo supplied, the D.45 B3. type, is a plain shunt machine designed on generous lines with the voltage regulator and cut-out contained in its assembly. This regulator is sealed and must not be interfered with, as all adjustments made are permanent and need no attention.

The cut-out is an automatic switch which closes the circuit between the battery and the dynamo when the latter has reached charging speed, and disconnects again when the speed drops below this point, thus preventing the battery discharging back through the dynamo.

Switchboard and Ammeter.—The switchboard is the 6.T. type which incorporates the ammeter, the main fuse and three switches for the head, side and tail lamps separately. The fuse carries the whole of the current generated by the dynamo, and the correct gauge wire *must* be used, *i.e.*, 1 strand of 32 gauge (0.011 inch) copper wire. The ammeter registers all current passing in and out of the battery, *i.e.*, when showing charge current is going in, and when showing discharge current is going out. To read the amount of current taken by the lamps, the dynamo must be stationary.

The switchboard is mounted on the dashboard, and can be illuminated by a reflector plate when driving at night. The front cover of the switchboard can be taken off when the instrument cover plate has been removed,

by taking off three nuts and spring washers. A single light covered by a reflector plate lights up all instruments and at the same time reflects on to the boiler gauge glass and the control levers.

A "press-in" switch in the centre of the instrument cover plate operates the reflector light. This light is taken direct from the busbars.

At the side of the switchboard a plug connection allows for the use of an inspection lamp.

Battery.—The battery, situated under the stoker's seat, is a 12 volt, type 12 M.X.E7 with a 45 ampere-hour capacity.

As explained in the section headed "Periodical Attention" in "Hints to Drivers," it must be inspected regularly and topped up if required with distilled water. It is advisable to complete the inspection by measuring the specific gravity of the acid. A hydrometer is used for this purpose, and is obtainable at any Automobile Accessory Firm or large Garage. It is advisable to smear the battery terminals with vaseline. This prevents the possibility of corrosion due either to too heavy a charge or acid spilling from the cells.

Dimming Headlights.—A switch on the steering column controls the dimming of the headlights. Each headlight has a double filament bulb, one filament being in focus with the reflector and the other not. The switching over from the former to the latter provides a sound anti-dazzle device.

Wiring.—The two-wire system is employed on this waggon; the positive wires are red, the negative black, and the dimming blue, or white.

Lamps.—The side and head lamps are fitted with highly polished reflectors, and on *no account* should the surfaces of these reflectors be polished with metal polishes.

The head lamps and their bulbs are marked "top" on the top side. When fitting bulbs see that these coincide, otherwise the dimming will not be effective.

The tail light is of rubber, thus being immune from any vibrations set up at the rear of the waggon.

Speedometer.—The speedometer records speeds electrically. The speed is shown on the dashboard dial, and the mileage on the mileometer mounted on the instrument itself. The speedometer is driven by a spring-belt from the Cardan Shaft.

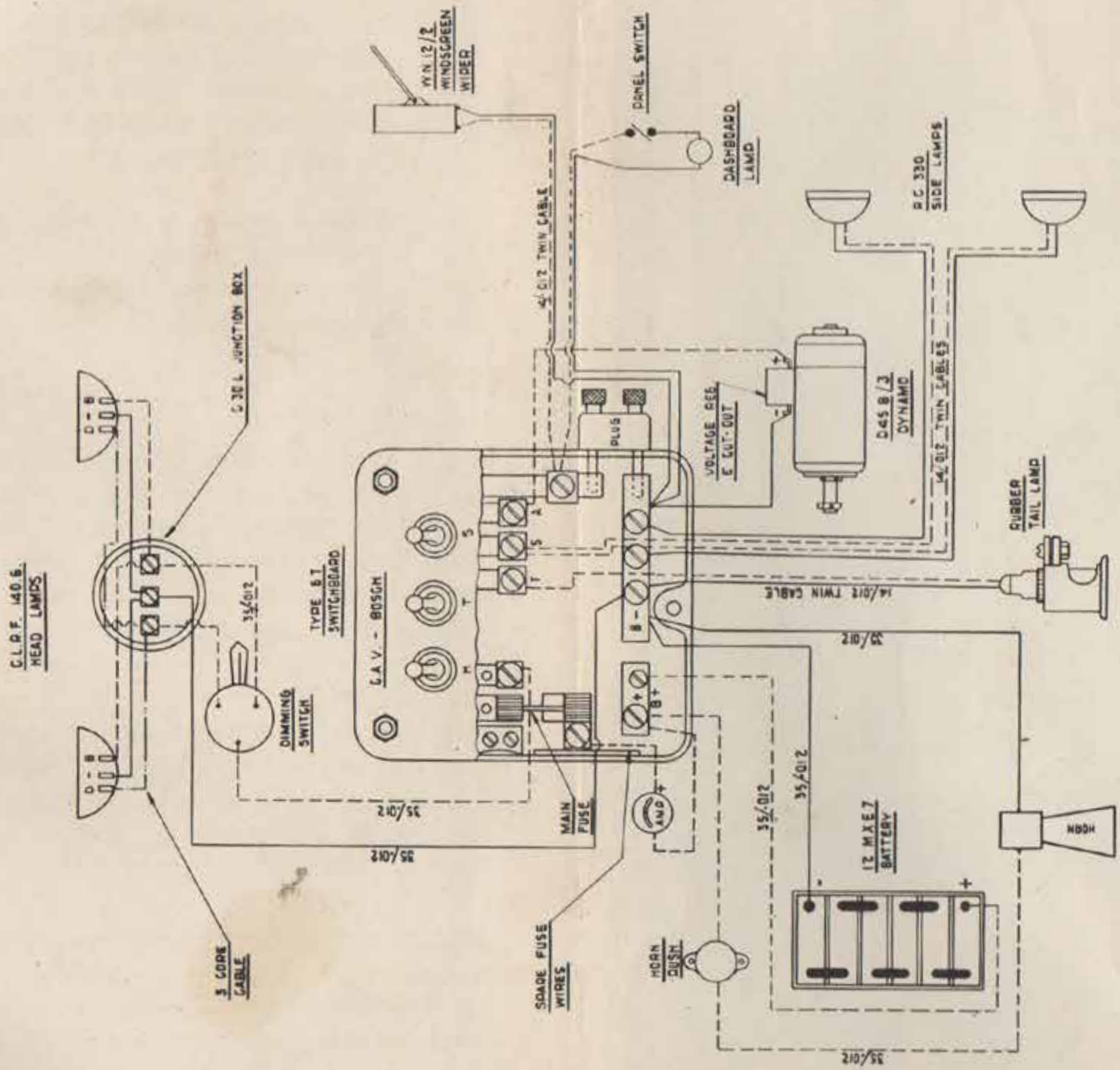
Location of Faults.

MAIN FUSE "BLOWING."—The main fuse protects the dynamo in the case of a battery connection breaking or short-circuiting. In the event of this fuse "blowing" all battery connections should be examined, including those between the cells. The terminals should also be examined in case they have worked loose. If the main fuse has blown the ammeter will not show its usual charge.

To fit a new fuse wire the switchboard front cover must first be removed by taking off the three nuts and spring washers securing it. The fuse holder, situated at the L.H. side of the box can then be withdrawn and a new wire fitted. Spare fuse wire is carried in the switchboard.

FAILURE OF LIGHTS.—If the lights fail when in use, the following are likely causes:—

- 1 Battery run down. This is usually caused by neglect, and the battery must be charged as soon as possible.



_____ INDICATES BLACK WIRE (-)
 - - - - - INDICATES RED WIRE (+)
 INDICATES BLUE WIRE (DIM)
 (OR WHITE)

WIRING DIAGRAM ~ S-TYPE SENTINEL WAGON

- 2 If the battery is charged and the lights suddenly all fail, the cause of the trouble is probably a short-circuit. The connections to lamps and horn should be examined, particularly at their ends, as this is where a break generally occurs. When the faulty connection has been discovered it should be disconnected *at the switchboard end*, and the remaining lamps will then light. The ammeter will not show a reading when there is a short-circuit.
- 3 If the lights gradually fail when the dynamo is not charging, the acid should be tested and if weak the battery should be charged before fresh solution is added.

MAINTENANCE OF SET.

- 1 CONNECTIONS.—These must be tight and clean, particularly the connections to the battery. These precautions apply to any system but are too often lost sight of.
- 2 FUSES.—Keep to the size recommended. If the fuses blow continuously the dynamo is overloaded, due to one or more cells in the battery being short-circuited, or through an excessive load being applied either in the form of lamps or accessories, or to a short-circuit in the wiring.
- 3 The regulator should never be interfered with. It is very carefully manufactured, adjusted, tested and sealed at the factory, and embodies the results of a very large amount of careful development work.
- 4 CUT-OUT.—This is also sealed, and should only be examined by a skilled electrician.
- 5 DYNAMO.—See that the brushes slide freely in their holders, and that the tags or pigtails do not catch in any part of the brush gear.
The bearings should be lubricated every 10,000 miles.

To test whether the set is working normally, run the dynamo at 1,200 r.p.m. or more and switch on all the lamps. If the battery is well charged the ammeter will indicate a small discharge at once. This discharge will gradually become less and within an hour the ammeter will show a small charge.

If the battery is discharged the ammeter will indicate a charge at once, and the more the battery is discharged the greater will be the charging rate.

NOTE.—The reason for this discharge is that when the lamp load is switched on suddenly, the dynamo output goes up and does not immediately cover the lamp discharge. This is because the battery voltage has risen so much that it temporarily takes a portion of the discharge. As the battery voltage settles down the whole of the discharge is taken by the dynamo and a small charge is also put into the battery.

Engine.

The engine is of the 4-cylr. single-acting trunk piston type with the reciprocating parts balanced by weights on the end crankshaft webs. Having a $5\frac{1}{2}$ " bore and 6" stroke, the engine is capable of developing 120 B.H.P. The feed pump and camshaft drive casing, the crank chamber, and the gear casing are all combined in one aluminium casting on to which the two twin cylinder block castings, the feed pump casing and the engine sump are bolted direct. The solid forged crankshaft of nickel steel is mounted on three main bearings, white metal lined, with a shim and liners at either side, the shims being $\frac{1}{32}$ " thick and consisting of 0.003" laminations. The connecting rods and caps, also of nickel steel, have floating gudgeon pins at the top end and split gun metal bushes, white metal lined, at the bottom end. Liners

and shims separate both sides of the crankpin brasses. Each shim is $\frac{1}{32}$ " thick, consisting of 0.003" laminations. The cylinder covers are cast in pairs and contain the steam and exhaust valve seats and ports, also faces for the steam and exhaust branches. Threads of caps should be covered with oil to which graphite has been added to the consistency of paint, this applies to all screwed connections.

The valves are of the poppet type, one steam and one exhaust for each cylinder. For removal and grinding in the steam and exhaust valves separate caps are screwed into the cylinder heads.

The camshafts are driven off a pinion on the crankshaft at the front of the engine. The steam camshaft runs fore and aft along the top of the crankcase. It is mounted on three cast iron bearings in a separate chamber, the exhaust camshaft is similarly housed at the bottom.

The end bearings are so designed that oil splashed from the gearings is retained and works its way along, lubricating the cams and the centre bearing. Each valve can be operated by five different cam profiles, *i.e.*, forward start, forward slow, forward fast, drain and reverse. Cam stops of aluminium with gun-metal bearing surfaces are bolted to either end of the crankcase, in order to prevent the camshaft from travelling too far in the fore and aft direction. The valve opening is brought about by a case-hardened cam follower sliding in a guide, a short push rod with spherical ends, and an adjuster screwed on to the valve stem. A return spring is held between collars, one on the adjuster and the other on the cylinder head casting.

The pistons, of cast iron, are fitted with four pressure rings, and one scraper ring. The latter scrapes back crankcase oil, which is splashed on to the cylinder walls, and allows it to return to the sump through holes in the

base of the crankcase. The pressure rings prevent as far as possible any water from getting into the crank chamber.

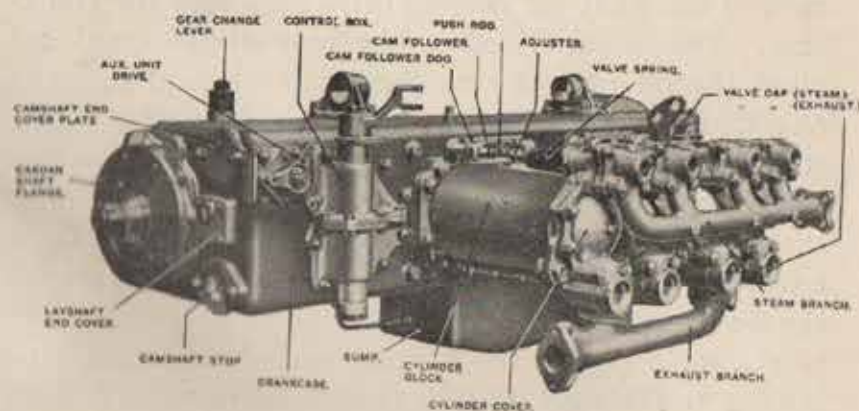
The back of the crankcase has three separate covers, one for the pump end, one for the gearcase, and one for the crank chamber. The gearcase cover houses the gear change lever spindle.

The gearbox contains two forward gears, top gear being direct driven, and low gear, through a layshaft, being 2.72 to 1. Top gear is effected by a spur gear, with an internal spline, which slides on the crankshaft extension piece. The layshaft is driven continually by a pinion on the crankshaft. At the back end of the layshaft a spiral gear driven by dogs drives the auxiliary unit.

The gearcase, pump end and camshaft housing are kept independent of the crank chamber by means of the division plates in the crankcase casting.

The complete engine is three point suspended on the frame. One of the suspensions is fitted with rubber buffers in order to prevent any vibrations set up by the engine, being transmitted to the frame.

A flywheel is fitted just behind the engine.



Engine of Model S Sentinel.

The cam operating fingers are housed in the control box casting, which acts as the gear casing front cover.

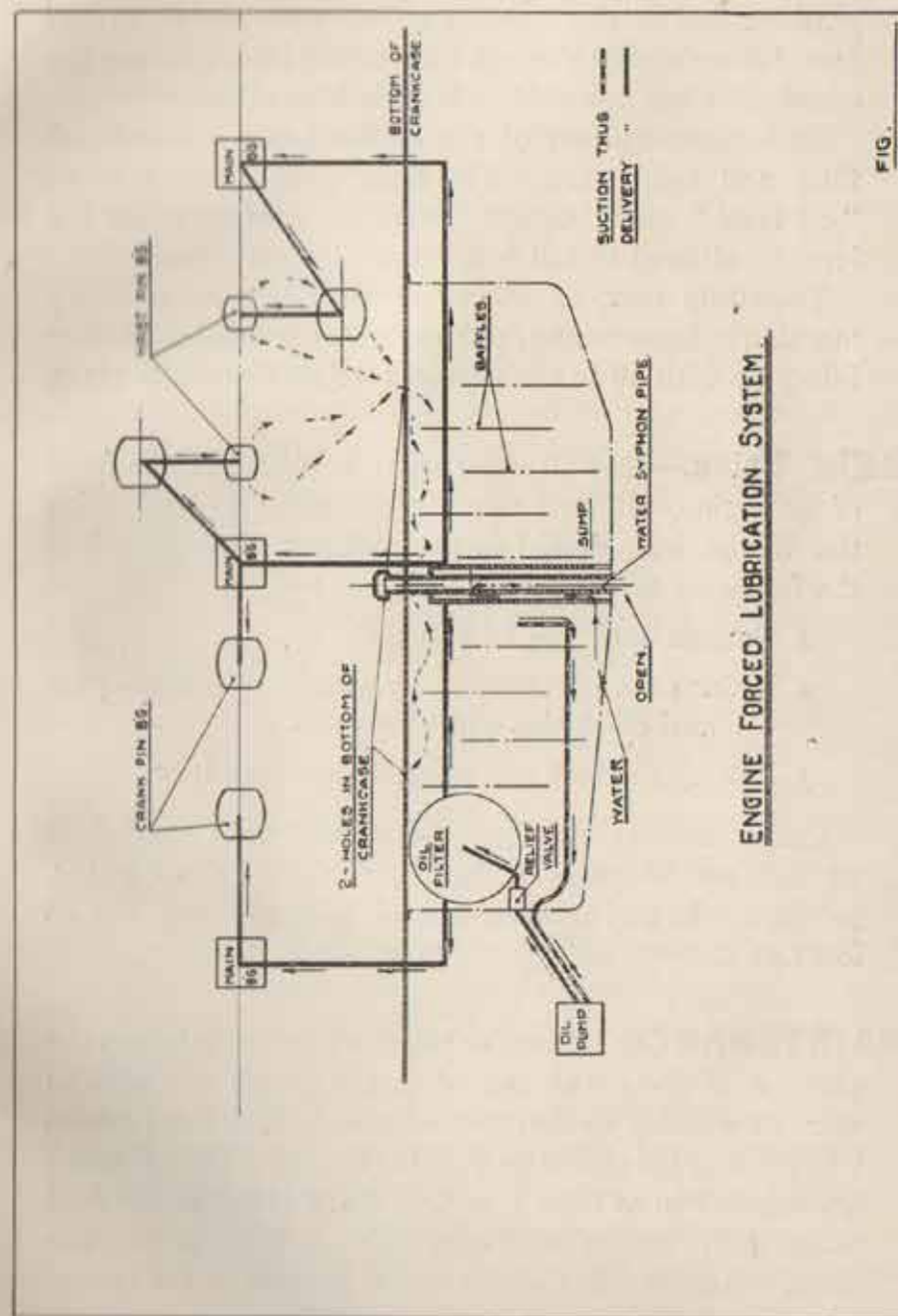
A breather situated on the top of the crankcase prevents any pressure from being built up by the movement of the pistons.

Engine Lubrication System.

The engine main bearings and connecting rod bearings are lubricated by a forced lubrication system. Oil returns to a sump where any water in it is separated and discharged automatically. The pump casing, gear casing, camshafts and their driving gear are lubricated by an entirely separate splash system.

Crankcase Forced Lubrication System.

Oil is drawn from the sump by a pump situated at the front of the engine. The delivery from the pump passes a relief valve to a fine mesh filter, from whence it is forced through holes cored in the crankcase and through a copper pipe to the three main bearings. The crankshaft and connecting rods are drilled so that the crankpins and wrist pins receive oil from the main bearings. This completes the pressure flow and the oil which is forced out at the ends of the wrist pin bushes, drips back into the crankcase. Two holes drilled in the base of the crankcase allow the oil to return to the sump where a series of aluminium baffle plates separates it from the water, thus allowing the latter to fall to the bottom. A syphon pipe is situated in the sump, by means of which water cannot rise above the level of the pump suction. Once a certain safe level is reached the weight of the oil pushes the water up through the outer pipe and through holes to the inner pipe. The bottom end of this inner pipe is open to the road, so that any excess of water is constantly drained off.



ENGINE FORCED LUBRICATION SYSTEM.

FIG.

A level equalising pipe connects the pump end to the gearcase end of the crankcase. This prevents one end from becoming dry through oil working its way along the camshaft when the vehicle is on a long slope.

Each compartment of the engine has a separate oil filler and sight glass. The sight glasses are marked "oil level" and "danger." On no account must the level be allowed to fall below the "danger" line.

The drain cock on the sump *must* be opened every morning before starting, and any water drained out before filling up with oil to the normal level on the gauge glass.

Relief Valve.—The oil relief valve is placed at the front of the engine. It is set correctly on every waggon leaving the Works, but, should further adjustment be required the following action should be taken:—

- 1 Slacken back the lock nut.
- 2 Reduce the oil pressure by turning the brass plug anti-clockwise and vice versa.
- 3 Pull up the lock nut against the sump boss.

Under normal running conditions when engine is warmed up, oil gauge on dashboard should show 10 lbs. pressure. In hot weather the oil pressure may fall as low as 2 lbs.

MAINTENANCE.—Inner or top dead centre refers to the position of the crank pin when the piston is about to start its working stroke, and outer or bottom dead centre when it is at the end of its working stroke. The cylinders are referred to as Nos. 1, 2, 3, 4, No. 1 being at the feed pump end. Steam admission order is 1, 4, 2, 3. The crank chamber refers to the centre portion of the crankcase.

Valve Gear.

ADJUSTMENT AND CLEARANCES.—It is essential that the clearances between the cam followers, push rods and valves be correctly maintained. Incorrect clearances lead to loss of power and uneven running of the engine, which may show itself in vibration.

To adjust the clearances slacken off the adjuster lock nut, hold the valve stem with the special thin spanner provided and screw the adjuster in or out as required, until the push rod can just be rotated by the finger and thumb when the engine is cold; then tighten up the lock nut. There should be the smallest appreciable clearance to the push rods when engine is hot. Make sure that cam follower is well clear of its cam when making adjustments.

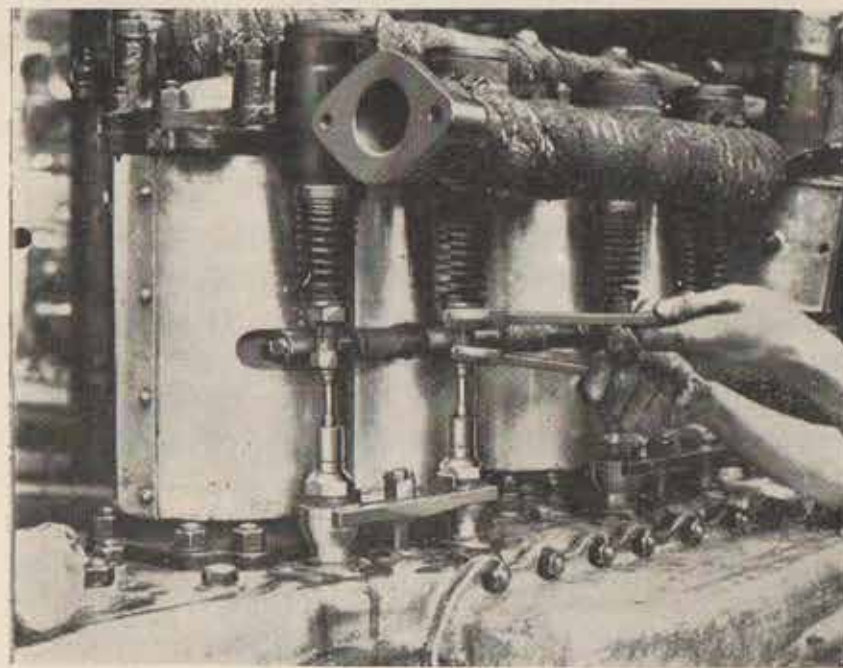
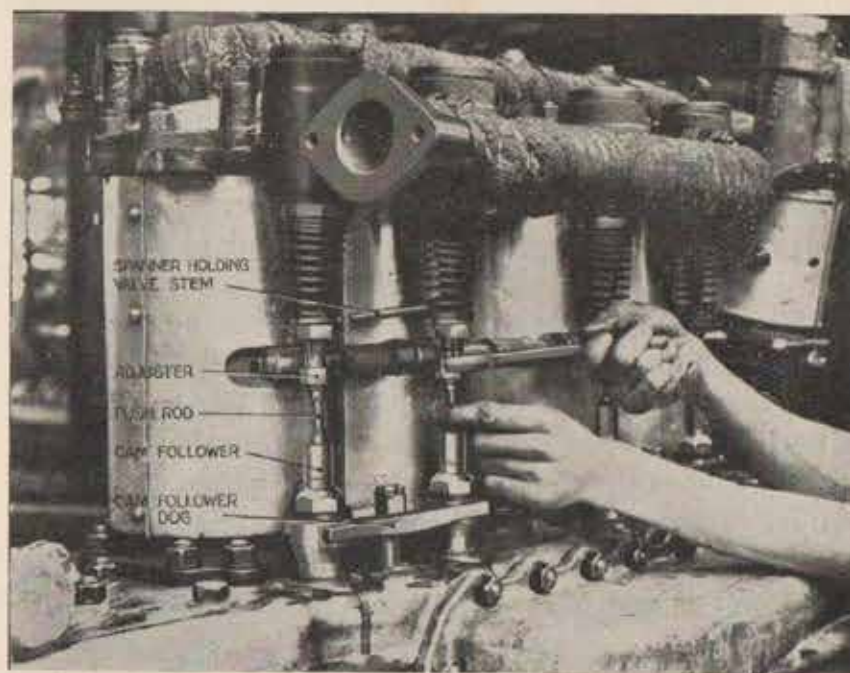
GRINDING IN VALVES.—Leaky valves will cause loss of power. Generally they will require examination and grinding in about every 25,000 miles.

VALVE STEMS.—The valve stems are provided with water grooves, and are a good working fit in the valve stem guides. When the former become worn, leakage will occur, and valves with oversize stems can be obtained and fitted, or a new valve and guide may be fitted.

CAM FOLLOWERS.—These are the parts of the valve gear which work in guides in the crankcase, and bear directly on the cams. They should be examined about every 25,000 miles, and replaced if undue wear has taken place.

VALVE SETTING.—The valve setting cannot alter unless the crankshaft or camshafts have been withdrawn, or the timing pinions moved. In order to reset or check the timing carry out the following instructions:—

No. 1 Cylinder cover is provided with a hole, sealed by a plug, the removal of which admits a timing rod for



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 the lower illustration the method of tightening the adjuster locknut after the correct clearance has been obtained is shown.

ascertaining "top dead centre." The best method to employ for finding this position is to turn the engine till No. 1 is approximately on top dead centre; then mark the timing rod 1" from the plug hole face. Now rotate engine both clockwise and anti-clockwise until this mark is flush with the plug hole face, marking both positions on the cardan shaft coupling to register with a pointer which can be temporarily fixed to any convenient stud. Mark the halfway distance between these lines, again turning the engine until the pointer coincides with this mark. The piston is now at the beginning of its working stroke, and the crankshaft on top dead centre. In this position the camshafts can be meshed with the crankshaft pinion with their arrows truly vertical. It must be noted that the steam and exhaust camshafts are not interchangeable, and are marked S and E respectively.

Withdrawal of Camshafts.—In order to withdraw steam and exhaust camshafts, take off flywheel on cardan shaft flange. Remove the camshaft stops, and the cover plate at the back end of the steam camshaft. Take off the control box, This is made in halves which need not be separated. (To do this the feedheater must be lowered from frame.)

Remove flexible shaft between auxiliary unit and engine (gear box end) and slacken off the four nuts securing housing. Withdraw housing complete with spiral gear. Take off camshaft timing pinions. A $\frac{3}{8}$ " Whitworth screwed rod should be used to withdraw these. Take out all push rods and draw cam followers clear of cams.

Push camshafts to the rear, using a piece of round wood, until they are clear and can be conveniently handled.

NOTE.—When meshing the camshafts with the crankshaft pinions see that the arrows point vertically upwards.

NOTE.—On short tipping waggons, where the engine is close to the boiler, the engine must be lifted clear of frame in order to withdraw camshafts.

Withdrawing Line of Parts.—A complete line of parts comprising piston, gudgeon pin and connecting rod may be removed in the following manner :—

Remove steam and exhaust branches, and take off cylinder cover complete with valves, springs, etc.

Slacken off nuts securing crankcase back cover and remove cover.

Turn engine to bottom dead centre and remove connecting rod cap and bottom half bush.

Again turn engine, bringing connecting rod clear of crankpin, and push piston through front of cylinder.

When replacing cylinder cover draw up evenly, tightening pairs of opposite nuts in rotation.

PISTON RINGS.—If there is a loss of power which cannot be traced to the valve gear, it is probable that the piston rings are worn. This would also show itself by more than the usual amount of water collecting in the crankcase. The line of parts should be withdrawn, and the piston rings renewed as necessary.

OIL SCRAPER RINGS.—It is desirable to replace these when the piston rings are renewed. If the oil consumption is tending to increase it is probably an indication that the oil scraper rings require renewal.

GUDGEON PINS.—These are of Nitralloy steel and are free to float in the connecting rod bush, and the piston bosses. They should run 100,000 miles without requiring attention.

BIG END BEARING.—These are provided with laminated shims for easy adjustment, and should be adjusted so that when the caps are tightened up with the rod in a horizontal position, the rod will just not fall by its own weight.

Crankshaft Withdrawal.—The crankshaft can be withdrawn without removing engine from chassis. To do this :—

Remove crankcase, gearcase and pump end back covers.

Uncouple big end bearings.

Remove division plates at either end of crank chamber, thus giving access to the main bearing cap nuts.

Remove main bearing caps.

Push connecting rods clear of crankshaft which can then be withdrawn.

When re-assembling, note that all main bearing caps, nuts, bolts, shims and brasses are numbered for their respective positions, and must be re-assembled accordingly.

NOTE.—Gearcase and pump end covers should not be removed until the oil is drained out of these compartments.

Crankcase Main Bearings.—These are fitted with laminated shims for easy adjustment. All the bearings must be adjusted together.

Separating Connecting Rods from Piston.—The gudgeon pin is a running fit in the piston, and is retained by a bolt with a large washer head and a light dished disc; when the bolt and washer head are removed the gudgeon pin will drop out. It should be noted that the

numbering on the connecting rod is on the same side as the pin fixing gudgeon pin, and when entering the cylinder should be towards the feed pump end of the engine.

Crankshaft Felt Rings.—Between the crankshaft and pump casing, and crankshaft and gearbox, felt rings are provided to prevent oil passing from crankcase to pump casing, or gearbox, or vice versa. It is important that these be kept tight and they should be renewed if necessary, having been soaked in oil before fitting.

Withdrawing Gearbox Layshaft.—This may be withdrawn by fitting a withdrawing clamp over the end of the layshaft and driving on the engine end with a long bar in the crankcase. The engine end is hollowed for this purpose. A special clamp, can be supplied either by us or by any "Sentinel" Depot.

Removing Engine from Chassis.—An eyebolt is provided on the crankcase between the two centre cylinders just over the camshaft. This is fitted vertically above the centre of gravity of the engine, and will allow of the engine being dropped without any elaborate arrangement of slinging.

Feedheater.

The Feedheater fitted to the Model 'S' "Sentinels" performs three entirely separate duties. Firstly, it heats the boiler feedwater to a high temperature; secondly, it separates out any water and oil which may be contained in the exhaust steam. This takes place by the action of the exhaust entering the heater circumferentially and being forced to swirl round inside it, any particles of oil or water striking the walls and thus falling to the bottom. This separation dries the steam,

thereby lessening the show of vapour at the funnel top, and by the removal of oil, helps to prevent the blast nozzle from making up with carbon. Thirdly, when the waggon is travelling downhill and the engine is creating a vacuum, any solid matter drawn down the blast pipe is trapped in the water at the bottom of the heater and is thus prevented from passing into the engine.

The Feedheater body is cast in halves, bolted together with an asbestos joint between them.

The single coil is not held by dogs in any way, but is a tight fit in the body, which is lagged with asbestos sheet covered with aluminium.

The drains from the feedheater and exhaust line are carried forward to the ashpan.

MAINTENANCE—Removal of Coil.—Should it be necessary to remove the coil, proceed as follows:—

- 1 Remove bottom cover. The drain valve *need not* be taken off this cover.
- 2 Take out the bolts joining the halves.
- 3 Take the bolt out of the bracket holding the rear half, and this half will come away.
- 4 Uncouple feedwater inlet and delivery pipes, and take off delivery pipe special nipple.
- 5 Take off both lock nuts.

The coil can then be withdrawn.

When the coil is out it should be thoroughly cleaned, as also should the inside of the body.

Feed Pump.

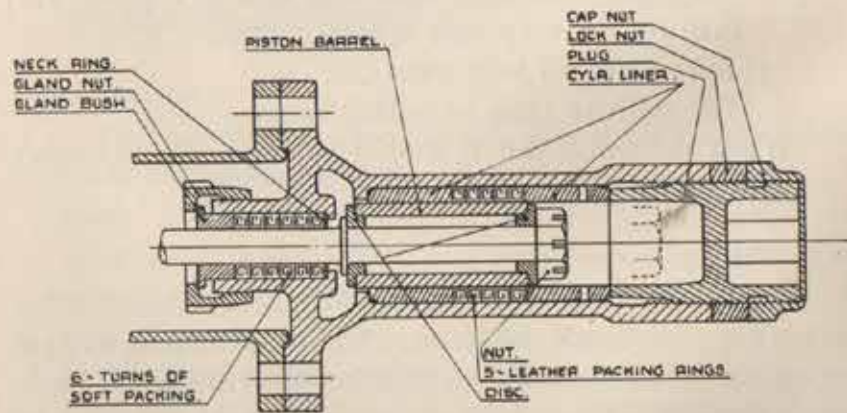
The feed pump is of the slow-running double-acting ram type driven off the forward end of the engine by spur gearing. The stainless steel bucket runs in leather packing rings which are held stationary in the cylinder by gunmetal liners. Built as a complete unit in itself, this

pump can be removed from the engine in a few minutes. It is smooth in action and simple to take down and reassemble in the event of any moving part or packing needing renewal.

MAINTENANCE.

FITTING NEW $\frac{1}{4}$ -INCH TALCROM PACKING RINGS.—Unscrew the cap and lock nuts, using the special open-jawed spanner provided. The plug can then be removed by a special hexagonal bar spanner. Turn the engine until the feed pump bucket is in the inner dead centre position. Withdraw the outer cylinder liner with a hook or piece of bent wire inserted in one of the holes provided. The packing rings can then be removed and new ones pressed in. Five turns of packing are used (four in the earlier engines). When the liner is put back the plug should be screwed up tight and the lock nut screwed up to the face of the body.

NOTE.—Two flats are cut on the thread of the plug. If there is thread showing between the lock nut and these flats when the plug is tight up, one turn must be



FEED PUMP PACKING

removed or the cap nut will not go on. If, on the other hand, the flats are completely covered by the lock nut, another turn must be pressed in.

This point must be closely watched should the cap have been removed and the plug tightened up because of leakage in the pump.

RE-PACKING PUMP ROD— $\frac{1}{4}$ " TALCROM PACKING.—Remove feed pump dust cover, gland nut and bush. All the old packing should then be removed and six new turns fitted. Replace the bush and tighten up the nut so that the rod can just be moved up and down in it. Replace dust cover.

FITTING NEW PISTON BARREL.—The pump should be dismantled as for fitting new packing rings. The packing rings should be taken out, and the piston rod nut taken off. The top disc can then be removed and the barrel withdrawn.

Removal of Feed Pump.—The Feed Pump assembly is a unit in itself, and can be removed from the engine in the following manner:—

- 1 Drain oil from pump end of crankcase by removing plug.
- 2 Remove back cover from pump end.
- 3 Remove nut and draw out pin connecting oil pump plunger with its connecting rod (if plunger pump is fitted).
- 4 Uncouple feed pump suction and delivery valves.
- 5 Remove nuts holding feed pump casing to engine crankcase.
- 6 Withdraw feed pump complete with eccentric and oil pump connecting rod.

NOTE.—If mechanical stoking gear is fitted, uncouple driving rod before removing back cover.

Renewal of the Crosshead Scraper Ring.—Should a leakage of oil be seen round the feed pump dust cover, the fault probably lies with the crosshead scraper ring. In order to inspect the existing ring and fit a new one, if required, the following instructions should be carried out :—

- 1 Remove feed pump from engine.
- 2 Slacken back piston rod lock nut.
- 3 Turn eccentric to inner dead centre.
- 4 Unscrew piston rod from crosshead by means of the flats on the rod.
- 5 Remove eccentric sheave pin set-pin and knock out eccentric sheave pin with a hammer shaft or block of wood.
- 6 The eccentric sheave, strap, and the crosshead can then be drawn out, the ring inspected and renewed, if necessary.
- 7 Assembly takes place in the reverse order. It is necessary to put a band or a piece of copper wire round the oil scraper ring to hold it tight down in its groove when entering it into the crosshead guide.

Defects.—If the pump does not deliver sufficient water to feed the boiler, the following are the probable causes :—

- 1 Pump valves leaking or not seating properly, due to dirt lodging on the valve faces; the valves should be examined and ground in if necessary.
- 2 Pump plunger packing leaking; tighten up or repack as described above.
- 3 Pump rod packing leaking; this will be seen by water dripping from the pump, and the gland should be tightened up or re-packed as required.
- 4 Pump piston barrel badly worn; renew as described above.

- 5 Water strainer on water tank choked or dirty; close shut down valve, take off end cover of filter and clean strainer.

Front Axle and Steering.

The front axle is of "H" section drop forged, heat treated alloy steel. The stub axles are mounted on "king" pins, the thrust and steering loads on which are taken by roller bearings at the top. The wheels are also mounted on roller bearings, which are made adjustable to take up any wear which occurs.

The springs are fastened by four bolts to strong pads on the axle.

The steering is of the screw and nut type, the nut being designed to give the maximum bearing surface. The casing, of aluminium, is bolted to the front cross channel, and offside channel of the frame. At the top of the steering spindle is mounted a ball race enclosed in an aluminium casing. This ball race takes all the steering load. The steering wheel is keyed directly to the spindle which is housed in a tubular casing. The steering nut is centrally supported by the weighshaft which is mounted on leaded bronze bearings, one in the casing and the other in the cover. The drop lever is keyed to the weighshaft.

DEFECTS.

Wheels out of Alignment.—The trackrod should be set so that the wheels are parallel or so that they are "toed in" up to but not exceeding $\frac{1}{16}$ " at the front. This should be checked periodically. If, for any reason, the wheels do get out of alignment (the wear on tyres and the "feel" of the steering generally shows this up), the ends of the track rod should be slackened off and the track rod screwed in or out as required.

Play in Steering.—There are two places where wear may take place; these are, either in the screw and nut, or in the ball ends of the drag link. Provided the steering casing is kept properly lubricated the former cause is very unlikely. The ball ends are screwed up tight and if any play is noticeable the end at fault should be dismantled and the worn part renewed.

Play in Hub Roller Bearings.—If side play in the wheels is noticeable the hub cap should be removed, the set pin withdrawn and the nut knocked round until this play is taken up. Generally speaking, backing off the nut three holes from the position where binding in the bearing is felt will provide approximately the end-play necessary.

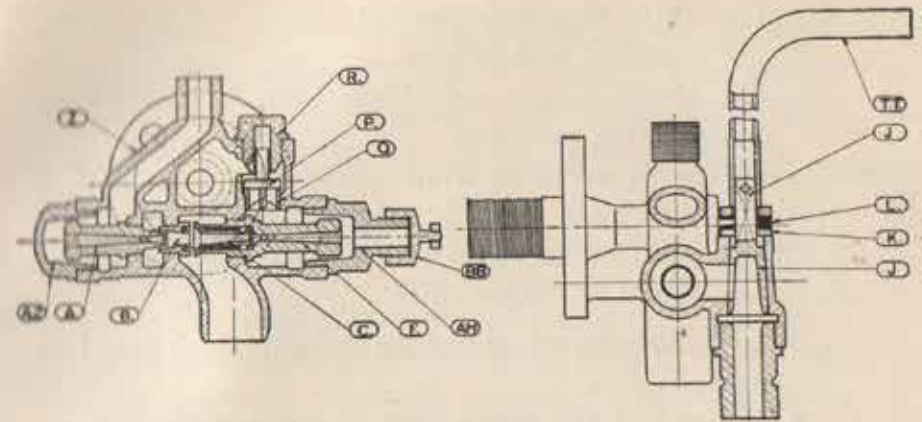
NOTE.—There *must* be a trace of rock or play in the bearings when the adjusting nut is in its final position, *i.e.*, with the locating pin inserted and the pinch bolt tightened.

Injector.

The Boiler Injector is situated centrally under the cab floor boards, and is supported by an aluminium bracket. A sectional illustration of the Injector is given on next page.

To work the Injector see that the Boiler Check Valve is open, and open the watercock (TT) full. Open the steam valve on the boiler slightly, waiting until the injector picks up water before opening it full. If the overflow is not "dry," gradually close the watercock until it becomes so, and the injector "sings." The overflow can be heard from the cab.

To shut off the injector close the steam supply valve, and then close the watercock in order that any leakage



A.	Steam Nozzle.	K.	Watercock Stop Washer.
A2.	Steam End Cap.	L.	Watercock Spring Washer.
AH.	Delivery End Nipple.	P.	Delivery Back Pressure Valve.
B.	Lifting Tube	Q.	Delivery Back Pressure Valve Seat.
BB.	Delivery End Cap.	R.	Delivery Back Pressure Valve Cap.
C.	Sliding Thimble.	TT.	Watercock Operating Rod.
F.	Delivery Nozzle.	Z.	Injector Body.
J.	Watercock Plug.		

through the steam and delivery stop valves will drain through the overflow. With the watercock open this leakage tends to heat up the suction pipe and make starting difficult.

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.

DEFECTS.—If, when the steam is turned on, the Injector will not pick up its water:—

- 1 The supply of steam is not dry.
- 2 Leakage has made the water pipe hot, which prevents the Injector lifting.

- 3 The water supply is too hot.
- 4 The overflow is restricted.
- 5 The steam nozzle or lifting tube is blocked or choked with sediment.

NOTE.—To remove sediment from nozzles, wash out with a solution of one part muriatic acid and ten parts water, or with paraffin ; then clean with a shaped piece of wood. Never use metal or emery cloth.

- 6 Air leakage in water pipe, or the watercock plug has worked loose.
- 7 The end of the water pipe or strainer clogged, or not covered by water in the tank.

If the Injector gets its water, but forces it out through the overflow :—

- 1 Defective steam supply.
- 2 The water supply is too hot.
- 3 Jumper or Delivery Nozzle choked. (See note to 5 above.)
- 4 Back pressure valve sticking.

NOTE.—When the steam pressure is under 160 lbs. per square inch water will often run from the overflow if the watercock is fully open, even though the injector is working, in which case the watercock should be regulated until the injector works dry. Do not confuse this with water running from the overflow owing to failure to work.

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.

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 fully until it picks up its water again, after which the watercock can be partially closed to its previous position.

MAINTENANCE.

Stripping the Injector.—By shutting off the steam supply, boiler check and water tank strainer valves, the Injector may be completely stripped whilst the boiler is under steam.

- 1 By removing the steam end cap (A2), the steam nozzle (A) can be screwed out.
- 2 To remove the delivery nozzle (F) and the sliding thimble (C), take off the delivery end nipple (AH).
- 3 Remove the delivery valve back pressure cap and the valve (P) can be withdrawn or ground in.
- 4 The delivery valve seat (Q) is pressed in and drivers must not attempt to take this out.
- 5 The lifting tube (B) requires a special tool for removal, and this should not be attempted by drivers.

(The letters apply to illustration on page 63).

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.

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

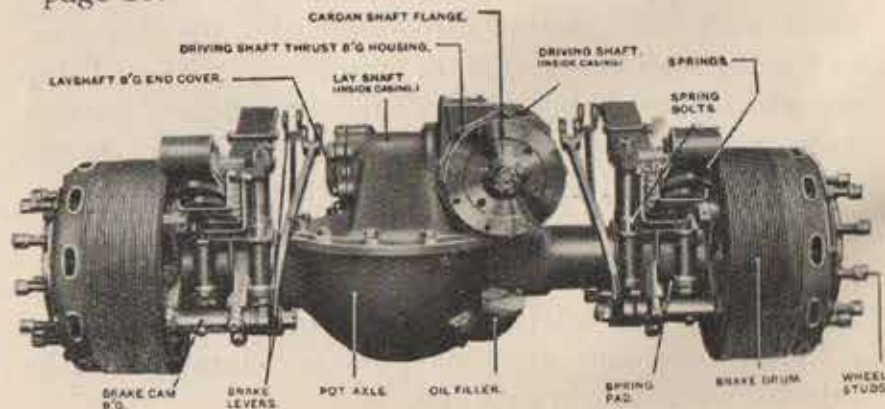
Water Lifter.—If this does not pick up water quickly, or is slow in filling tank, faults may be as follows:—

- 1 Leaky water lifter steam valve causing water lifter to become overheated so that it is difficult to start lifting water.
- 2 Suction hose pipe choked, collapsed, or perished so that lifter draws air.
- 3 Steam nozzle or injector body partly choked, or steam nozzle corroded.

Rear Axle.

The rear axle is of the three-quarter floating type consisting of a single "pot" forging with double reduction gear, comprising a spiral bevel drive to a layshaft and thence to the differential by double helical gears. Hubs are dispensed with, the driving shafts being flanged over at the ends to carry the disc wheels. The lay and driving shafts are mounted at either end on roller bearings with one additional ball race on each to take the end thrust of the gears. Spring pads are pressed on to the ends of the axle. These are designed to carry the brake shoe spindles and cams as well as the springs.

For lubrication of rear axle, see "*Weekly Attention*," page 16.



Rear Axle of Model S4.

MAINTENANCE.

To Remove Differential—

- 1 Take off the rear wheels, after jacking up the axle.
- 2 Remove nuts from brake drum studs and the drums will pull off.
- 3 The wheel stud back nuts can then be slackened off and the studs withdrawn.
- 4 Pull out the driving shafts.
- 5 Remove nuts from studs securing rear axle casing to pot axle.
- 6 After uncoupling the cardan shaft at the axle end, the casing can be lifted off complete with differential.
- 7 To remove differential take off the bearing housing caps.
- 8 The differential casing can then be split and the gears removed as required.

Removal of Layshaft.—The layshaft lies crosswise on top of the axle, and is driven off the double helical gear in the differential.

Before the layshaft can be withdrawn, the driving shaft must be removed as explained below. The layshaft can then be withdrawn thus:—

- 1 Remove bearing housing cap and bearing housing complete with ball race, and roller bearings.
 - * 2 Insert special flanged sleeve and tighten up on housing studs.
 - 3 Remove blank cover from other end of rear axle casing and take off nut and locking washer.
 - 4 By means of a round bar, drive the layshaft off the bevel gear, the special sleeve taking the load off the roller bearing.
- * This sleeve can be obtained either direct from us, or from one of the "Sentinel" Depots.

- 5 After removing the shaft, the bevel can be withdrawn through the opening for the driving shaft bevel.

Removal of Driving Shaft.—The driving shaft is that shaft which is coupled direct to the cardan shaft. In order to remove it from the rear axle casing, take off the end roller bearing housing and remove the nuts from the studs, securing the casing cover at the cardan shaft end. The casing cover can then be withdrawn complete with driving shaft, bevel gear, ball race and roller bearing.

Removal of Brake Shoes.—Remove wheels and brake drums in the manner already described, and by removing the nut and spring from one end of the relieving spring rod the shoes can be withdrawn.

Tools and Accessories.

A list of Tools and Accessories supplied with "Sentinel" Model 'S' Waggon and their uses, is given below. Long tools and spanners are stowed in a tool box under the footrests, and lighter ones are kept in the drawers under the driver's seat. The jack is fixed on the tyre carrier under the platform at the rear, and the Tecalemit Grease Gun is held in clips under the dashboard. The coaling ladder, if supplied, is carried under the platform in the case of flat-platform waggons, and across the rear wings on tippers. The combined slicer and pricker is carried across the front of the bunkers. The hose is hung on a carrier on the near side of the waggon. Oil cans are carried at the side of the driver's and stoker's seats.

Tool or Accessory.

Use.

Tool or Accessory.	Use.
1 Coaling Ladder.	(if required).
1 Leather strap for Coaling Ladder.	" "
1 Lifting Jack.	" "
1 30ft. Suction Hose and Strainer.	
2 Leather Straps for Hose Pipe.	
1 Set of Firebars.	
1 " Tecalemit " Grease Pump.	
2 1 gall. Cans for oil.	
1 3-pint Can for paraffin.	
1 2-lb. Tin of Grease.	
1 Fire Slicer and Pricker.	
1 Hammer and Shaft.	
1 Podger for Box Key.	
1 $\frac{3}{8}$ " to $\frac{1}{2}$ " Box Key.	
1 Boiler Filler.	
1 $\frac{1}{2}$ -pint Oil Feeder.	
1 Fire Shovel.	
1 Flat Chisel.	
1 Valve Stem Spanner.	Adjusting Clearances.
1 $\frac{5}{16}$ " to $\frac{3}{8}$ " D.E. Spanner.	
1 $\frac{1}{2}$ " to $\frac{1}{2}$ " ..	
1 $\frac{7}{16}$ " to $\frac{9}{16}$ "	
1 $\frac{9}{16}$ " to $\frac{11}{16}$ "	
1 $\frac{1}{2}$ " to $\frac{3}{4}$ "	
1 $\frac{3}{4}$ " to $\frac{1}{2}$ "	
1 $\frac{3}{4}$ " to 1"	
1 $1\frac{1}{4}$ " to $1\frac{1}{4}$ "	
1 $\frac{1}{2}$ " & $\frac{3}{4}$ " Hex Bar Key.	Steam and Exhaust Valve Caps.
1 Special $\frac{1}{2}$ " Box Key.	Cyl. Head Nuts.
1 $\frac{3}{8}$ " to $\frac{3}{16}$ " Box Key.	Main Bearing Bolts.
1 $1\frac{1}{4}$ " Spanner.	Feed Pump Cap Nut.
1 Boiler Flex. Cleaning Pipe.	
1 Licence Holder.	
2 Reg. Number Plates.	
1 Driving Mirror.	
1 Boiler Washout Plug Bar.	
1 Stop Valve Gland Spanner.	
1 Long Box Spanner for Wheels.	
1 Fusible Plug.	

Tool or Accessory.

Use.

- 12 Copper Washers.
- 11 Cut Joints.
- 1 Sq. ft. Jointing Material.
- 5 Pump Packing Rings, $\frac{1}{4}$ " sq. Feed Pump Barrel and Rod.
- 1 18" length of Stop Valve Packing.
- 1 3 ft. " Asbestos Cord.
- 2 Water Gauge Glasses.
- 4 " " Glass Washers.
- 1 Tyre Pressure Gauge.
- 1 Conical Seated Nut, R.H.
- 1 " " " L.H.
- 1 Fitting Tool.
- 1 Valve Box Spanner.
- 1 Operating Tool Cranked
- 1 " " Straight. } Tyre Tools
- 1 Length Air Hose.
- 4 Tyre Valve Adapters.
- 2 Cushions.
- 1 Engine Lifting Eye Bolt.
- 1 Key for Feed Pump Gland Packing Nut.

Water Tanks.

Two water tanks are situated in the cab, one on either side of the boiler, and are three-point mounted on the frame with rubber blocks. On the front of each an easily removable manhole door is placed for cleaning purposes. The tanks are connected near the bottom with a rubber equalising pipe. The tank on the stoker's side carries the filling connection, which is cut away to let any overflow run down the side of the boiler and through the floor boards, and carries the main level indicator, which shows the level of the water in both tanks. The other tank is fitted with a small indicator. This only starts to rise when the tanks are on the point of being filled to the top, warning the driver to take the hose away to avoid flooding the cab.

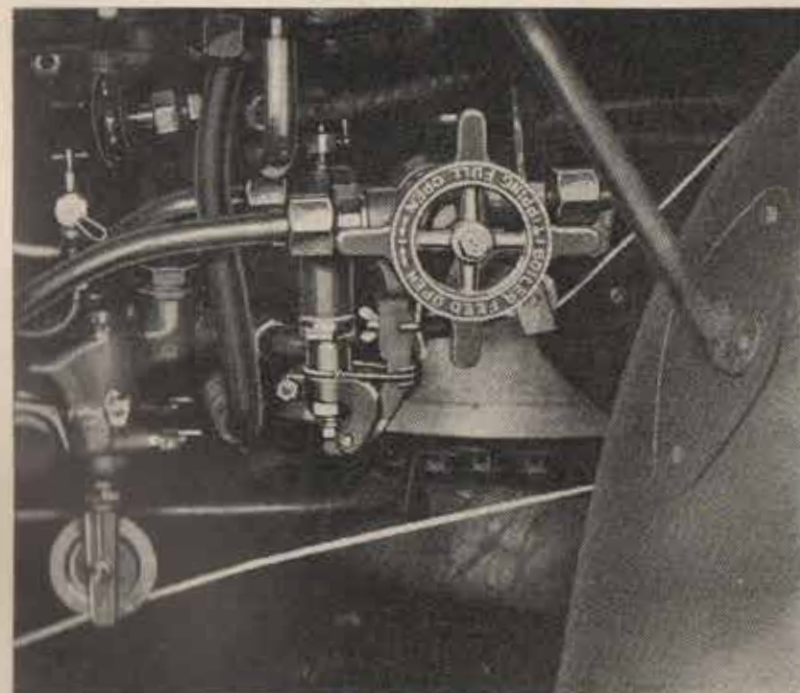
MAINTENANCE.—Washing out, etc., see "Occasional Attention," page 17.

Model S Tipping Waggon.

The tipping mechanism 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 sides 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 two-way control valve shown below should then be opened anti-clockwise. This diverts the feed pump delivery from the boiler check valve to the tipping system. The engine should then be run in neutral at a moderate



speed by opening the engine auxiliary valve under the offside tank. Water will now be pumped into the tipping system, but will be by-passing through the relief valve which is provided in this system.

By the side of the driver's seat there is a tipping control valve. When this is raised, pressure is exerted on the relief valve spring, thus causing pressure to rise in the tipping cylinder and tip the body.

The engine speed should be controlled to give even tipping action. If running too slowly, the body will rise with slight jerks. If too fast there may be undue strain on the tipping gear or pump.

When the body is raised to the requisite height, stop the engine.

To lower the body pull down the control valve handle by the driver's seat, thus releasing the pressure on the release valve spring and allowing pressure to escape and by-pass the water from the tipping cylinder back into the feed tank.

After tipping, be sure and turn the two-way valve to cut off the feed pump delivery from the tipping cylinder, and open again to the boiler feed system.

In the event of the driver forgetting to operate his two-way valve after tipping, the relief valve in the tipping cylinder will prevent any excess of pressure in the tipping cylinder provided the control valve on the driver's seat is in the down position.

"SENTINEL" SERVICE DEPOTS.

LONDON :

Minerva Road, Chase Estate, Action, N.W.10. Tel. : Willesden 6942

LIVERPOOL :

131, Vauxhall Road. Tel. : North 1264.

BIRMINGHAM :

35, Windmill Lane, Smethwick. Tel. : Smethwick 0331.

MANCHESTER :

Rugby Street, Broughton Lane. Tel. : Blackfriars 9664.

GLASGOW :

464, Pollokshaws Road. Tel. : Queen's Park 391.

ABERDEEN :

231, Market Street. Tel. : Aberdeen 3435.

STOCKISTS.

Reid & Lee. Tel. : Exeter 2368.

W. Bater & Sons. Tel. : Skewen 66.

A. S. McHugh & Co. Tel. : Newcastle 24068.

J. Fish & Sons, Ltd. Tel. : Bristol 5370.

Wingham Eng. Co., Ltd. Tel. : Wingham 2.

Mr. Fred Dyke. Tel. : Fareham 76.

NOTES.

Names of some Coals which are suitable for "Sentinel" Waggon.

Not all the Coals listed have been actually tested on the road, but "brands" submitted in sufficient quantity for this purpose and found to be satisfactory are marked T. Welsh Smokeless Coal is the best fuel for steam waggon. We ourselves use "Windber" for testing "Sentinels."

Welsh Coals.

"Aberclwyd."
Cory Bros. & Co., Ltd.,
Cory's Buildings,
Cardiff.

T Telephone : Cardiff 3114.
or Telegraph : "Cory, Cardiff."

"Ajax" Selected Large Steam Coal.
Stephenson, Clarke & Assoc. Collieries, Ltd. Telephone : Cardiff 7960.
Cardiff Docks. or Telegraph : "Stephenson,
Clarke, Cardiff."

"Bryn Navigation Smokeless."
Baldwins Ltd.,
45, Wind Street,
Swansea.

T Telephone : Swansea 4941.
or Telegraph : Baldwins,
Swansea."

- "Camroux Merthyr Motor Large."**
Q. M. Camroux & Co.,
121, Holland Park Avenue,
London, W.11. **T** Telephone: Park 6100,
or Telegraph: Camroux'phone,
London."
-
- "Cefn Castell Large Steam."**
Cann & Glass, Ltd.,
Cardiff. **T** Telephone: Cardiff 85,
or Telegraph: "Diadem,
Cardiff."
-
- "Clyne Merthyr Lorry Coal."**
Brace & Presswell,
1/2, Queen's Buildings,
Swansea. **T** Telephone: Swansea 4565,
or Telegraph: "Force, Swansea."
-
- "Cwmaman Motor Large."**
Gueret, Llewellyn & Merrett, Ltd.,
Cambrian Buildings, Cardiff. Telephone: Cardiff 8000,
or Telegraph: "Gueret."
-
- "Cwmneol."** See "Ajax."
Stephenson, Clarke & Associated
Coys., Ltd.
-
- "Cyfarthfa."**
Llewellyn (Cyfarthfa) Ltd.,
128, Exchange Buildings,
Bute Docks, Cardiff. Telephone: Cardiff 1203, 1204,
or Telegraph: "Llewfarthfa,
Cardiff."
-
- "Cymric Rhondda Large."**
Holman Ltd.,
Merthyr House,
James St., Cardiff. Telephone: Cardiff 973,
or Telegraph: "Holman, Cardiff."
-
- "Davies Merthyr Special Smokeless."**
Davies & Murray Coal Co., Ltd.,
23-24, Dowlais Chambers,
Docks, Cardiff. **T** Telephone: Cardiff 2849.
-
- "Duffryn Navigation."**
Joseph Moore,
Wellington Bridge,
Leeds. **T** Telephone: 24124,
or Telegraph: Moore, 24124,
Leeds."
-
- "Ebbw Vale Large."**
T. Beynon & Co., Ltd.,
Merthyr House,
Cardiff. Telephone: Cardiff 5220,
or Telegraph: "Beynon,
Cardiff."
-
- "Essery's Felin Smokeless."**
W. H. Essery & Co., Ltd.,
East Burrows,
Swansea. Telephone: Swansea 5041,
or Telegraph: "Essery,
Swansea."
-
- "Ferndale Record Navigation."**
Judd, Budd, Ltd.,
Oxford House,
John St., E.C.3. **T** Telephone: Royal 7301,
or Telegraph: "Juddbud,
Ald, London."
-
- "Ferndale Large."**
P. F. Eckles & Co., Ltd.,
Paragon Buildings,
Hull. Telephone: Central 5606,
or Telegraph: "Perfredch,
Hull."
-
- "Fernhill Large."**
T. Beynon & Co., Ltd.,
Merthyr House,
Cardiff. Telephone: 5220,
or Telegraph: "Beynon,
Cardiff."
-
- "Glenavon Merthyr."**
Glenavon Garw Collieries, Ltd.,
Post Office Chambers,
Port Talbot. Telephone: Port Talbot 282,
or Telegraph: "Glenavon,
Port Talbot."
-
- "Gorsllan Large."**
J. & S. Colliery Co.,
18, Somerset Place,
Swansea. Telephone: Swansea 3426,
or Telegraph: "Noix, Swansea."

- "Grifmawr Large."** Telephone: Swansea 2607.
H. B. Griffiths,
40, Pembroke Buildings,
Swansea.
-
- "Locket's Merthyr" Large.** Telephone: Cardiff 4138,
Locket's Merthyr Collieries (1894) Ltd., **T** or Telegraph: "Locket's,
Bute Docks, Cardiff." Cardiff."
-
- "Lucy Thomas Merthyr Large."** Telephone: Cardiff 4665,
R. Llewellyn Thomas & Co., **T** or Telegraph: "Arelte,
Bute Docks, Cardiff." Cardiff."
-
- "Llwynhelig Steam."** (See "Cwmaman.")
Gueret, Llewellyn & Merrett, Ltd.
-
- "Mabey's Merthyr Smokeless."** Telephone: Avenue, 8823,
Edwin Mabey & Co., Ltd., **T** or Telegraph: "Kolmabey, Fen,
106, Fenchurch St., London." London, E.C.3.
-
- "Merthyr Aberdare" Smokeless.** Telephone: Swansea 3049,
Imperial Colliery Co., or Telegraph: "Imperial
Swansea." Swansea."
-
- "Merthyr Motor Lorry."** Telephone: Cardiff 7117,
Christopher Jones & Co., or Telegraph: "Zone, Cardiff."
The Docks, Cardiff.
-
- "Motor Coal."** Telephone: London Wall, 7553,
D. L. Flack & Son, Ltd., or Telegraph: "Civisim, London."
96, Gresham House,
Bishopsgate, E.C.2.

- "National Merthyr Smokeless."** Telephone: 769 Waterloo,
Wm. Morris, Ltd., **T** or Telegraph: "Hardico,
23, Canning Street, Liverpool." Liverpool."
-
- "Nixon's Navigation Motor Coal."** Telephone: Cardiff 4173,
Nixon's Navigation Co., Ltd., **T** or Telegraph: "Nixon's, Cardiff."
33, West Bute Street, Cardiff.
-
- "North's Lorry Coal."** Telephone: 5870,
North's Navigation Collieries or Telegraph: "North's,
(1899) Ltd., Cardiff." Cardiff."
73, Exchange Buildings,
Bute Docks, Cardiff.
-
- "Ocean Merthyr Smokeless."** (See "Ferndale Record
Judd, Budd Ltd. **T** Navigation.")
-
- "Penrikyber Navigation."** (See "Aberclwyd.")
Cory Bros. & Co., Ltd., **T**
Cardiff.
-
- "Pentre Large."** (See "Aberclwyd.")
Cory Bros. & Co., Ltd. **T**
-
- "Steco Large."** (See "Ajax.")
Stephenson, Clarke & Assoc. Coys' Ltd.
-
- "Tirherbert."** (See "Cwmaman.")
Gueret, Llewellyn & Merrett, Ltd.,

"Tydraw Smokeless." T (See "Aberclwyd.")
Cory Bros. & Co., Ltd.

"Werfa Dare." Telephone : Cardiff 338,
' Greenslade & Co., Ltd., or Telegraph : "Gloda, Cardiff."
Bute Docks, Cardiff.

"Windber." T (See "Cwmaman.")
Gueret, Llewellyn & Merrett, Ltd.,

"Wyndham Large." T (See "Aberclwyd.")
Cory Bros. & Co., Ltd.

English Coals.

"Arcot Main." Telephone : Central 4471.
John Scott & Sons,
Newcastle-on-Tyne.

"Barmoor." Telephone : Hepscott 12.
Hepscott Coal Co., Ltd.,
Barmoor Colliery, Morpeth.

"Best Barnsley Hard Steam Coal." Telephone : 35 & 36 Mexboro',
Manvers Main Collieries, Ltd., or Telegraph : "Manvers, Wath-
Nr. Rotherham. on-Dearne."

"Brodsworth Hards." Telephone : 633,
The Doncaster Collieries Assn., Ltd. or Telegraph : "Sales,
Doncaster. Doncaster."

"Bullcroft Hard." (See "Brodsworth Hards.")
Doncaster Collieries Assn., Ltd.

"East Hetton." Telephone : 3133,
Walter Scott, Ltd., or Telegraph : "Walscot,
National Provincial Bank Buildings, West Hartlepool."
Church St., West Hartlepool.

"Eldon Cobbles." Telephone : 2630 Darlington,
Pease & Partners, Ltd., or Telegraph : "Pease, Darlington."
Darlington.

"Firbeck Main." (See "Brodsworth Hards.")
The Doncaster Collieries Assn., Ltd.

"Hickleton Main Hards." (See "Brodsworth Hards.")
Doncaster Collieries Assn., Ltd.

"Houghton Main Best Hards." Telephone : 284,
Houghton Main Colliery Co., Ltd., or Telegraph : "Houghton,
Near Barnsley. Barnsley."

"Kingswood Great Vein." Telephone : 93, Kingswood,
East Bristol Collieries Ltd., or Telegraph : "Coal, Bristol."
Kingswood Colliery,
Speedwell Road, St. George's,
Bristol.

"Markham Main." (See "Brodsworth Hards.")
Doncaster Collieries Assn., Ltd.

"Norton & Biddulph Hardmine." Telephone : 7131 Hanley,
Norton & Biddulph Collieries, Ltd., or Telegraph : "Heaths, phone,
Biddulph, Stoke-on-Trent. Stoke-on-Trent."

"Shire Oaks Best Hand Picked." Telephone : 26 & 93,
Shire Oaks Colliery Co., Ltd., or Telegraph : "Colliery, phone
Shire Oaks Colliery, Shireoaks."
Nr. Worksop, Notts.

"Sneyd's Bowling Alley." Telephone : Hanley, 7251,
Sneyd Collieries, Ltd., or Telegraph : "Sneyd, Burslem."
Burslem, Stoke-on-Trent.

"Sneyd's Hardmine." (See Sneyd's "Bowling Alley.")

"Yorkshire Main Hards." (See "Brodsworth Hards.")

Scottish Coals.

"Avonside Tractor Coal." Telephone : Douglas 3888-3889,
Summers & Co., or Telegraph : "Coalition, Glasgow."
166, Buchanan Street,
Glasgow.

"Batonrigg Tractor Coal." Telephone : Edinburgh 25232,
Shotts Iron Co., Ltd., or Telegraph : "Shotts, Edinburgh."
1, Castle Street,
Edinburgh.

"Cowie Jewel." Telephone : Alloa 3.
Alloa Coal Co.,
Alloa.

"Gartshore Tractor." Telephone : 2683 Douglas (5 lines),
Wm. Baird & Co., Ltd., or Telegraph : "Bairds."
108, West George Street,
Glasgow, C.2.

"Herbertshire Tractor." Telephone : Central 6380,
Robert Addie & Sons Collieries, Ltd., or Telegraph : "Addie,
127, St. Vincent Street, Glasgow."
Glasgow, C.2.

"Polmaise Tractor." Telephone : Central 9280,
Archibald Russell, Ltd., or Telegraph : "Archibald,
195, West George Street, Glasgow."
Glasgow, C.2.

"Southblair." Telephone : Central 4642-3,
James Waldie & Son, Ltd., or Telegraph : "Waldie,
87, Haymarket Terrace, Haymarket, Edinburgh."
Edinburgh.

Patent Fuel.

"Ricoal." Telephone :
T. & R. W. Bower (Illingworth) Carbonization
Co., Ltd., 46 & 47 Garforth.
Allerton Main Collieries,
Woodlesford,
Nr. Leeds.

This fuel can also be obtained from Pearson and Dorman Long,
Ltd., 19, Victoria Street, London, S.W.1.

Coal "Pick-up" Stations.

Telephone Numbers are given : (100).

W=Water. S=Night Shelter for waggon.

(Ask for a "brand name" coal and show this booklet).

Aberdeen	.. ..	Aberdeen Lime Co., Ltd., Blaikie's Quay. G. Elsmie & Sons, Market Street. A. McKenzie, Ltd., Market Street. "Sentinel" Depot, 231 Market St. (3435).
Alloa	.. ..	Alloa Coal Co. (3).
Alresford	.. ..	Southern Counties 'Agricultural Trading, Ltd.
Alton	.. ..	A. Flowers & Co., Ltd., Station Rd., (179) S.
Annan	.. ..	W. J. M'Kay, Coal Agent.
Ashford	.. ..	A. G. Bailey, 34 Bank St. Wharf, Ashford West Stn. (113).
Ashton-under-Lyne		Tom King, Oldham Road (343).
Audlem	.. ..	J. Meakin & Son, Ltd.
Ayr	.. ..	D. Allan & Son, Beresford Depot (712).
Bacup	.. ..	Hacking & Ainsworth, Pippin Bank (135).
Bampton	.. ..	J. W. Scott & Sons (6).
Barnet	.. ..	F. Warren & Co., L.N.E.R. Coal Depot, Barnet Hill (2299).
Barnsley	.. ..	British Co-op Society, Ltd., Traffic Dept. Wilson, Bulmer & Co., The Smithies, Barnsley.
Barnstaple	.. ..	G. T. Andrews, Town Mills (92). W. Dalling & Son, Rolle Quay.
Basingstoke	.. ..	Stephens, Phillips & Co., G.W.R. Goods Station. (6). R. Toomer & Co., Ltd. (194).
Bath	.. ..	Dunkerton Coal Factors, Ltd., L.M.S.R. Station. J. W. Meredith, Lower Bristol Road. Western Counties Haulage Co., Ltd., Charlton Works, Lower Bristol Road.
Bedford	.. ..	Chas. Franklin, 10, Bank Buildings. (2244). and L.N.W.R. & Midland Wharfs. Fred Ray, Cauldwell Street. (54).
Beverley	.. ..	J. Ridsdale, Beverley Depots, L.N.E.R. W.S.

Bideford	.. ..	I. Baker & Son, Brunswick Wharf (85) W.S.
Birkenhead	.. ..	James Crutchley, Esq., 2, Argyle St., South. A. V. Crutchley, Esq., 156, Cathcart St. B. Dudley & Sons, 28, New Chester Road, New Ferry (on Chester Main Road, near Car Terminus). D. K. Rea & Son, Ltd., 81, Argyle St. South. (2531).
Birmingham	.. ..	Rickett, Smith & Co., King's Court, 115, Colmore Row. (Central 2093). S. W. B. Stephen & Co., Ltd., Rolfe St., Smethwick. S. W. B. Stephen & Co., Ltd., Windsor St., Coal Wharf (L.M.S. Rly.), Avenue Road, Aston. Wilson, Carter & Pearson, Ltd., Lawley St., (Mid. 2707). Henry Dumolo Ltd., Lawley St. (Aston Cross 0612). J. Ellis & Sons, Ltd., Highgate Wharf, (Mid. 286). J. W. Gadsden & Co., Ltd., Vauxhall Wharf. (East 249). J. P. Lawley, Ltd., Lawley St. Wharf. (Central 3307). L. Miller, Ltd., Lawley Street. (Central 7554 & 7555). J. Mills & Son, Curzon St. Wharf. (Central 7985). E. Silk & Son, Curzon St. Wharf. (Aston Cross 0262). W. H. Sims, Vauxhall Wharf. (East 1165). Kimberley, Beddoes & Co., Ltd., Banbury St. & Soho Pool. (Northern 2653). C. Thomas, 4, Grove Lane, Dudley Road, Smethwick. Brentnall & Cleland, Ltd., Lawley St. (Central 1722). J. Eaves & Son, 17, Pearman Road, Smeth- wick.

Birmingham	..	Davenport & Co., Park Station Wharf, Sutton Coldfield (Sutton Coldfield 59). Williams & Sons, Lichfield Road, Aston.
Bishop's Stortford	..	J. Miller & Co., Ltd., L.N.E.R. Depot.
Blackburn	..	G. B. Leach & Sons, King St. Sidings. (6790). Crook & Thompson, Ltd., 73, Whalley Banks. (4173).
Blackwater (Hants.)		J. James, Adjoining Station. (Camberley 102).
Bolton	..	Jos. Thornley, 15, Queen's Gate. (1365).
Boston Docks	..	Walter Woodthorpe Ltd. (319).
Bournemouth	..	Bradford & Sons, Ltd., 76, Charminster Rd., (460). C. H. Thurgate & Co., Royal Chambers, Richmond Hill. (2793).
Bradford	..	W. & J. Williams, Ltd., Market St. J. Webster, 41, Edderthorpe St.
Braintree	..	Grooves & Co., Ltd., L.N.E.R. Coal Depot. (43).
Brentford	..	Clements Knowling & Co., Goat Wharf. (Ealing 39). W. Spenser Whatley Ltd., G.W.R. Station, Brentford Wharf, Brentford.
Brentwood	..	Barratt Ltd., L.N.E.R. Station.
Bridport	..	Ralls & Son, Station Yard. (5). W.
Brighton	..	F. Palmer & Son, 115, North St. (2271). Depot: Hove Goods Station, Sackville Road, Hove.
Bristol	..	Speedwell Colliery, St. George. Deep Pit Colliery, St. George. East Bristol Collieries Coal Depot, Midland Road, St. Philips. Lowell Baldwin Ltd., Redcliff Wharf. (2504).
Broxbourne	..	F. Warren & Co., Ltd., L.N.E.R. Station. (Hoddesdon 239).
Burslem	..	Sneyd Collieries, Ltd., Nile St. or Park Rd. Sidings.
Burton-on-Trent	..	Marriott & Co., Station Yard.
Bury	..	James Cross Ltd., Saw Mill Siding, Ferndale Rd. (39). J. E. Southern & Co., Ltd., 21, Haymarket St. (970 and 971).

Canterbury	..	R. Brett & Sons, Wincheap St. (588). W.S.
Castle Douglas	..	John Ewing & Son. (95).
Cardiff	..	G. M. Puddicombe & Co., Adam St. Sidings.
Carlisle	..	S. J. Binning & Son, 52, English St. (209). Walter Wood & Co., Dentonholme. (366).
Cheadle	..	Ormesher & Wells, Station Yard.
Chelmsford	..	Coote & Warren, Ltd., London Rd. and L.N.E.R. Depot. (39).
Cheltenham	..	A. Jordan & Co., Ltd., 12, Promenade. (2487). Wm. D. Farrar, 103, High St. (2220). J. Williams & Co., Ltd., 383, High St. (2078).
Chesterfield	..	J. Gothard & Sons. Depots: West Bars and Brampton Sidings. (2870).
Chichester	..	O. H. Purchase, 29, South St. Coal Depot, Canal Wharf. (186). W.
Clitheroe	..	O. Rowe & Co., Ltd., Low Moor Sidings.
Cockfield	..	W. R. Ennals, Cockfield Station.
Colchester	..	J. Tovell, Ltd., Magdalen St. (opp. St. Boltoph's Coal Yard). (427). W.S.
Congleton	..	Norton & Biddulph Coleries Ltd., Congleton Wharf. (27).
Coulsdon	..	M. A. Ray & Son, Station Wharf. (Purley 69). W.S.
Coventry	..	Peters, Coundon Rd. Rail Depot. (548).
Cowdenbeath	..	Fife Coal Co., Ltd.
Crediton	..	A. March & Son, Station Yard. W.S.
Creetown	..	D. & W. Bowman, Coal Agents.
Crewe	..	S. Jackson & Sons, Hunts Bank Works, Wistaston.
Cropwell Bishop	..	S. Heasleden & Sons, Ltd. (Radcliffe-on-Trent 37 Y 4).
Croydon	..	Hall & Co., Ltd., Victoria Wharf.
Dalbeattie	..	George Wilson & Son. (81).
Darwen	..	G. B. Leach & Sons, Railway Siding. (65).
Derby	..	Rigby & Chandler, City Rd. Wharf. Direct Supply Coal Co., Babington Lane. Plant & Sons, 1, Norton Place, Burbage.
Doncaster	..	H. Kemp, Ltd., Milethorne Lane Garage, Wheatley Lane.
Dorchester	..	J. M. Lock, G.W.R. Station. (4). W.S. Dorset Farmers Ltd., Unity Chambers, Dorchester. (115). W.S.

Dorking F. Warren & Co., 42, South St. (307).

Droitwich T. A. Everton, Worcester Rd., Witton. (11).
W.S.

Dukinfield E. K. Smith & Co., Ltd., 2, Charles St.

Dumfries Allison & Hunter. (197).

Dunmow Groves & Co., Ltd., L.N.E.R. Coal Depot.
(26).
Hasler & Co., Ltd., Dunmow Stn.

Dunstable Chas. Franklin, Station Approach. (265).
W. Lockhart, L.M.S. Station. (43).

Durham T. Kipling, 51, Gilesgate. (439).

Eastbourne William Wood, High St., Polegate. (Pole-
gate 11). W.
S. Bradford & Sons, Whitley Rd. Wharf.

Edinburgh J. Waldie & Sons, Haymarket. (62074).

Eling Burt, Bolton & Haywood, Ltd., Eling
Wharf. (Totton 6).

Ellesmere Port Geo. Catchpole & Sons, Woodfield Rd., North

Epping E. W. Hayden & Sons, Epping Station.

Evesham W. H. Wallis & Co., Ltd. (7).

Exeter G. Heywood & Sons, Queen St. Station Yard.
(193). W.
Ward & Co., St. David's Station.

Fareham A. Flowers & Co., Ltd., 151, West St. (3). S.

Farnham Hickle & Co., Ltd., Burlington Buildings.
(6). W.
Wood & Co., Ltd.

Faringdon (Hants.) George Goddard & Son.

Fleet R. Toomer & Co., Ltd. (66).

Frome J. Udell (H. Riley, prop.), 90, Broadway.
(89). W.S.

Gainsborough W. J. Warren & Sons. (198).

Girvan A. C. Mitchell & Co. (40).

Glasgow Andrew Young & Co., Gushetfaulds Siding.
(South 811).
Birkenshaw Coal Co., London Rd. Mineral
Depot. (Bridgeton 884).
James Waldie & Sons, 118, Queen St.
(Central 4642).
Arch. Russel, Ltd., 195, West George St.
(Central 9280).

Glasgow Walker & Cameron, Stock Exchange Build-
ings, 75, St. George's Place (Central 6802).
" Sentinel " Depot, 464, Pollokshaws Road,
(Queen's Park 391).

Glossop Abel Harrison Ltd., Surrey St.

Gloucester C. F. Hipwood, 16, Quay St. (2928).
J. Williams & Co., Ltd., Eastgate House.
(2470).

Gosport W. J. Leach & Co., Market House, High St.
(53).

Grantham Spittlegate Coal Depot, Bridge End Road.
(112).

Gravesend M. A. Ray & Sons, Rosherville Siding,
Southern Rly. (204 & 451). W.S.

Great Marlow R. Toomer & Co., Ltd. (188).

Grimsby Ed. Bannister & Co., Ltd., Royal Dock
Chambers. (626).

Hanley Norton & Biddulph Collieries, Ltd., Black
Bull Wharf. (7131).
Norton & Biddulph Collieries, Ltd., Nettle-
bank Wharf. (7324).

Hastings Medway Coal Co., Southern Rly. Station.

Hawarden W. Morris, Colliery Agent.

Hereford South Wales Coal Co. (W. Blake & Sons,
Ltd.), Barton Station. (1173).

Henley-on-Thames R. Toomer & Co., Ltd. (19).
G. Dunlop & Son. (6).

Heywood Smith & Gregson, Railway Station. (6380).

Hoddesdon J. Page & Son, Hoddesdon Forage Stores.
(44).

Horsehay W. J. Lane, Coal Merchant.

Horsham G. F. Scrase, 82, Station Road.

Hull Ridsdale & Walker, St. Stephen's Square.

Hungerford Alexander Bros., Station Rd. (3).

Hyde J. Parry & Co., Woodley. (Hyde 170).

Ipswich Ipswich Coal Co.

Kingston-on-Thames Geo. Bristow Ltd., 1, London Rd. (2516). W.S.
G. J. Palmer & Sons, 30, High St. (4661).

King's Lynn J. I. Derrick (near King's Lynn Parish
Church). (138).

Kirkeudbright Samuel Hastings, Coal Agent. (86).

Knutsford R. Holden & Sons, Station Yard.

Lancaster S. Thompson & Co., East Rd.
W. & J. Turner, Aldcliffe Rd. Coal Wharf.
(23).

Launceston Bate & Son.

Leeds Joseph Moore (Coal) Ltd., L.N.E.R. Coal
Depot, Wellington Bridge. (24124).
Wilson, Bulmer & Co., 14-15, North British
& Mercantile Bldgs., East Parade. (28276)

Leek Norton & Biddulph Collieries, Ltd., Leek
Wharf. (14).

Leicester J. Smedley, Coal Merchant, Northgate St.
C. J. B. Wood & K. Martin, No. 9 Siding,
Soar Lane Wharf. (2328). S.

Leominster Leominster Coal Supply Co. (W. Blake &
Sons, Ltd.), Rly. Wharf.

Lewes J. Chandler & Son, Southern Rly. Station.

Lincoln W. J. Warren & Sons, City Chambers. (65).

Liverpool Bradbury, Son & Co. (1920), Ltd., 43, Ex-
change Chambers.
J. P. Higginson & Co., 173, Crown St. and
I.M. & S. Crown St. Stn. (Royal 1747).
Daniel K. Rea & Son, Ltd., 20, Water St.
(Central 2740).
Daniel K. Rea & Son, Ltd., 201, Marsh Lane,
Bootle. (Bootle 300).
Bromilow, Foster & Co., Ltd., Sandhills
Yard, 331, Stanley Road. (Bootle 516).
John Griffiths & Son, Ltd., 201/203, Great
Howard St.
R. W. Roulston & Son, Crown St. Depot.
(Royal 656 & Bank 497).
William Fowler & Sons, Blackstone St.
Depot (off Great Howard St.).
William Morris, Ltd., 23, Canning St., Water-
loo, near Liverpool. (Waterloo 769).
Daniel K. Rea & Son, Ltd., Blackstone St.
(Central 4869).
J. S. Riley & Co., Ltd., 56, Bank Hall St.
Wm. Marsh, 275 & 289, Rice Lane. (Walton
53 and 411).
Wm. Marsh, Ormskirk Rd., Aintree. (Walton
318).

Liverpool Wm. Marsh, 66-68, Bank Hall St. (Bootle
383).
Manchester Collieries, Ltd., 223, Crown St.
(Royal 1781 and 1782).
Mersey Coal & Coke Co., Lloyds Bank Bldgs.,
11-13, Victoria St. (Central 2893).
"Sentinel" Depot, 131, Vauxhall Road.
(North 1264).

Llandudno J. S. Whitelegg, "Enville," Gloddaeth Av.

Lockerbie J. B. Donaldson & Son, Coal Agents. (28).

London J. H. Beattie & Co., Ltd., 1, Pancras Road,
N.W.1. (North 3330), and Warwick
Road, Kensington, W. (Kelvin 8571).
Charrington, Gardner & Locket & Co., Ltd.,
Gray's Inn Rd., W.C. 1, and Great Western
Railway's Depot, Shepherd's Bush, W.
Bradbury Son & Co. (1920), Ltd., 71, St.
Axe, E.C. 3.
F. Warren & Co., G.W.R. Coal Depot, 142,
Westbourne Park, W.2. (Park 3667).
Albert Coe, L.N.E.R. Depot, Blackwall.
E. & A. Shadrach, Barking Rd. & Upton
Park. (0025).
W. J. Earley, Esq., 135, Westbourne Park
Road, W.2.
King Coal, Ltd., Railway Sidings, White
Hart Rd., Plumstead, S.E.18.
E. Ashby & Co., 66, Bankside, Somers Town,
S.E.1.
F. Warren & Co., 83, Eleanor Cross Rd. &
L.N.E.R. Station, Waltham Cross. (236).
F. Warren & Co., L.N.E.R. Station, Hoe St.,
Walthamstow. (0150).
F. Warren & Co., Merton Abbey, Southern
Rly. Station, Wimbledon. (0411).
Rickett Smith & Co., Ltd., 108, Midland Rd.
N.W.1.
Wm. Dowell & Co., Ltd., Creek Bridge Wharf,
Greenwich, S.E.10.
F. B. Cameron & Co., Ltd., 33, Pancras Rd.,
N.W.1.

London Facer & Co., Ltd., L.M. & S. Stn., Somers Town.

Facer & Co., Ltd., L.M. & S. Stn., Cricklewood.

T. S. & C. Parry, Caledonian Road, N.1. (North 0931), and Prestons Road, Poplar, E.C.14.

Sargeant Longstaff & Co., Old Ford, L.M.S. Rly. (East 1283).

Sargeant Longstaff & Co., Maiden Lane, L.M.S. Rly. (North 1690).

Charrington's, Cable St. (L.N.E.R.), E.1.

Charrington's, Hornsey (L.N.E.R.), N.8.

Charrington's, Highbury (L.M.S.), N.5.

Charrington's, Queen's Park (L.M.S.), N.W.6.

Charrington's, Cremorne (L.M.S.), S.W.10.

Charrington's, Somers Town (L.M.S.), N.W.1.

R. Tozer & Sons, Somers Town (L.M.S.), N.W.1.

Fulton's, Cambridge Street Bays, St. Pancras, N.W.1.

J. H. Mitchell & Son, Somers Town (L.M.S.), N.W.1.

C. Gregory, Kentish Town (Spring Place Sidings), N.W.5.

Spenser Whatley, Ltd., Mileage (Westbourne Park), G.W.R., W.2.

Spenser Whatley, Ltd., L.M.S., Station, Shepherd's Bush, W.12.

Spenser Whatley, Ltd., L.M.S. Station, West Kensington, W.14.

Q. M. Camroux & Co., 121, Holland Park Avenue, W.11. (Park 6100).

M. A. Ray & Son, Eltham & Mottingham Station, S.R. (Lee Green 1510). W.S.

Chas. Franklin, 25, Euston Road, King's Cross, N.W.1 (Terminus 6161, 4 lines).

Chas. Franklin, 133, Pancras Road, N.W.1. (Terminus 6161).

Chas. Franklin, City Coal Depot, Worship St. E.C.2. (Bishopsgate 1086).

London Chas. Franklin, 283, North End Rd., W. Kensington, W.14. (Fulham 2482).

Chas. Franklin, L.M. & S. Rly., Station Rd., Willesden Junction, N.W.10. (Wilkesden 1085).

" Sentinel " Depot, Minerva Road, Chase Estate, Acton, N.W.10.

Lostock Gralam .. P. L. & G. S. Harris, Ltd., (Northwich, 327). W. Barrow. (Northwich 200).

Luton Wm. Lockhart, Leagrave Stn. (1587).

Chas. Franklin, 17, Manchester St. (174).

Maidstone R. Benzies Successors (G. Styles), West Kent Wharf & 48, High St. (3178). S.

Manchester Thos. Lamb, Wellington St., Gorton. (45 Openshaw and 238 Rusholme).

J. E. Southern & Co., Ltd., 162, Chester Rd., (8071 Central).

E. & F. Beattie, Ltd., Ardwick L.M.S. Depot.

W. Perkins & Co., 38, Ordsall Lane, Salford. (City 7131). Depot: Ordsall Lane Sidings (near Regent Bridge), Salford.

A. E. P. Furse & Co., Ltd., 3, Old Millgate. (Central 6028). Depots: Liverpool St., Salford and Ardwick.

Wm. Bentley, Ltd., L.M. & S. Rly. Yard, Miles Platting. (Central 4982).

Jas. Edge, Ltd., Royal London Buildings, 196, Deansgate. (Central 1140, 1141, 1142).

Riley & Roberts, Dean Lane Station.

Thrutchley & Co., Ltd., 22, St. Mary's Gate. (Blackfriars 5042). Depot: Ordsall Lane Coal Siding, Salford.

Samuel Hooley & Sons, Patricroft. (Eccles 3239).

Samuel Hooley & Sons, Ardwick. (3616).

T. H. Dunbabin, Ordsall Lane, Salford. (City 197).

T. H. Dunbabin, Ardwick, Cornbrook, Pendleton. (712).

Manchester	" Sentinel " Depot, Rugby St., Broughton Lane. (Blackfriars 9664). F. Fox & Partners, Ltd., Ardwick. The Midland Coal Co., Ashton Road Goods Yard.
Margate	F. L. Pettmann, Ltd., Athelstan Rd. & Margate Sands Stn. (Margate 363). W.S.
Mauchline	Jas. Walker, Coal Agent. (35).
Maxwellton	George M'Courtie & Co., (Dumfries 492).
Maybole	William Houston, Coal Agent.
Mickle Trafford	C. Wright & Sons, Mill Farm.
Middlesbrough	Reed & York, Richmond St. Depot. (4061). Rutherford & Co., Ltd., Atlas St. (4295).
Milnthorpe	J. B. Hudson, Dixies House, Sandside.
Morecambe	A. J. Wilton & Sons, L.M. & S. Coal Yard, Euston Road.
Nelson	Hirst & Sons, Ltd., Grafton St.
Newcastle-on-Tyne	John Scott & Sons, 2, Oxford St. (4471, 4472, 4468 Central). George Isbister, Hayhole Depot, near Northumberland Dock. Connel & Grace, Ltd., Proctor House, (Central 2798).
Newcastle-under-Lyne	J. Orwell & Sons, Liverpool Rd. (6158).
New Galloway	A. Geddes, Coal Agent.
Newton Abbott	Watts, Bearne & Co.
Northwich	H. E. Nixon, Contractor, Sandiway.
Oldham	Co-operative Wholesale Socy. Ltd., Clegg St. J. Garth (Oldham), Ltd., Harold St.
Ormskirk	Wigan Coal & Iron Co. (46).
Oxford	Stevens & Co., L.M.S. Coal Wharf. (3188).
Paignton & Torquay	Nicks & Co., 56, Victoria St. (Paignton 154). W.S.
Pangbourne	G. Dunlop & Son. (39).
Perth	Alloa Coal Co., Ltd. (Perth 135).
Petersfield	G. Ewen, Charles St. Depot.
Petworth	C. Rickets, High St. (24). W.
Plymouth	John Westcott, Ltd., Commercial Yard. H. G. Polkingthorne & Co., 11, Whimble St. and North Quay. (89). W.S.
Pontefract	H. A. Burton, Tanshelf Coal Depot.

Portsmouth	J. E. Smith, Ltd., Goldsmith Avenue. (3841). S. A. Flowers & Co., Ltd., Flathouse Wharf. (2159 & Trunks 2150). W.S. And at Goldsmith Avenue.
Preston	W. & J. Turner, Oxhey's Coal Yard, Bold St., near Cattle Market. (78). J. H. Martin (Preston), Ltd., Deepdale Junc. Skeffington Rd. (1471). Wm. Rawcliffe & Co., 80a, Fishergate & Maudlands Stn. (861).
Prestwick	R. F. Waters, 4, Beech Tree Bank. (Whitefield 44).
Reading	G. Dunlop & Son, Oxford St. & Caversham Rd. (410). W.S. Stevens & Co., G.W.R. Coal Depot, Caversham Road. (512). R. Toomer & Co., Ltd., 9, Blagrove St. (207).
Retford	Milner, Lazenby & Co., Ltd., Exchange St. (75).
Rochdale	Thos. Nuttall, Wandleworth Coal Depot. (570).
Romford	F. Warren & Co., 6, The Pavement, South St. and L.M.S. Coal Depot. (36).
Romsey	A. Ward & Son, 21, Palmerston Rd., Romsey, W.
Ross	S. Llewellyn & Sons.
Rugby	T. Quarterman & Son, London Rd., Stretton on Dunsmore. (Wolston 17).
Rye	Wright & Pankhurst, Cinque Port St. (32). W.S.
Salisbury	F. Bird & Co., 146, Fisherton St. (22).
Sandbach	Jackson Bros.
Scarborough	C. P. Heselton, 7, Aberdeen Walk. W.S.
Semley & Shaftesbury	J. Westcott & Son, Shaftesbury.
Sheffield	Longbottom & Co., Ltd., Harvest Lane (24201 & 24202).
Shiplake	G. Dunlop & Son, Mortimer (2).
Shrewsbury	Is provided for by the " Sentinel " Waggon Works, Ltd. (2011). W.S.
Sidmouth	J. Skinner, Church St. (18). W.S.

Southampton	..	E. Jones & Co., Ltd., Victoria & Sunderland Wharves, Marine Parade. (182). S. Bradbury, Son & Co. (1920), Ltd., 95, Above Bar. A. Flowers & Co., Ltd., 126, Macnaghten Rd., Bitterne Park. (4120). S. A. Flowers & Co., Ltd., Albany Rd., Freemantle. (2475). S. William Tickle, 76, London Rd. Wharf, Mulfords Sidings, Southern Rly. (3547).
Southend	..	F. Warren & Co., L.M.S. Coal Depot, Southchurch Avenue. (53).
Southport	..	Wigan Coal & Iron Co., 126, Lord St. (68). Richard Wright (Southport) Ltd., 11, Tulketh St. (5131). L.M.S.R. Coal Sidings, London St.
Staines	..	E. & G. Gomm, High St. Fear Bros., Southern Rly. Stn., Kingston Rd.
Stanstead Abbots	..	J. Page & Sons, Tollbridge Wharf.
Stalybridge	..	Silkstone Coal Co., Joint Railway Yard. (89).
Stirling	..	Alloa Coal Co., Ltd., (Stirling 8).
Stockport	..	T. & H. Roscoe, Georges Rd. (18). W. Ormesher & Wells, Coal Factors. (3007).
Stockton	..	Rutherford & Co., Ltd., 22, Bath Lane. (6358)
Stranraer	..	William Miller & Co., Coal Agents. (26).
Stratford-on-Avon	..	Hutchings & Co., Ltd. (3).
Stroud	..	Martin & Sillett, Barnett's Wharf, Canal Rd. (Chatham 580). W.S.
Stroud	..	Lambert & Cox, Russell St. (147x).
Sunningdale	..	Fear Bros., Sunningdale Station, Main Road.
Swansea	..	Jas. Pridmore, Hafod Yard, G.W.R. Atlantic Coal Co., North Dock, G.W.R. W. Laugharne Morgan & Co., Victoria Stn., L.M.S.
Taunton	..	Goodlands Ltd., N. Town Wharf. (275). W.S.
Thornhill	..	Walter M. Millan, Coal Agent. (14).
Tonbridge	..	C. Leonard, Station Bridge Wharf. Medway Coal Co., Southern Rly. Hills Bros., Southern Rly.
Torquay	..	Parkes Coal Co.

Tring	..	W. Lockhart, L.M.S. Station.
Trowbridge	..	F. H. Blair & Co.
Tunbridge Wells	..	Medway Coal Co., Southern Railway.
Twyford	..	R. Toomer & Co., Ltd. (21).
Walton-on-Thames	..	F. Warren & Co., S.R. Station. (183).
Warminster	..	J. Button & Sons, East St.
Ware	..	J. Page & Son, Ware Forage Stores and Willow Wharf. (89).
Wareham	..	James Foot, South St. W.
Warrington	..	J. Pendlebury & Co., Dallam Lane. (43). E. B. Ward, 6, Beech Road, Stockton Heath.
Welnetham	..	W. R. Ennals, Welnetham Station.
West Hartlepool	..	F. Peart & Co., Ltd., 3, Upper Church St. (2982).
Weybridge	..	F. Warren & Co., Queen's Rd. (183).
Weymouth	..	A. Hutchings, King St. (280).
Wigan	..	Conroy Bros., Hope St. (132).
Winchester	..	A. Early & Son, 90, Cheesehill St. S. A. Flowers & Co., Ltd., Station Hill. (47) S.
Windermere	..	W. & J. Turner, Station Yard.
Windsor	..	R. Toomer & Co., Ltd. (435).
Woking	..	F. Warren & Co., 18, Guildford Rd. (180).
Wolverhampton	..	B. & H. Smith, Ltd., Can Lane Wharf.
Worcester	..	G. F. Summers & Son, Tybridge St. South Wales and Cannock Chase Coal & Coke Co., Ltd., 54, Foregate St. (99). Underwood & Co., Ltd., 6, Lowesmoor Place. (30).
Worksop	..	Milner Lazenby & Co., Ltd., Dock Rd. (158).
Wrexham	..	Barton & Co., (Coal) Ltd., G.W.R. Wharf, Watery Road.
Yeovil	..	Burt & Son, Ltd. Bradford & Sons, Ltd., Pen Mill Sidings.
York	..	C. Swaby & Sons, 68, St. John's Street and Gladstone Street. (505).