Instructions to Drivers

For Running and Tending

"Sentinel-Cammell" Steam Rail Cars

(Chain Driven Type)

and

"Sentinel" Patent Locomotives

The "Sentinel" Waggon Works, Ltd.

LONDON and SHREWSBURY

LUBRICATING OILS.

The "Sentinel" Waggon Works, Ltd., recommend and supply for their vehicles two classes of oil, namely:—

For Crankcase and Axleboxes—"Sentinel" Crank Case Oil.

For Cylinders—"Sentinel" Cylinder Oil.

The price, which varies according to the market price of oil, is to-day (June, 1929) 3s. 0d. per gallon delivered in 40 gallon casks f.o.b. British port.

The following other grades of oil are also considered suitable:—

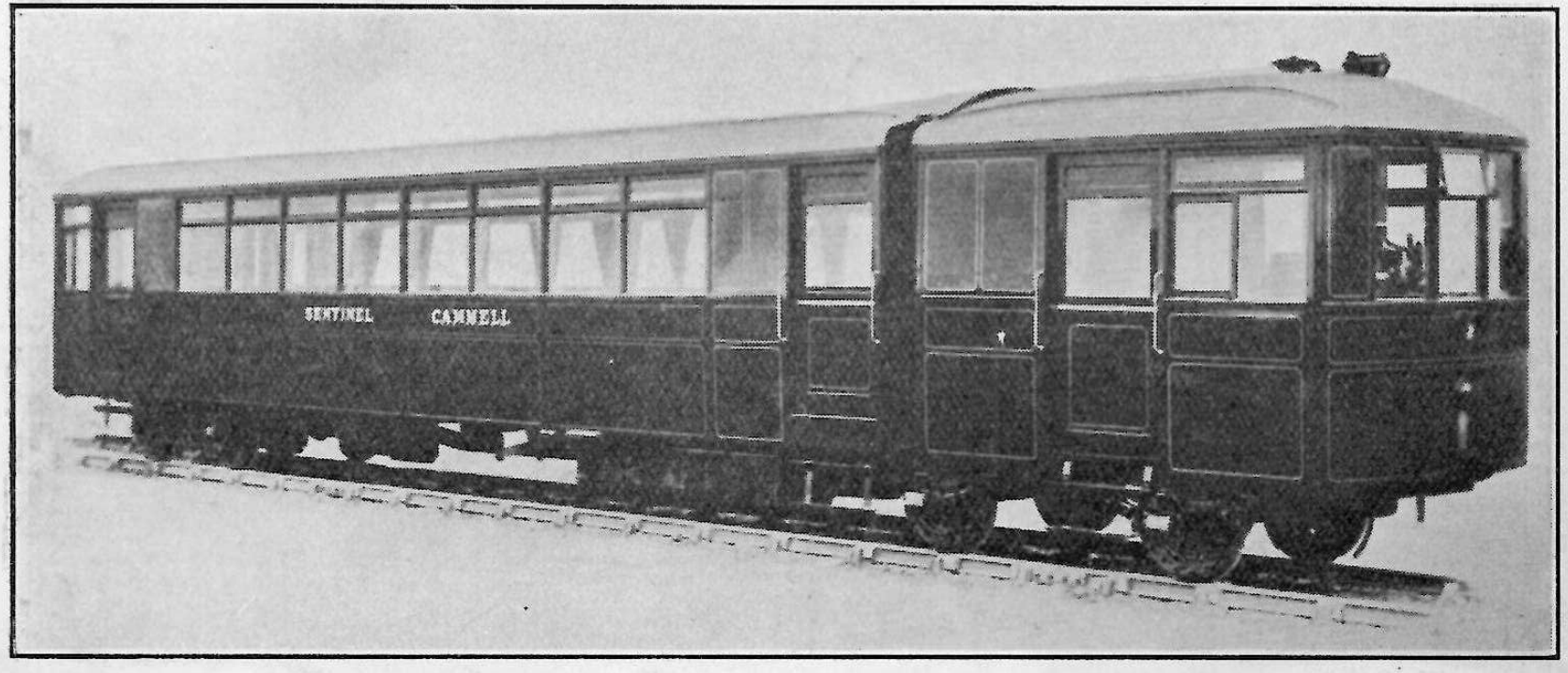
C. C. WAKEFIELD & CO.

For Cylinders—"Super-Sentinel" Cylinder Oil.
For Crankcase—"Super-Sentinel" Crankcase Oil.

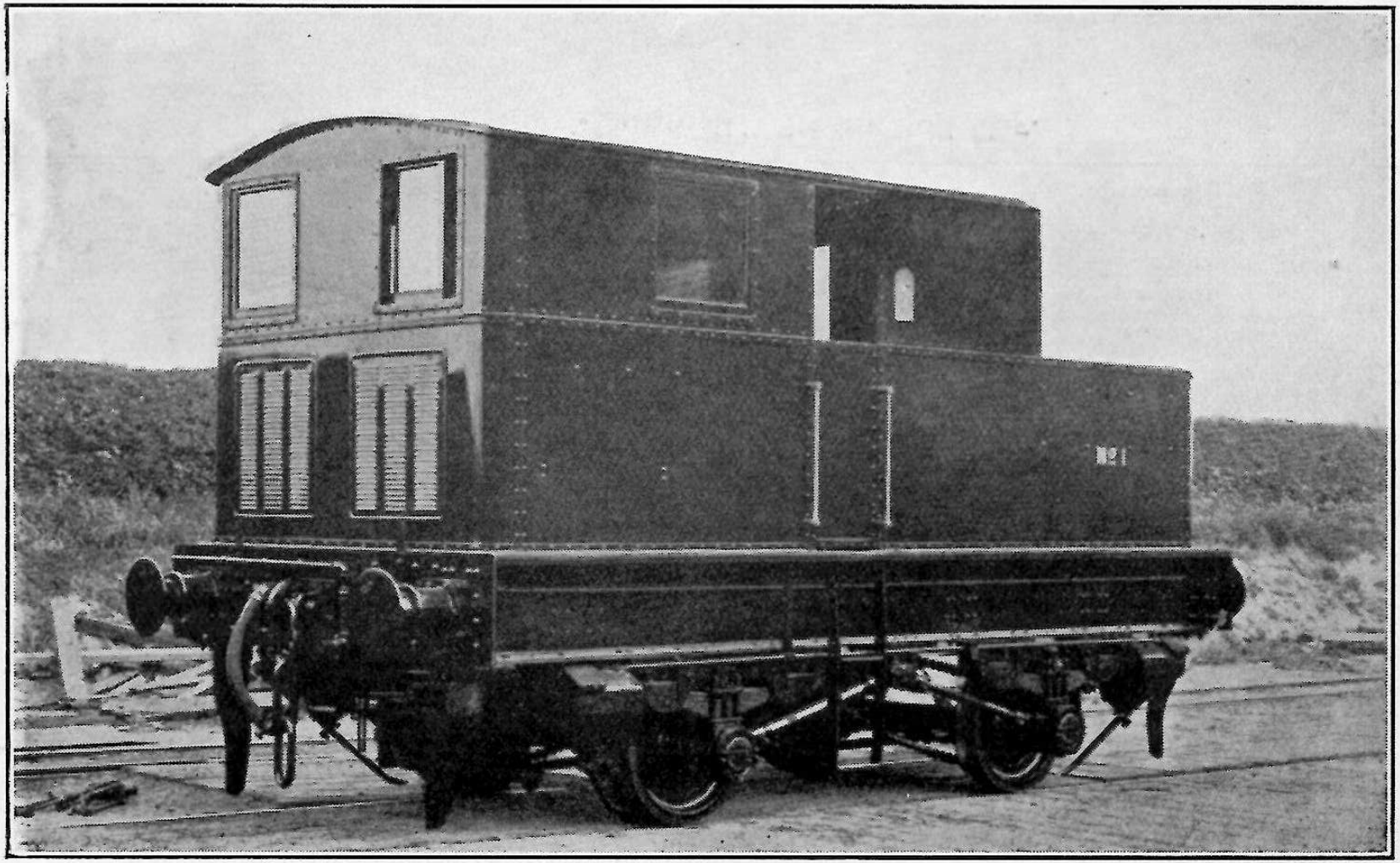
VACUUM OIL CO., Ltd.

For Cylinders—Gargoyle Cylinder Oil 600 W.
For Crankcase—Gargoyle D.T.E. Oil, extra heavy.

NOTE.—The use of unsuitable lubricating oil is a very fruitful source of trouble due to carbon deposit on the nozzle. The nozzle gradually becomes choked and the back pressure in the exhaust pipe rises to an excessive amount thereby causing loss of power, and danger of blowing out the feedheater joints.



A "Sentinel-Cammell" Steam Rail Car.



A " Sentinel '' Patent Locomotive.

Ref. No. 201R/C.

Instructions to Drivers for
Running and Tending . .

"Sentinel-Cammell" Steam Rail Cars
and
"Sentinel" Patent Steam Locomotives

Subject to alteration without notice.

The "Sentinel" Waggon Works Ltd.

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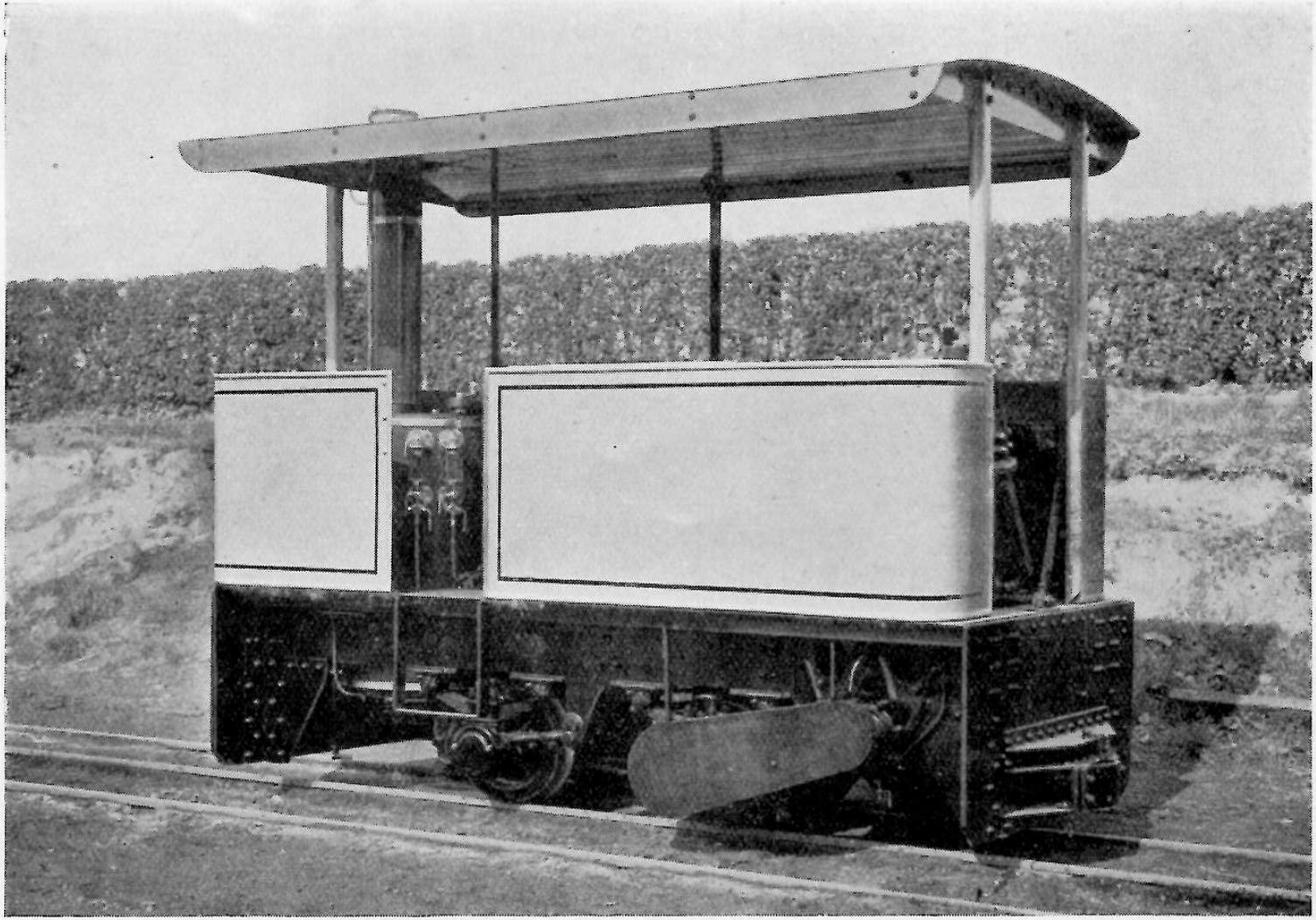


"Sentinel" Light Locomotive for Narrow Gauge Railways.

"Sentinel-Cammell" Steam Rail Cars and "Sentinel" Patent Steam Locomotives.

Instructions to Drivers.

Instructions for Raising Steam and Starting.

Filling Boiler.—The correct water level, when the boiler is cold, is 2 in. from the bottom of the gauge glass. To fill the boiler, remove brass filling plug in shell on left-hand side and fill with clean water to working level. Test working level as follows: Turn the three gauge cock handles horizontal, turn the top and bottom handles back again vertical, then turn the middle handle vertical, when the water should rise to working level.

Fuelling.—Use the most suitable fuel to be obtained. For example :—

ENGLAND :—

Good steam coals such as " Windber " or " Penrykyber " are very suitable, while gas coke of standard quality also gives excellent results. Coke will be found as economical as coal, providing its cost is not more than 55 per cent. or 60 per cent. that of Welsh coal.

For good quality coal $\frac{3}{8}$ in. spaced firebars are fitted but where the coal is dirty or of a smoky nature, $\frac{5}{8}$ in. or wider spaced firebars should be used.

Anthracite is unsuitable as it becomes reduced to powder and clogs the grate.

INDIA :—

Some of the best Bengal steam coals are " Jheria 14 seam," " Dishergarh," " Borrea 17 seam," " Giridih " ; while for hilly country " Poniati " quick steaming coal is recommended. For Bengal Coal rocking firegrates generally fitted with $1\frac{1}{4}$ in. spaces.

SOUTH AFRICA :—

Rocking firegrates with 13/16 in. spaces are usually fitted for South African coals.

Other Fuels.—Where coal is difficult to obtain or too costly to use, wood or oil fuel may be used, but, in these cases, it should be borne in mind that the customer should advise the Sentinel Co. at the time the vehicle is purchased in order that modifications may be embodied

in the boiler to suit these special fuels. Where wood fuel is used with the standard coal-fired boiler very hard and dry wood should be selected that has been cut 3 or 4 weeks. The size of this wood for firing down the central stoking chute should be 4 in. × 4 in. × 9 in. The calorific value of the average wood fuel is one-third that of good coal, and therefore about 3 times the quantity, by weight, of wood is required by comparison with good coal.

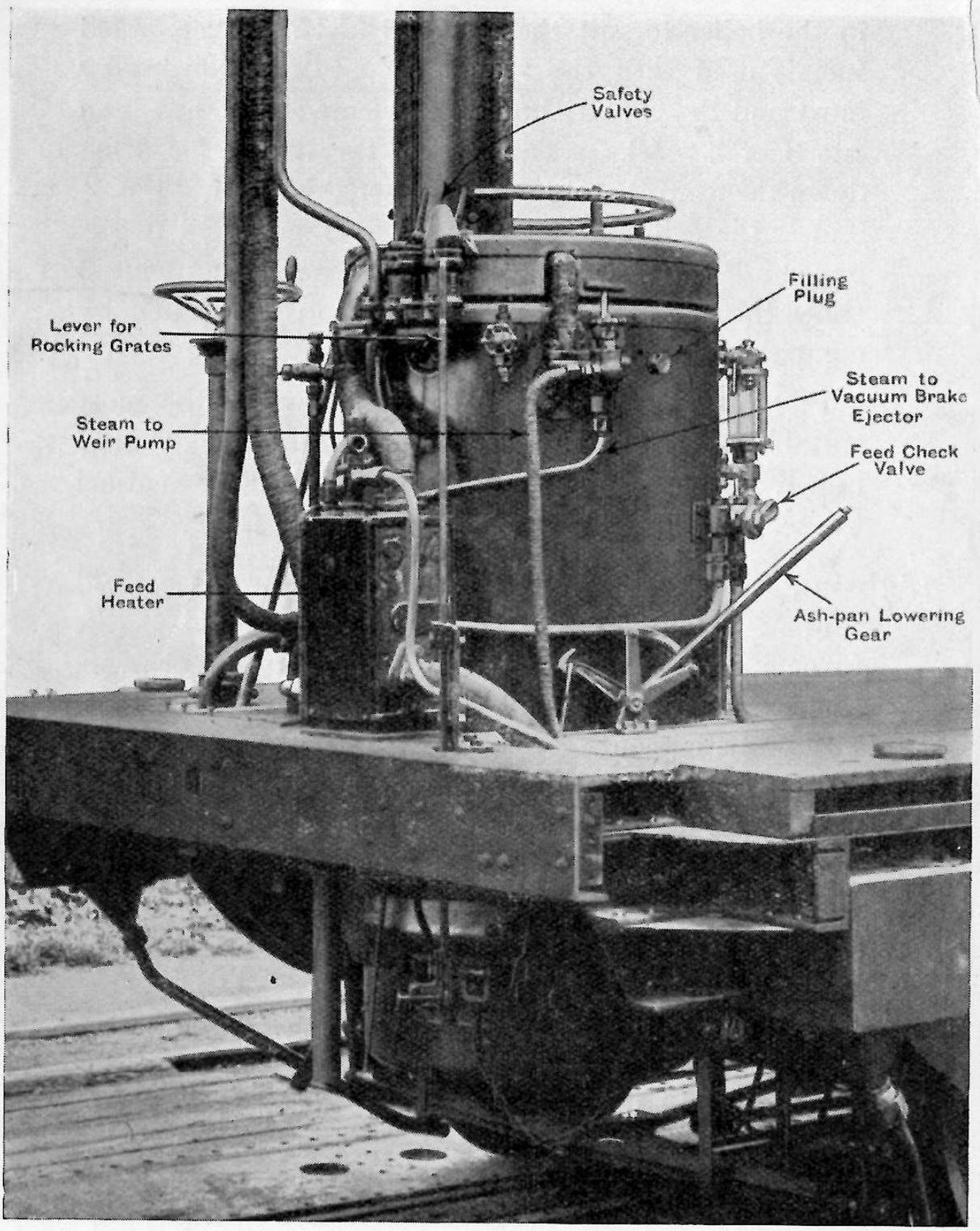
Firegrates with $\frac{3}{8}$ in. spacing are usually the most suitable when burning wood in the standard coal-fired boiler. Separate instructions are supplied by Sentinel Co. where Oil Fuel Gear is fitted to a boiler.

Lighting Fire.—Lower firegrate, clean and replace. Fill ashpan with water to level of water angle. Lift furnace door on boiler top, light some shavings or waste soaked in paraffin and throw down on to grate. Follow with plenty of firewood until there is a good blaze, then add coal on top and when red hot add more slowly, ensuring that the coal is distributed evenly over the grate by spreading the fuel around as it leaves the shovel.

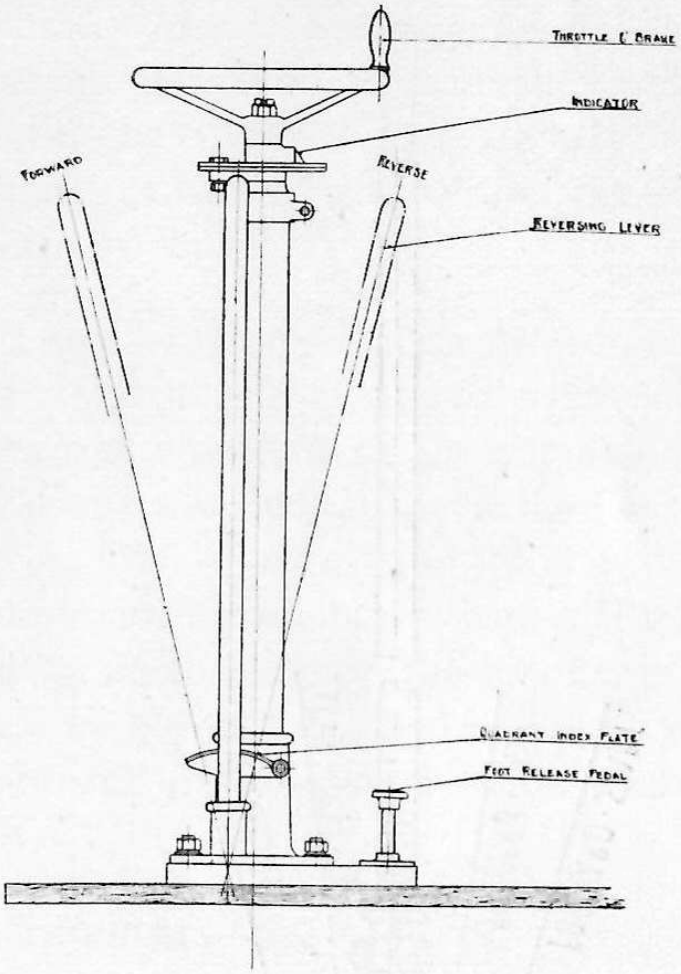
Testing Valves and Hand Levers.

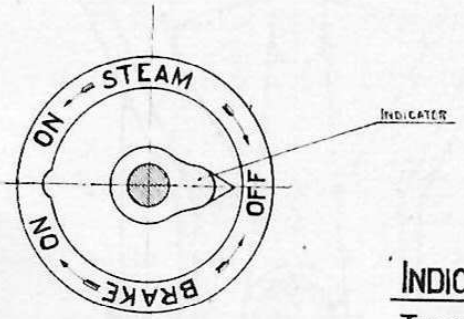
See that the stop valve, the control wheel and the auxiliary steam valves work freely. Try the reversing lever, and place it in Drain notch. Test the hand brake.

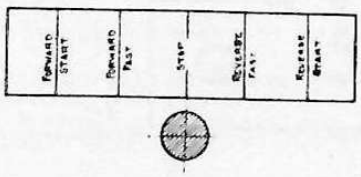
Raising Steam.—Only use the Blower when absolutely necessary. With proper care and good fuel, steam may be raised from cold water in 50 minutes without the Blower. When inferior coal is being used it is



View of Boiler showing Controls, Boiler Mountings, etc. (Railcar)

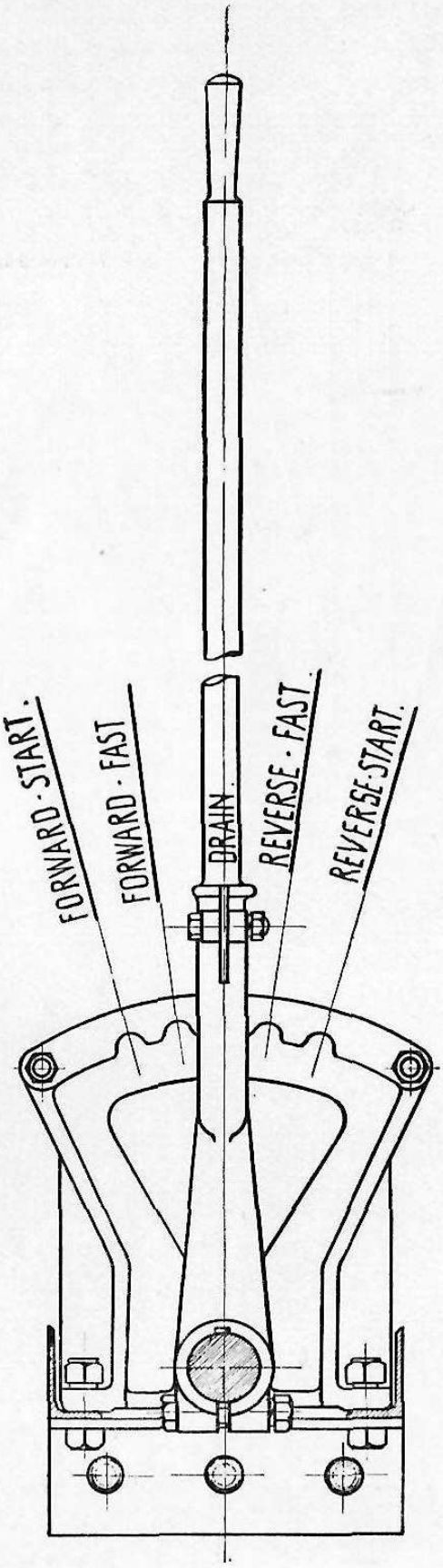






INDICATOR PLATE FOR THROTTLE & BRAKE AND QUADRANT INDEX PLATE FOR REVERSING GEAR

RAILCOACH



VIEW OF QUADRANT LOOKING TOWARDS BOILER.

[LOCO.]

sometimes found advantageous, in order to get rid of the accumulation of smoke in the combustion chamber, to open the Blower Valve slightly. This should not be done, however, with a less pressure than 50 lbs. per square inch.

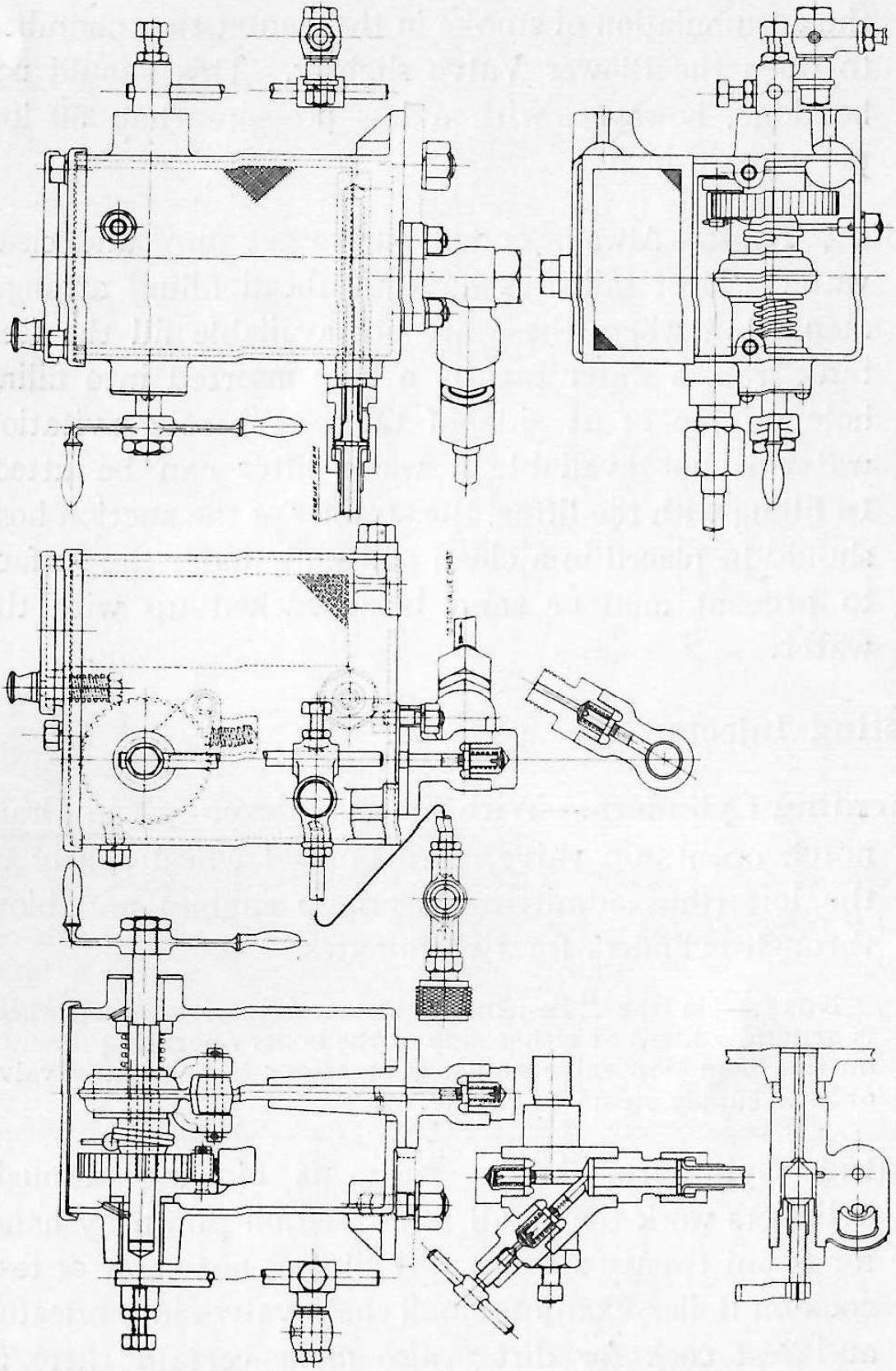
Filling Tank.—Always endeavour to get pure and clean water. Most railways have overhead filling arrangements but where these are not available fill the feed tank from a water tap by a hose inserted into filling hole on top or at side of tank. Where gravitation water is not available a water lifter can be fitted. In filling with the lifter, the strainer of the suction hose should be placed in a clean pail sunk under the surface to prevent mud or sand being sucked up with the water.

Testing Injector.—See page 29.

Warming Cylinders.—With reversing lever still in Drain notch open stop valve, turn Control wheel gently to the left (thus admitting steam to engine) and blow through cylinders for two minutes.

NOTE.—On the "Sentinel" locomotives a control wheel is generally fitted at either side of the boiler operating directly on the main stop valve and it is necessary to open stop valve only to supply steam to engine.

Oiling Cylinders.—While steam is blowing through cylinders work the small force feed oil pump by hand for about twenty strokes. If oil does not show at test cock on Boiler, examine small check valves in lubricator and test cock for dirt; also make certain there is no water in pipes.



Sentinel Lubricator (Railcar and Loco.)

Never let the cylinder lubricator run dry. Use "Sentinel" Cylinder oil, or the proprietary brands recommended by our agents. Do not use cheap oil.

Lubrication.

Lubrication.—This is most important, and must be looked to before starting.

See that all dirt and dust is carefully removed from oil boxes, etc., before oil is put in, or it will do endless damage.

Engine and Crank Case.—Look to this daily and pour new oil through crank case filler until oil level is above test cock provided on left-hand side of engine. On later engines a dipper rod with marks at correct oil level is fitted in lieu of the test cock.

Camshaft Control Spindle.—An oil plug is provided on the control box dust cover for oiling this. Fill up with crankcase oil weekly.

Axleboxes.—Fill with high-grade oil to the level of the oil-filler twice weekly. See that the filler closes properly, and keep it clean. Take off bottom half box once in two months, and examine oiling pad. If glazed, renew it.

Chains.—Keep well lubricated by adjusting the drip feed on the chain lubricator provided. Chains should be removed at least once per month, thoroughly cleaned in paraffin and carefully lubricated by being soaked in oil. An alternative method is to remove the chains every seven or fourteen days and heat them in a bath of grease and graphite sufficiently for the

grease to flow between the links. If this method is adopted, no oil lubrication is required.

NOTE.—Do not put grease on chains except as described above, as grease on chains prevents the oil getting to the bearing surfaces.

Reversing Gear.—Fill all stauffers with grease, and go round all grease nipples weekly.

Brake Gear.—Go round all grease nipples and oilcups weekly.

Dual Controls (on Railcar).—Go round all grease nipples and oil-cups weekly.

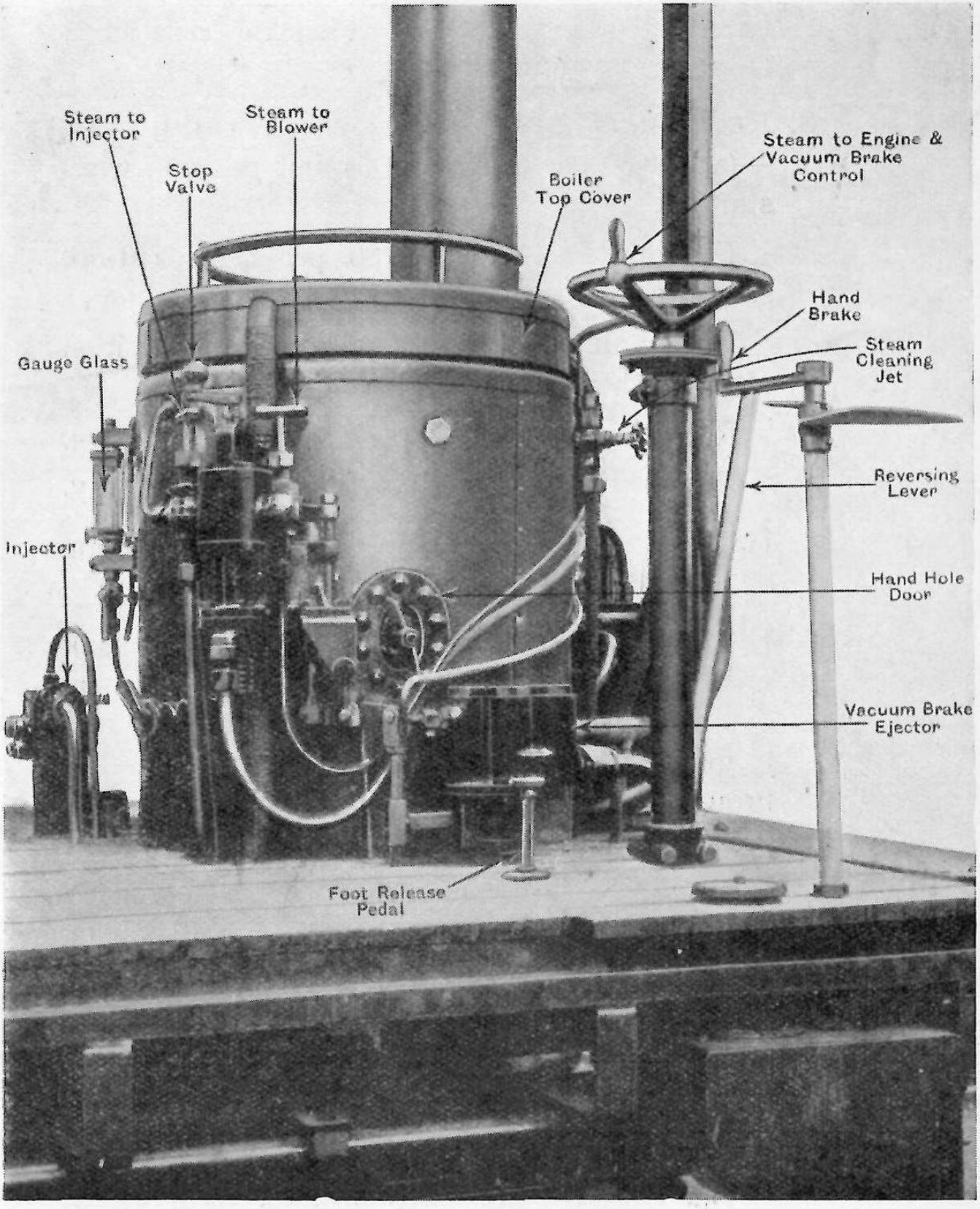
Spring Slippers and Radius Rods.—Go round grease nipples weekly, except nipples on spring brackets, which should be given a charge every morning.

IMPORTANT.—Open the drain cock or plug in the engine sump every morning and drain off any accumulation of water. If a plug only is fitted a drain cock can be provided on application to the makers or their agents.

Running Instructions.

Car.—Controls are fitted in the Engine and rear end of Car, and therefore the following instructions apply whether the car is being driven from power unit or rear end of car. The controls are :—

1. STOP VALVE.—Controls the steam supply from boiler.
2. CONTROL WHEEL.—When turned to the left from neutral position : Controls amount of steam supplied to engine by means of a throttle valve



View of Boiler showing Controls (Railcar).

after the stop valve has been opened. When turned to the right from neutral position: Operates Vacuum Brake.

3. REVERSING LEVER.—Positions: Forward start —(about 80 per cent. cut-off) first position when starting.

   Forward Fast—(about 30 per cent. cut-off) second position when under way.

   Drain—all engine valves open, normal position of lever when vehicle is stationary.

   Reversing Start—first position when reversing.

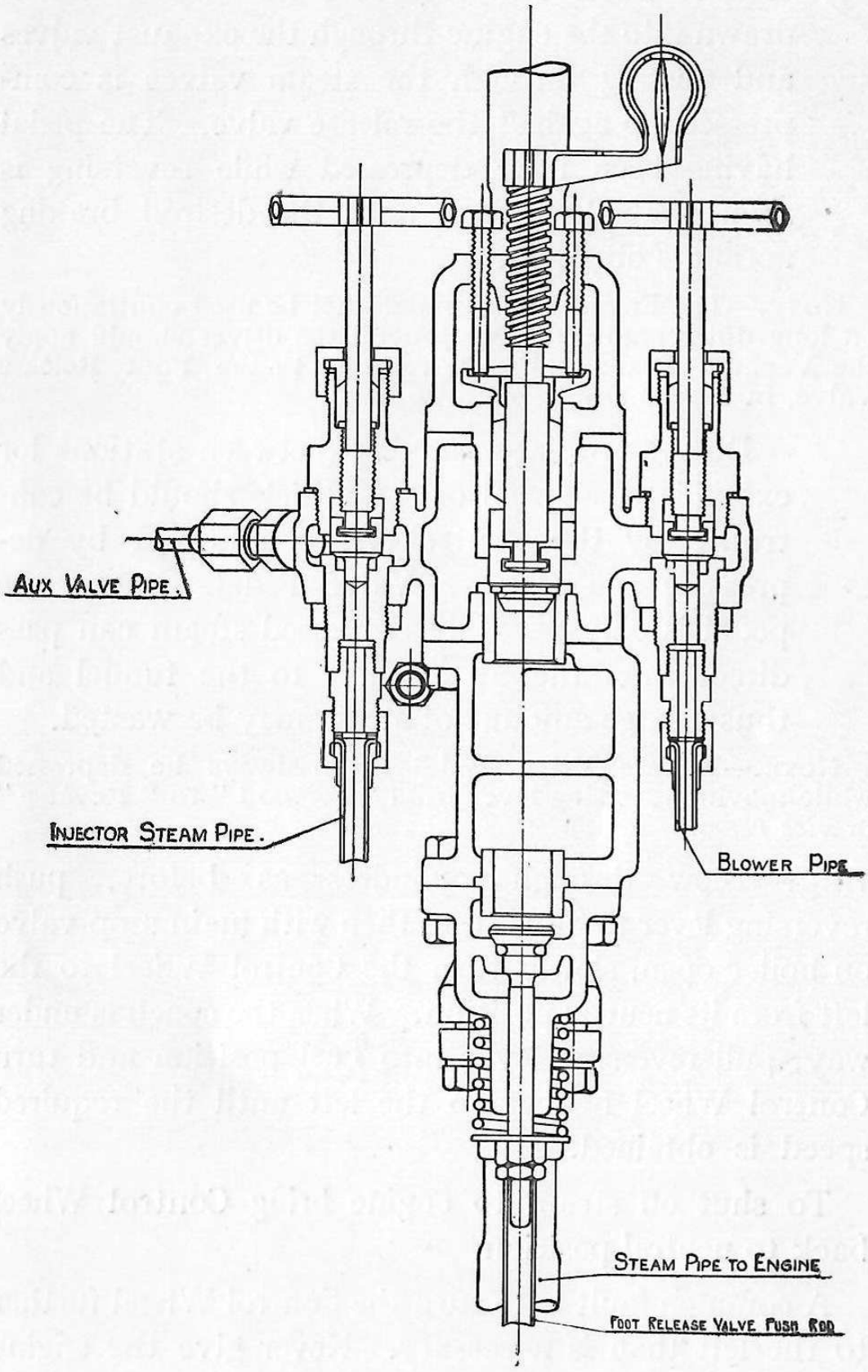
   Reverse Fast—second position when under way.

4. HAND BRAKE.—Operated by hand and acting on all wheels.

5. RELEASE VALVE PEDAL.—This release valve is of great value especially in manoeuvring, for by depressing the pedal steam is cut off quickly and it may be kept shut until the control wheel is brought to the "off" position. This also provides an independent means of shutting off steam in case of emergency.

   The Release Valve Pedal should always be depressed while moving the reversing lever as it momentarily shuts off steam and opens communication from the steam pipe to the exhaust, thus relieving the valves of steam pressure and allowing the cam shafts to be moved easily.

   The release valve may also be used as an emergency brake; by shutting off steam at the



Stop, Auxiliary and Release Valves (Railcar).

control wheel and reversing the engine, air is drawn into the engine through the exhaust valves and passing through the steam valves is compressed up against the release valve. The pedal having been fully depressed while reversing is then gradually raised until the desired braking action is obtained.

NOTE.—The Engine Brake should not be used continuously on long down gradients. In general the driver should apply the Vacuum Brake and have recourse to the Foot Release Valve, in case of a quick pull up only.

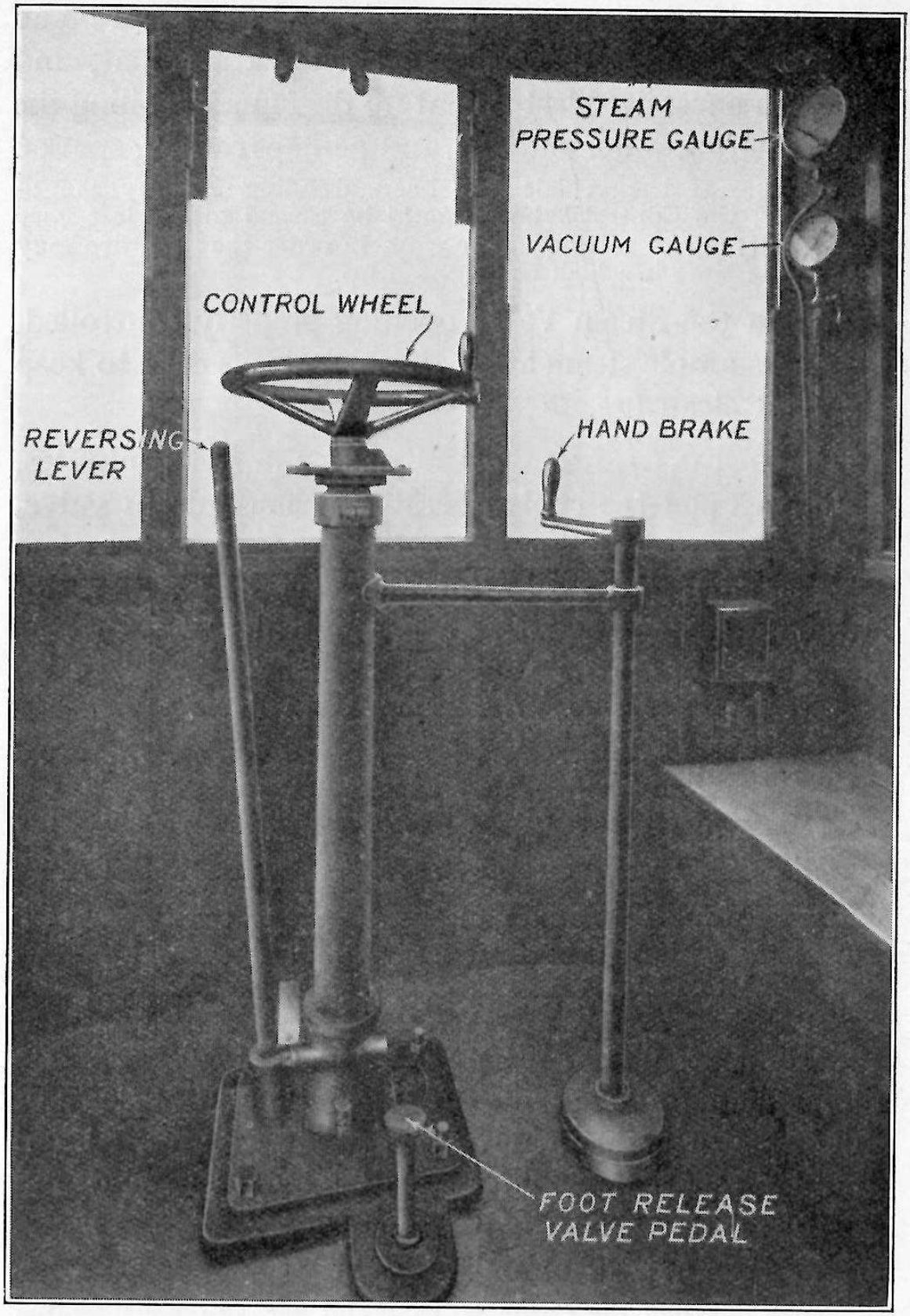
During ordinary running (between stations for example) the speed of the vehicle should be controlled by the Control Wheel and not by depressing the Release Valve Pedal. When the pedal is only partially depressed steam can pass direct from the Stop Valve to the funnel and thus a large amount of steam may be wasted.

NOTE.—Release Valve Pedal must always be depressed while moving reversing lever from "Forward" to "Reverse" or *vice versa*.

Starting.—Blow through cylinders as before, push reversing lever to Start, and then with main stop valve on boiler open, slowly turn the Control Wheel to the left from its neutral position. When the coach is under way, pull reversing lever into Fast position and turn Control Wheel further to the left until the required speed is obtained.

To shut off steam to engine bring Control Wheel back to neutral position.

A common fault is to turn the Control Wheel further to the left than is necessary. Never give the engine more than just enough steam for the work it is required



Showing the Car Controls at Rear End.

to do ; if an excessive amount is used there will be no reserve of pressure when needed for a gradient, and also an excessive blast is sent up the funnel, spoiling the fire, wasting water and fuel, and perhaps causing sparks.

NOTE.—If the vehicle has been standing for any length of time, the Control Wheel should be turned to the left very gradually when getting under way, in order that the fire may be given time in which to brighten up.

With the Steam Valve opening properly controlled, there is ample steam at all times, and it is easy to keep a good clean fire.

IMPORTANT.—After standing for a few minutes, always open the cable operated exhaust drain valve, and blow steam through cylinders for a short time with the lever in the " drain " position. The drain valve may be left open until well under way.

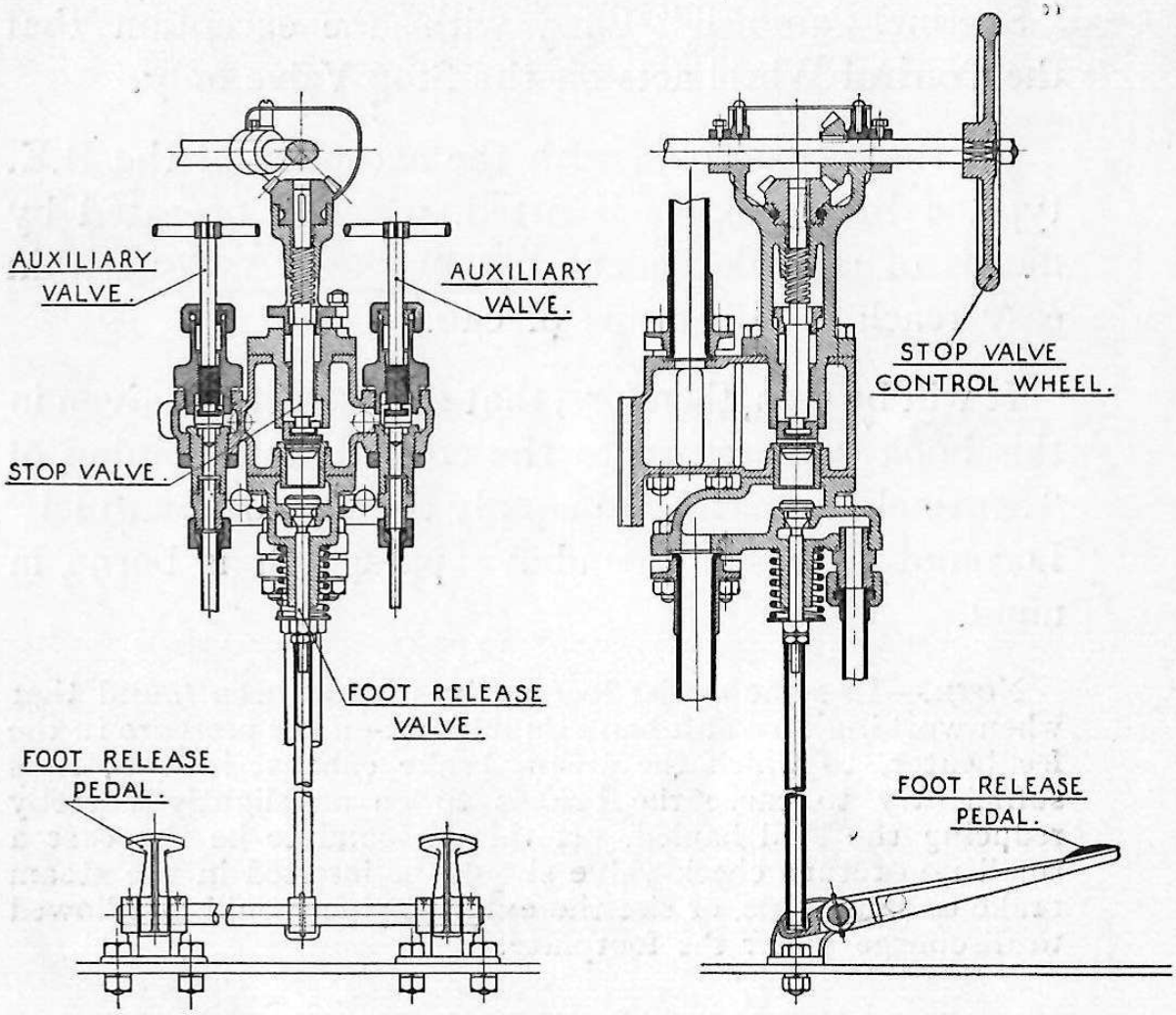
Vacuum Brake.—The Vacuum Brake usually fitted is of the straight vacuum type. Steam is admitted to the vacuum ejector by turning the Control Wheel to the right, thereby creating a vacuum in the train pipe which acts on the vacuum cylinders.

When applying the Vacuum Brake watch the needle of the Vacuum Gauge which should rise quickly and steadily to 15 in. to 20 in.

If the needle rises very slowly or tends to hang at a low vacuum, leakage in the pipe system or a dirty or damaged cone in the ejector should be suspected and an examination should be made at once to find and rectify the cause.

Test your brakes daily before leaving the sheds.

NOTE.—When the Coach is to stand for any considerable time *close the main Stop Valve and put the Reversing Lever in the Drain position.*



ARRANGEMENT OF STOP, AUXILIARY AND RELEASE VALVES.

FOR

"SENTINEL" PATENT LOCOMOTIVE.

Locomotive.—The controls on the Locomotive are duplicated in order that it may be driven from either the off or near side.

All the controls are similar to those fitted on "Sentinel-Cammell" Cars, with the exception that the Control Wheel acts on the Stop Valve only.

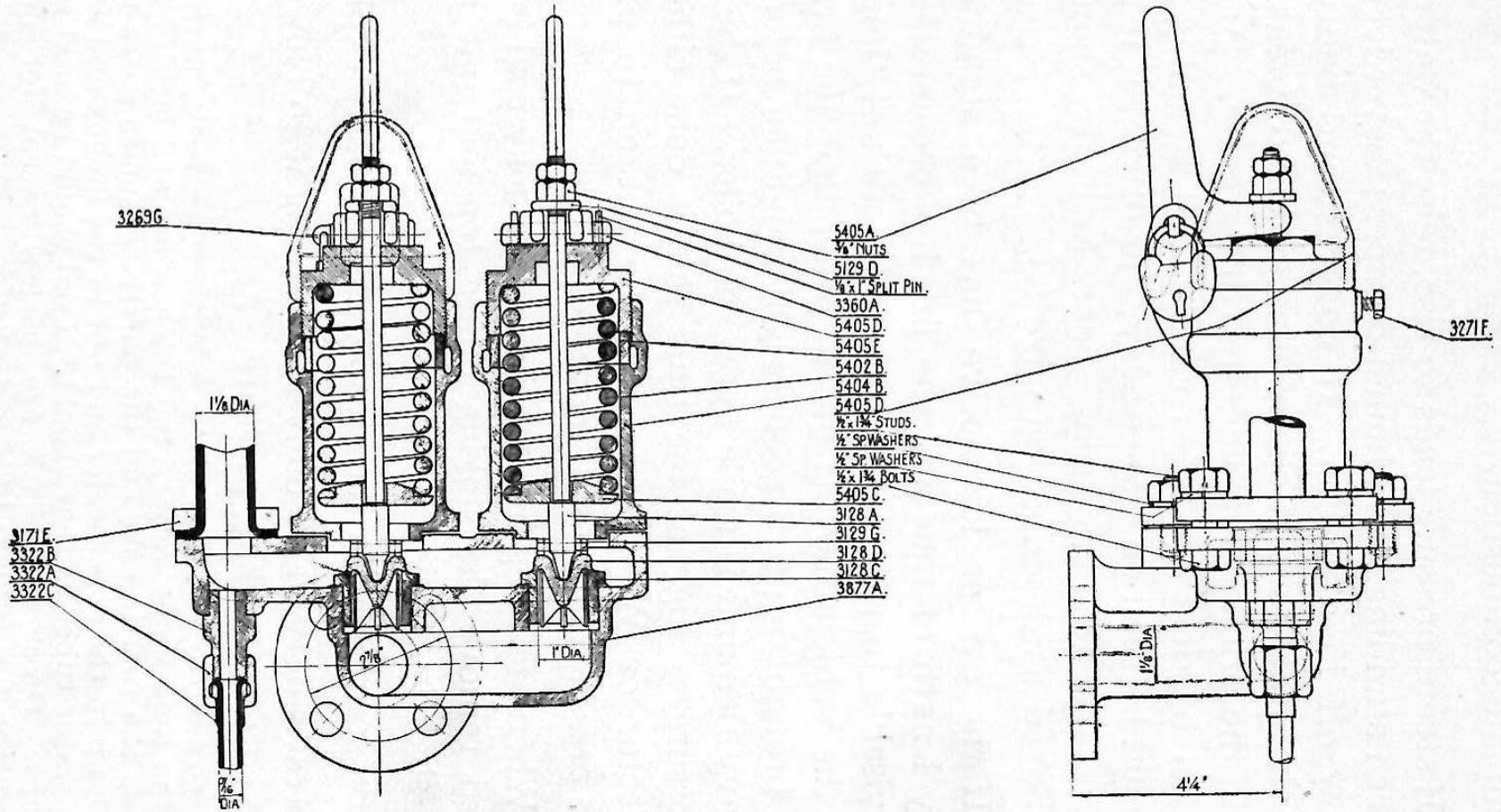
On the locomotives, with the exception of the B.E. type, a Steam Brake is fitted, which is operated by means of an independent Steam Brake Valve within easy reach of either side of cab.

It will be seen, therefore, that all instructions given in this book with regard to the control, and running of "Sentinel-Cammell" Cars apply equally to "Sentinel" Locomotives when the above paragraph is borne in mind.

NOTE.—In some earlier locomotives it has been found that when working up a stiff bank on late cut-off the pressure in the feedheater, to which the steam brake exhaust is lead, rises sufficiently to cause the brakes to go on slightly thereby reducing the load hauled. If this is found to be the case a small non-return check valve should be inserted in the steam brake exhaust pipe, or else the exhaust pipe should be allowed to discharge under the footplate.

Care of Car or Locomotive when in Service.

Management of Boiler.—With a little practice a steady water level at about 3 ins. from bottom of glass, and a good head of steam are easily maintained. Care must be taken to keep the fire clean and bright and distributed evenly all over firegrate. Put in fuel frequently aiming always to keep a bright fire about 6 in. thick,



Safety Valves (Railcar and Loco).

and allowing enough space between fire and tubes for complete combustion.

If steam pressure tends to rise, raise the water level. When standing, close funnel damper ; never let steam blow off in a station. If boiler steams badly look to the grate, and if clinker has gathered, break it up with the pricker from underneath the grate. Accumulation of dust on tubes causes bad steaming ; this should be seen on " Shed Day," or oftener if it proves necessary through using poor fuel. It should be removed as described on page 38.

If the car or locomotive has been standing for any length of time and the fire has become low it is advisable to put on the blower for a short time prior to the vehicle moving off, in order that the fire may be brought up to a good bright condition before any heavy demand is made upon the boiler. If the steam pressure is high at the time this is done either the injector or Weir pump may be put on to prevent the pressure rising still more.

When standing in a station and smoky coal is being used remove the stoking chute top and put blower on slightly.

Be sparing with the steam, as previously explained.

Test safety valve daily by allowing it to blow off at the correct working pressure.

NOTE.—Do not over stoke. With some coals, particularly of the long flame variety, too thick a fire and lack of air will cause the fuel to coke and the partly-consumed gases to burn high up in the superheater and not in the firebox and amongst the water tubes as they should. Coal should be used in *small* lumps. Dross and slack are useless except for damping down the fire. *Stoke little and often.*

Climbing Gradients.—On approaching a gradient see that you have a full head of steam, water rather over 3 in. from bottom of glass, and a bright fire about 6 in. deep. Use the Fast notch of your reversing lever, and only if vehicle labours at all use the Start notch, regulating the supply of steam to engine to suit.

NOTE.—It should very rarely be necessary to use the *Start* position after Car has been got under way.

Use of Exhaust Relief Valve.—On later Cars and Locos (except B.E. Locos) an adjustable relief valve is fitted on the Engine Exhaust branch, and must be used in conjunction with the Blast Pressure Gauge as set out below. A blast nozzle smaller than it would otherwise be possible to use is fitted when the relief valve is provided, so that an appreciable funnel blast can be maintained when the boiler is working on light load, thus ensuring maintenance of a full head of steam.

1. Working on late cut-off, throttle wide or fairly wide :—
   Open or partially open relief valve, to keep blast pressure at 8 to 10 lbs. per square inch. Higher pressures cause excessive sparking.
2. Working at low speeds on early cut-off with throttle wide :—
   Open relief valve slightly, to maintain blast pressure at 5 to 7 lbs. per square inch. At this pressure steam should be well maintained.
3. Working at high speeds on early cut-off with throttle wide :—
   Close relief valve. Blast Pressure should be 6 to 8 lbs. per square inch.

4. Working at high speeds on early cut-off, level line or slight down grade, throttle partially closed :— Close relief valve. Blast pressure should be 3 to 4 lbs. per square inch.

If these pressures cannot be obtained, try a smaller nozzle.

If pressures are excessive, try a larger nozzle, or see if the nozzle is choked with carbon. (See page 44—" Blast Nozzles.")

Locos. or Cars without Adjustable Relief Valve. Where no adjustable relief valve is fitted, a rather larger nozzle is used, to keep blast pressures down to a reasonable figure. Under these conditions, blast pressures should be as follows. (See paragraphs above).

1. Not more than 20 lbs. per square inch.
2. 3 to 5 lbs. per square inch.
3. 5 to 7 lbs. per square inch.
4. 2 to 3 lbs. per square. inch.

Under condition (4) it may sometimes be necessary to use the blower slightly, but avoid doing so if possible.

Descending Long Gradients.—Do not use the engine as a brake. You run the risk of getting water into the cylinders, or even pulling cinders and dirt from the funnel through the exhaust pipe. Put the reversing lever into drain, and close the throttle (or stop valve). Use the Blower if necessary to keep the fire bright, or while stoking. Warm through the cylinders before reaching the bottom of the grade if it has been long.

It is sometimes necessary to use Blower when running down long gradients with steam shut off,

so that a good head of steam may be maintained to climb the next gradient. Under these circumstances the Blower may also be used slightly to prevent flames and smoke entering the cab when the furnace door is removed for stoking.

Boiler Feeding.—When the vehicle is running, the boiler is fed by the engine feed pump, the amount being controlled by the Bye-pass Valve. Where specially requested a Weir type steam feed pump is also fitted. A Booklet giving instructions on the maintenance of the Weir Pump will be sent upon application to The Sentinel Waggon Works, Ltd.

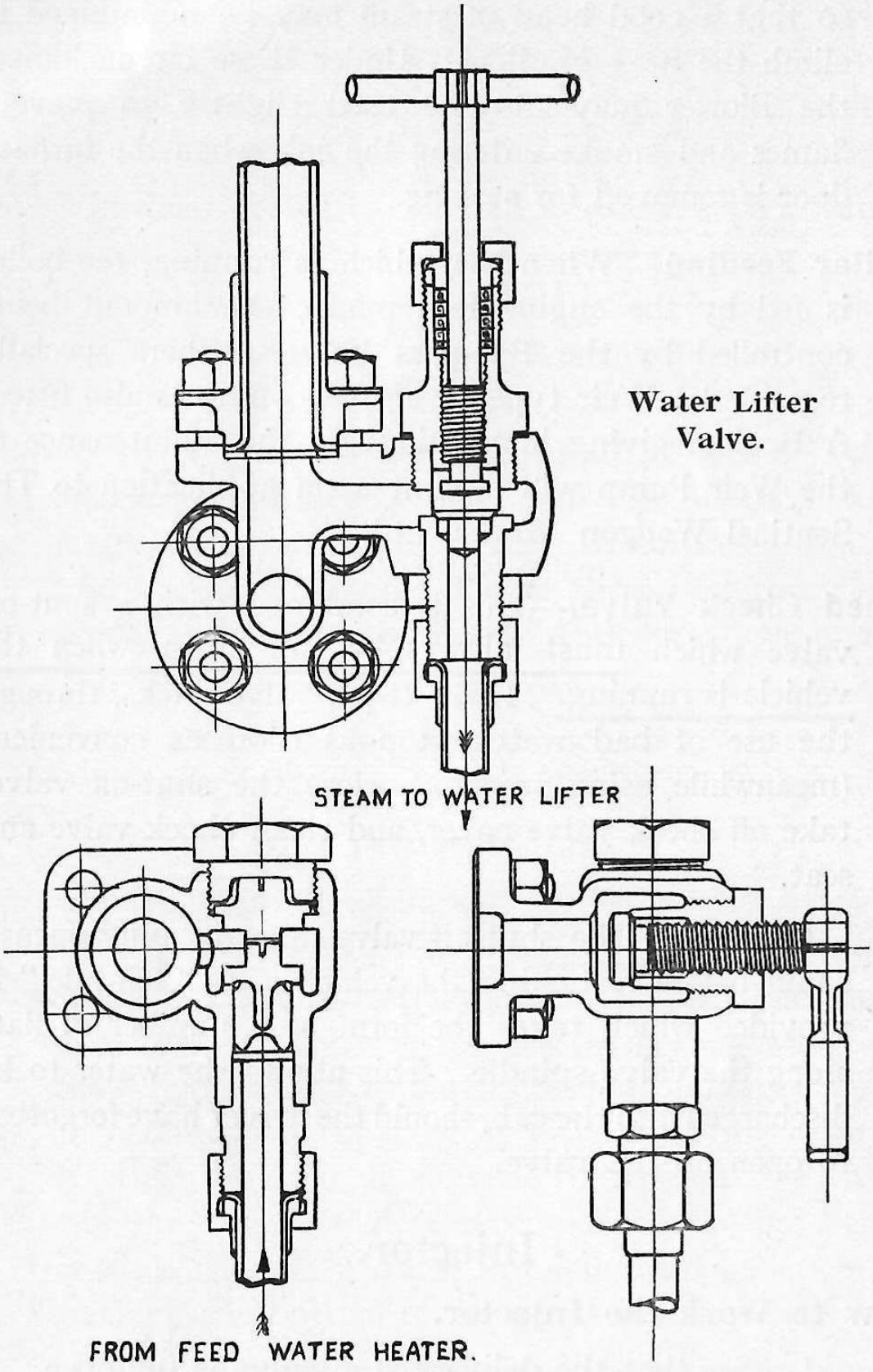
Feed Check Valve.—This is combined with a shut-off valve which must always be full open when the vehicle is running. If the check valve sticks, through the use of bad water, stop as soon as convenient (meanwhile using Injector), close the shut-off valve, take off check valve cover, and clean check valve and seat.

CAUTION.—The shut-off valve must be fully opened again before restarting the vehicle. A " tell-tale " is provided which takes the form of a number of flats along the valve spindle. This allows the water to be discharged into the cab, should the driver have forgotten to open up the valve.

Injector.

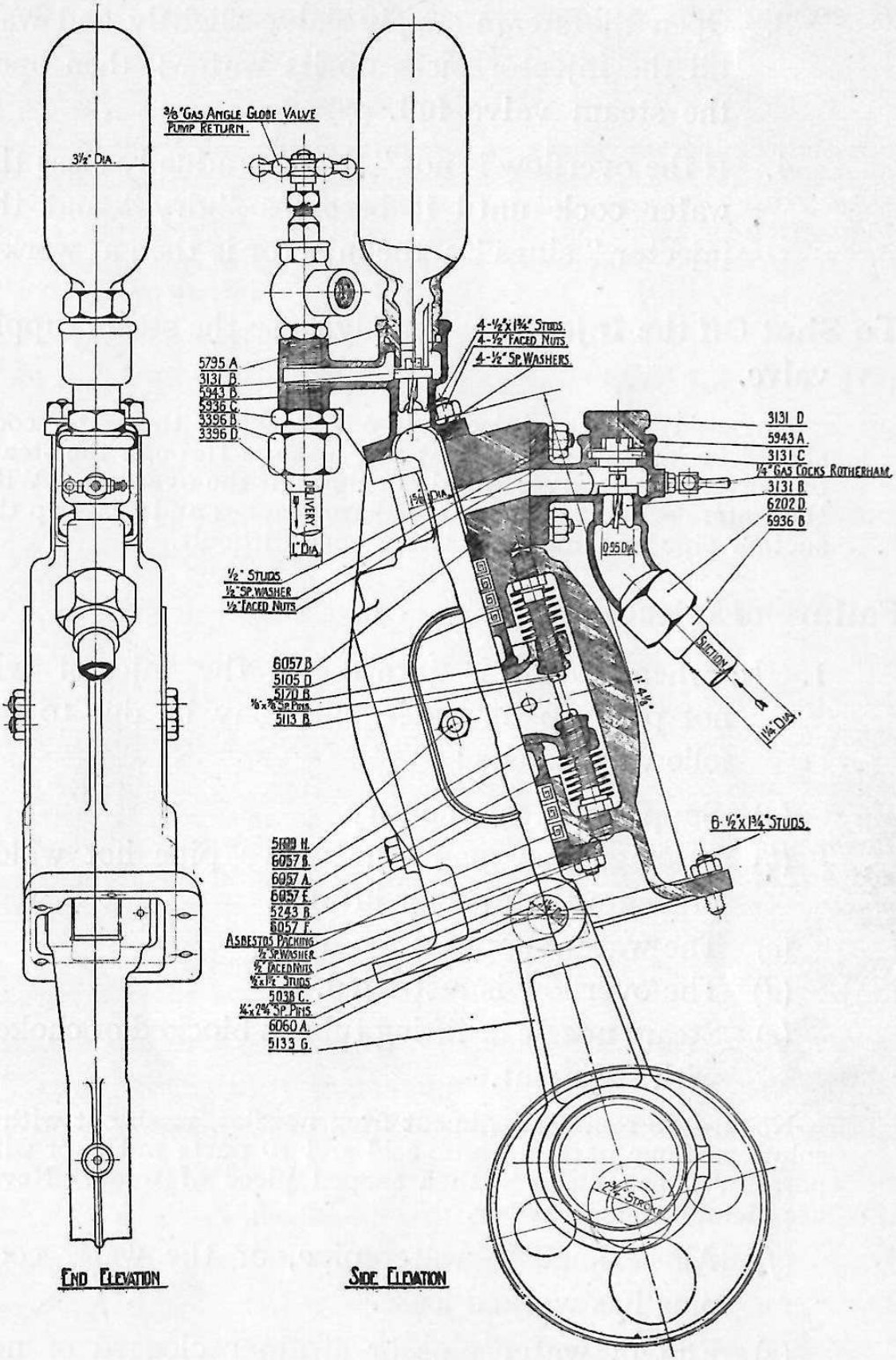
How to Work the Injector.

1. See that the delivery stop valve is full open.
2. Open the water cock full.



Water Lifter Valve.

Feed Check Valve (Railcar and Loco.)



Engine Feed Pump (Railcar and Loco.)

3. Open the steam supply valve slightly and wait till the injector picks up its water; then open the steam valve full.

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

To Shut Off the Injector.—Simply close the steam supply valve.

NOTE.—When the injector is not working, the water cock should be kept closed so that any leakage through the steam or delivery stop valves will drain through the overflow. With the water cock left open, this leakage reaches and heats up the suction pipe and makes starting very difficult.

Failure of Injector.

1. If, when steam is turned on, the injector will not pick up its water, this may be due to the following causes:—

(*a*) Supply of steam not dry.
(*b*) Leakage has made the water pipe hot which prevents the injector lifting.
(*c*) The water supply is too hot.
(*d*) The overflow is restricted.
(*e*) 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 10 parts water, or with paraffin; then clean with a shaped piece of wood. Never use metal or emery paper.

(*f*) Air leakage in water pipe, or the water cock plug has worked loose.
(*g*) End of water pipe or strainer clogged or not covered by water in the tank.

2. If the injector gets its water but forces it out through the overflow*:—

(*a*) Defective steam supply.

*When the steam pressure is under normal, water will often run from the overflow if the water cock is full open even though the injector is working, in which case the water cock should be regulated until the injector works dry. Do not confuse this with water running from the overflow owing to failure to work.

(*b*) Water supply too hot.

(*c*) Jumper or delivery nozzle choked (*see* Note 1(*e*) page 32).

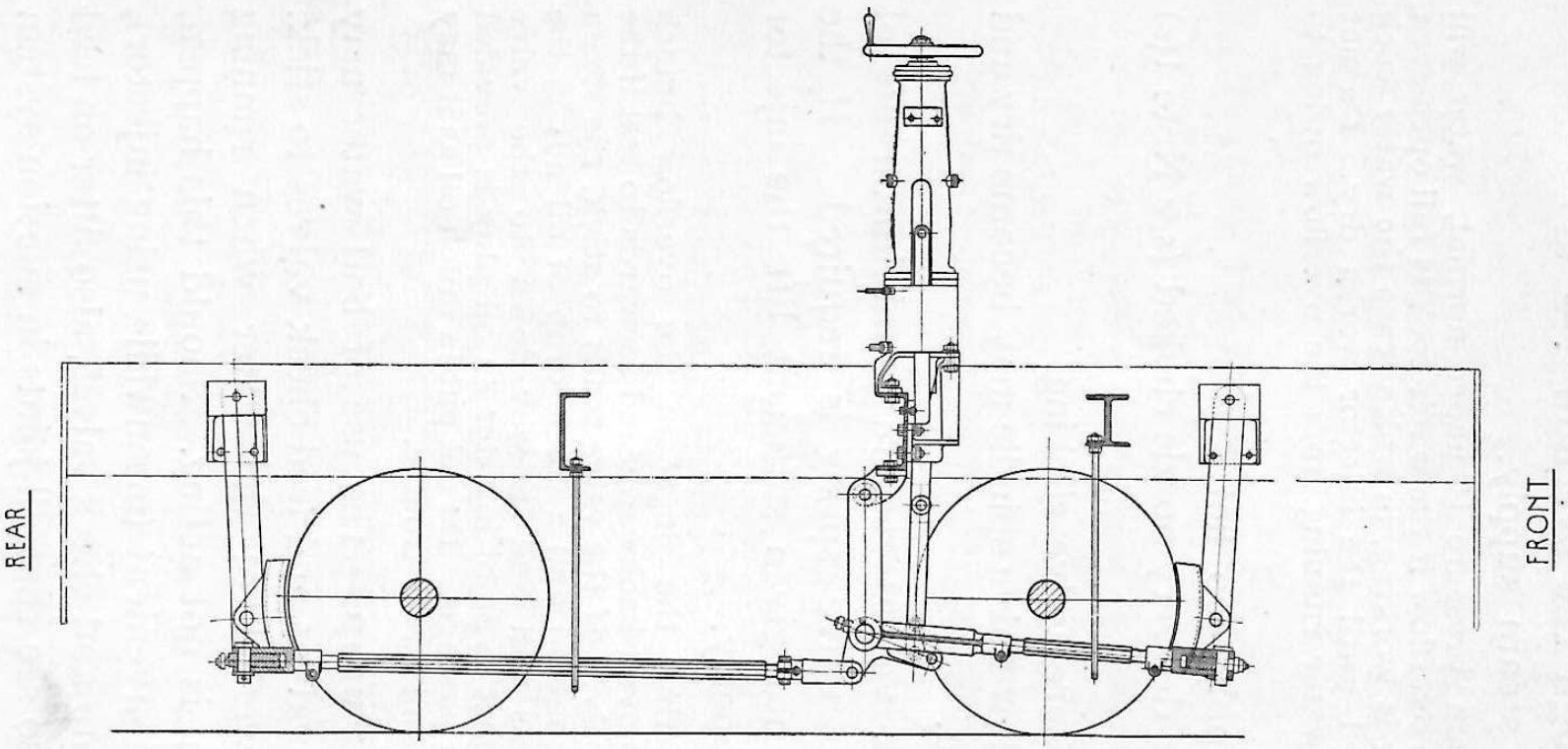
(*d*) Back-pressure valve sticking.

(*e*) The overflow valve spindle may become dry and stick open.

Injector check valves require a minimum lift of 3/32 in. and no valve spring is required. If the check valve is not given sufficient lift the injector cannot work properly.

NOTE.—By inserting the finger in the overflow branch the valve may be moved backwards and forwards to test if the valve is moving freely. If the valve tends to stick, the steam pipe should be uncoupled and a single drop of oil put in the steam branch. This will find its way down to the valve spindle. In the latest type of injector an oil plug is provided on top of the steam passage. Do not put in much oil as it may get into the boiler and cause trouble.

Failure of Engine Pump.—The use of bad water may cause the pump valves and feed check valves to stick. The gradual lowering of the water when running shows that pump is not acting. Should this happen, stop as soon as convenient (meanwhile using injector), and examine pump and check valves, also filter on feed water tank. Also see that all joints in suction system are tight, as a slight air leak may entirely stop the feed pump working.



ARRANGEMENT OF STEAM & HAND BRAKE

FOR

"SENTINEL" PATENT LOCOMOTIVE.

If a Weir type feed pump is fitted on the vehicle there will be no necessity to stop as the water level can easily be maintained.

See page 31 for illustration of Feed Pump.

All check valves on the pump delivery pipes require a lift of 1/64 in. and it is always advisable to fit a spring on to the pump delivery check valve in the check valve chest attached to the boiler.

Failure of Pumps and Injector.—The water level should not be allowed to fall below bottom of gauge glass otherwise there is a risk of the fusible plug melting. If the water level gets very low due to failure of pumps and injector stop the vehicle, close funnel damper, and if steam still rises damp fire down with coal or coke dust. If the defect in pumps or injector can be traced without undue delay the fire need not be drawn out, but this is a matter which must be left to the discretion of the Driver.

Cylinder Lubrication.—Test this occasionally by opening oil test cock on stop valve.

To Stop Slowly on Level.—Shut off steam, and allow Car or Locomotive to roll to a standstill. Put on hand brake hard and put reversing lever at Drain notch.

To Stop more Quickly.—Apply Vacuum Brake on Car gradually, and if this is not sufficient press foot pedal, put reversing lever into Reverse notch, and gently release foot pedal. As soon as vehicle is stopped put reversing lever into Drain notch. As a rule the vacuum

brake should be used for pulling up, and the foot release valve be retained as an emergency brake only.

Hand Brake.—This brake is used for holding Car or Locomotive when stationary, and for checking speed of vehicle when descending long and steep hills.

Both vacuum and hand brakes are adjusted by means of the take-up gear on the rods. They should be set so that when the brakes are released the brake shoes just clear the wheels. If the brakes are adjusted too closely, fuel and water will be wasted.

NOTE.—The instructions regarding Vacuum Brake apply equally to the steam brake fitted on Sentinel Locomotives. See page 34 for illustration of Loco. Brake Gear.

Leaving Car or Locomotive for the Night.—Put reversing lever to Drain. Put hand brake hard on, fill boiler by injector well above glass, remove clinker from firegrate, if necessary, but do not draw out fire. Fill furnace, close ashpan and funnel damper, and shut off water gauge top and middle cocks in case gauge glass breaks. After a few trials it will be found easy to keep the boiler hot and with about 10 lbs. of steam until the morning.

NOTE.—Always place control wheel and reversing lever in mid position and shut stop valve before leaving vehicle for the night.

If the reversing lever is left in running position a slight leakage at the stop valve might cause the car to move and damage itself.

A few lbs. steam pressure should be showing in the morning, when the fire must be cleaned out and re-lit, and full steam pressure may be raised in about 20 minutes. Always remember that the boiler must be heated slowly and cooled slowly and there will never be leaking joints or such troubles in service.

Shed Day.

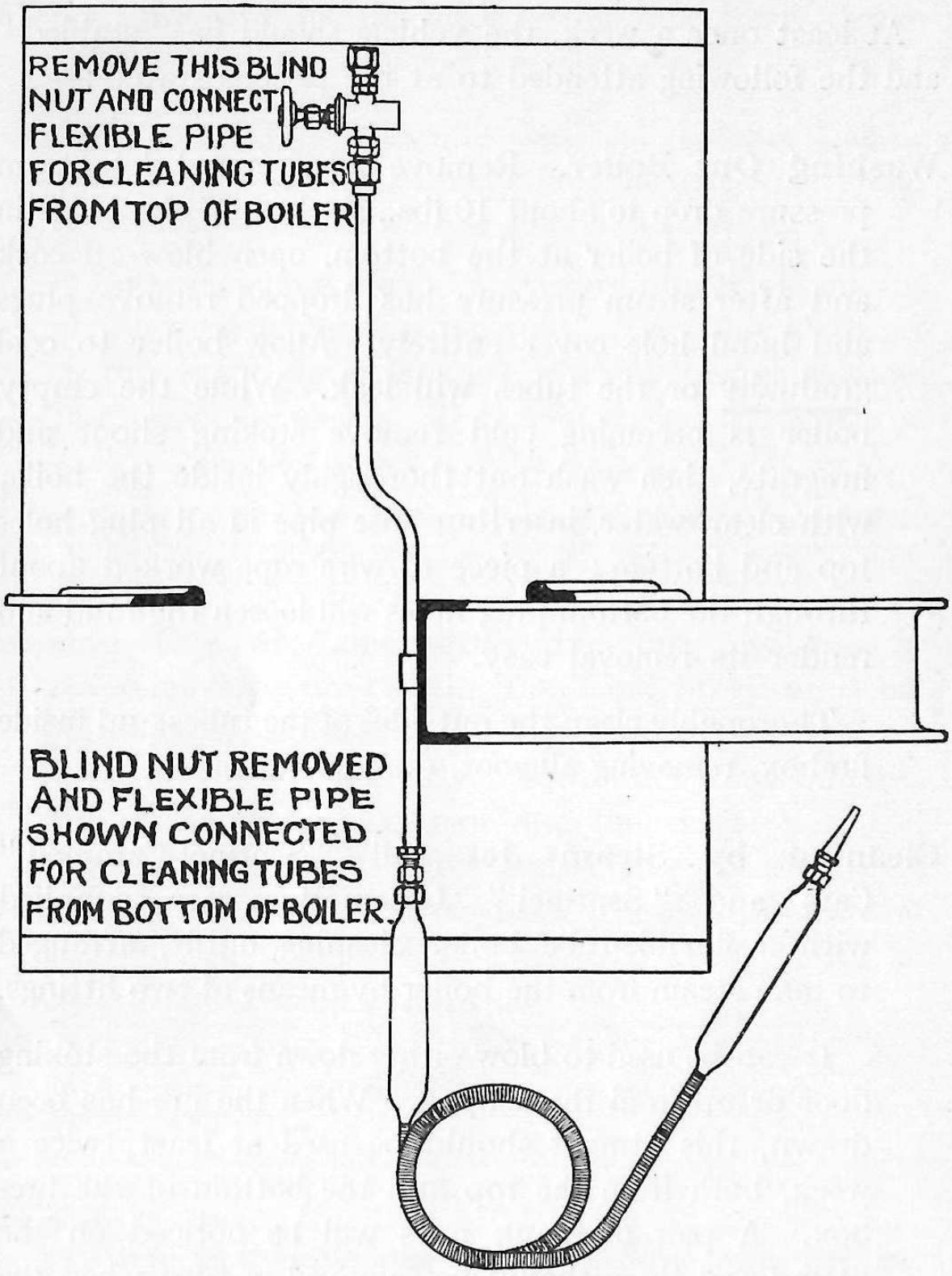
At least once a week, the vehicle should be " stabled " and the following attended to at the periods stated :—

Washing Out Boiler.—Remove all fire and let steam pressure drop to about 10 lbs., slacken off the plugs in the side of boiler at the bottom, open blow-off cock and after steam pressure has dropped remove plugs and hand hole cover entirely. Allow boiler to cool gradually or the tubes will leak. While the empty boiler is becoming cold remove stoking shoot and firegrate, then wash out thoroughly inside the boiler with clean water, inserting hose pipe in all plug holes top and bottom ; a piece of wire rope worked about through the bottom plug holes will loosen the mud and render its removal easy.

Thoroughly clean the outsides of the tubes and inside firebox, removing all soot, dust and coke.

Cleaning by Steam Jet.—All " Sentinel-Cammell " Cars and " Sentinel " Locomotives are supplied with a flexible-tube boiler cleaning outfit, arranged to take steam from the boiler by means of two fittings.

It can be used to blow either down from the stoking door or up from the ashpan. When the fire has been drawn, this fitment should be used at least twice a week, both from the top and the bottom of the fire-box. A pair of blank nuts will be noticed on the fitting and these should be removed in turn when the flexible-tube is in use. It will be found advantageous to use Blower slightly while jet is on.



Boiler Steam Cleaning Jet (Railcar and Loco.)

Blowing Down Boiler.—This should be done as often as convenient during the week to save work on "shed-day." With a low steam pressure put on injector and open the blow-off cock to remove mud from the bottom of the boiler.

Scale in Boiler.—If you are compelled to use hard unsuitable water, a sample (say one gallon) should be sent to a competent analyst, or direct to The "Sentinel" Waggon Works, Ltd., for analysis. A suitable boiler compound will then be recommended and this should be added consistently. Dosage is best carried out by adding the proportional amount (as advised) to each tank of water. When we advise on feed water treatment, we supply the requisite composition made up in tablet form. One or more of these should be added to each tank of water as specified.

To Remove Firebox.—For thoroughly cleaning the inside of boiler the firebox must be lowered and all scale and deposit removed from the inside of the tubes and walls of the boiler. If pure water is used this need only be done about once a year; if very bad, hard, or dirty water is used the firebox should be lowered and cleaned every six months. This period depends entirely on the mileage run and the quality of the water used.

The vehicle shed should be provided with a well-drained pit deep enough to permit of access to the engine, and especially the boiler firebox.

To remove firebox if there is no overhead lifting tackle handy: Take off the stud cover and boiler top, remove superheater coil, firegrate, and ashpan.

Arrange a strong bar across the top of boiler shell and another below bottom flange of firebox with lowering chains between them passing down through the centre of firebox.

Take off all nuts from both top and bottom joints and gently lower firebox, starting it by tapping with a heavy hammer, taking care to have a hardwood buffer between hammer and top of firebox. It may be found necessary to part the joints by driving in, say, half a dozen thin wedges at various points around.

An alternative method is to lower firebox as far as it will go by slackening off the nuts on the long studs on the top flange. When the firebox is lowered to the end of these studs it is possible to insert a plate between the top of the short studs and the inside of boiler shell flange. The plate may be then secured to say four of the short studs.

By hooking lifting tackle to the middle of this plate, the firebox can be lowered away evenly without any chance of its tipping to one side.

Special Caution.—Never take hold of the tubes or hit or strain them in any way when lowering or lifting firebox.

NOTE.—Where a Railway employs a number of " Sentinel " vehicles it is a convenience to possess properly made tackle for lowering the firebox and drawings of such a gear will gladly be sent by the " Sentinel " Co. to users upon request.

Fusible Plug in Firebox.—This must be removed for inspection and cleaning at least once a quarter. Access to it is obtained by removing the hand-hole door.

Caution.—Pure lead only should be used for re-filling fusible plugs.

Boiler Joints.—With care the large joints at top and bottom and also the hand hole door joints will last a long time. Before replacing firebox always smear sides of each joint with graphite and grease, and before bolting up see that no dirt is on joints or metal surfaces.

Boiler Mountings.—Pass a wire through all passages in water gauge fittings Weekly, if dirty water is being used. Examine check valves and clean out deposits if any. Remove pressure gauge pipe at intervals and see that it is clear. Test safety valve Daily by allowing it to blow off at working pressure, and re-grind valve when required. Pack the steam regulator gland, when necessary, with suitable packing, and re-grind all the steam valves if they leak, however slightly.

Retubing Boiler.—(See illustration). When retubing boiler, or re-expanding existing tubes, it is essential to use expanders of the correct size, with long rollers ($2\frac{1}{2}$ in. to 3.3/8 in.). The expander flange must be pushed hard against the end of the tube. No ridges should be made by the ends of the rollers.

On very recent boilers, the longer tubes are bent slightly. When putting these in, drop the boiler top on temporarily, clamp it central, and insert the stoking chute. Tap the new tube (or tubes) into place, twist them until they are just clear of the chute, and of one another, and then expand. Failure to do this may result in insufficient clearance being allowed for the stoking chute.

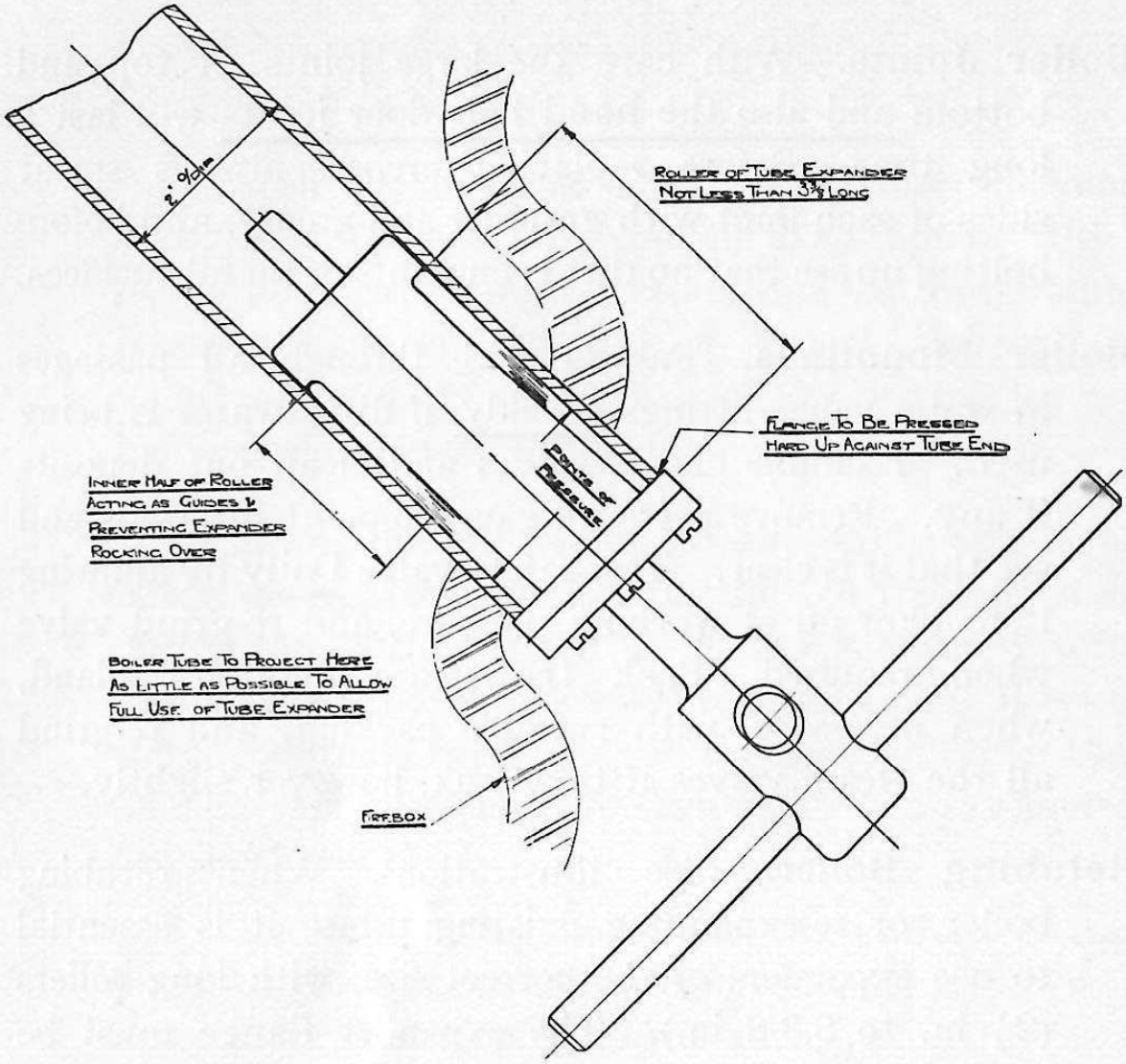
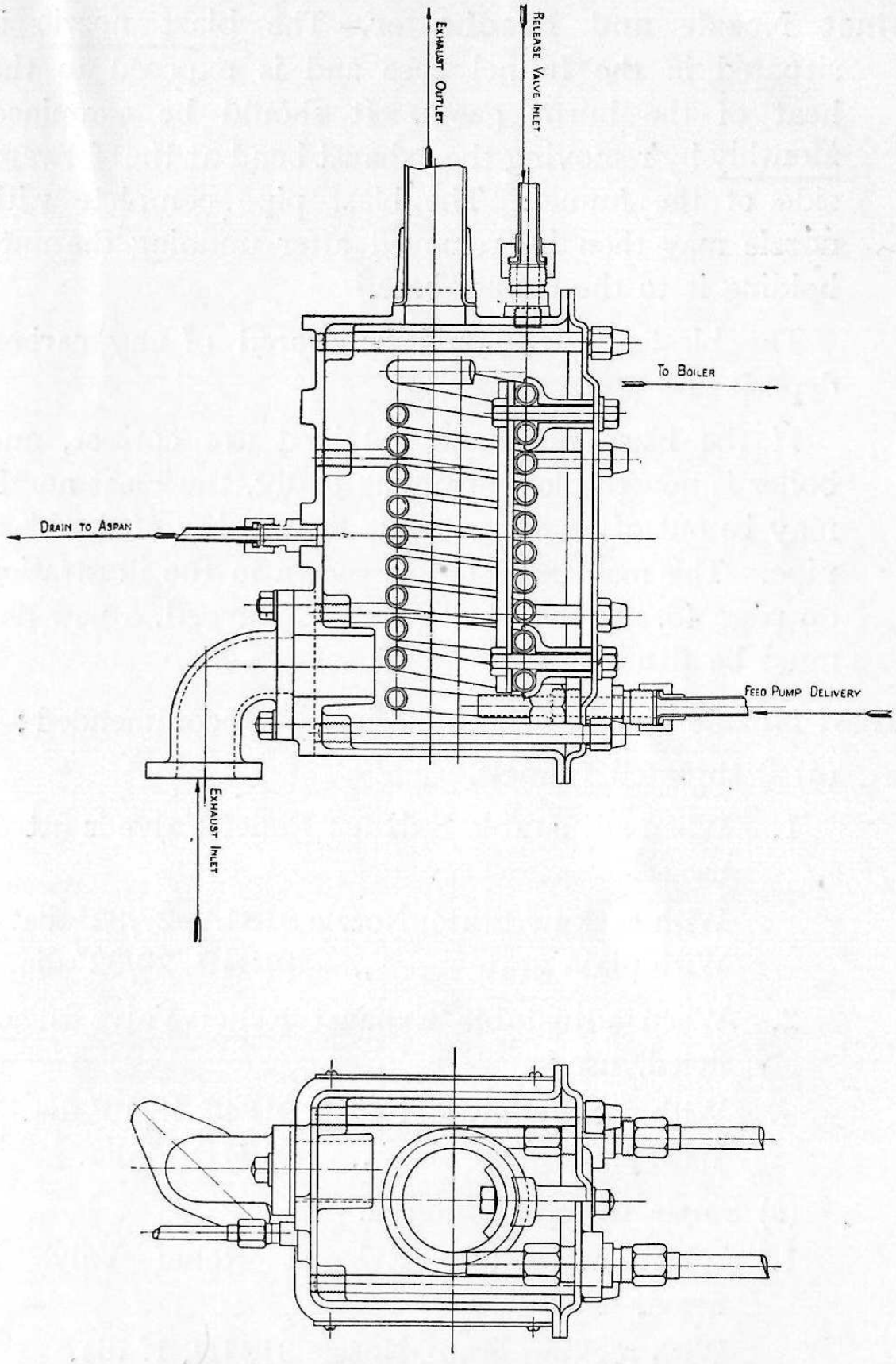


Illustration showing Boiler Tube Expander in position on 25% larger than Standard Sentinel Boiler.

NOTE.—Attention is drawn to the fact that it is impossible to replace less than a complete bank of straight tubes by curved tubes. The insertion of a curved tube in a bank otherwise composed of straight tubes will result in the tubes fouling one another. One complete bank of curved tubes can, however, be put into a boiler otherwise tubed with straight tubes.



Feed Water Heater (Railcar and Loco.)

Blast Nozzle and Feedheater.—The blast nozzle is situated in the funnel base and is exposed to the heat of the burnt gases. It should be examined Monthly by removing the exhaust bend at the forward side of the funnel. The blast pipe complete with nozzle may then be removed after undoing the nuts holding it to the funnel base.

The blast nozzle should be cleared of any carbon deposit and replaced.

If the blast pressures obtained are correct, and boiler is nevertheless steaming badly, the blast nozzle may be out of alignment, due to warping of the blast pipe. This may be tested as shown in the illustration on page 45. If the blast pipe has warped, a new one must be fitted.

Blast Nozzle sizes.—The following are recommended :—

(*a*) 2 throated funnels.

1. When adjustable Exhaust Relief Valve is fitted, use :—

   With rocking grate, Nozzle 9184A, 27/32″ dia.
   With plain grate ,, 9184B, 29/32″ dia.

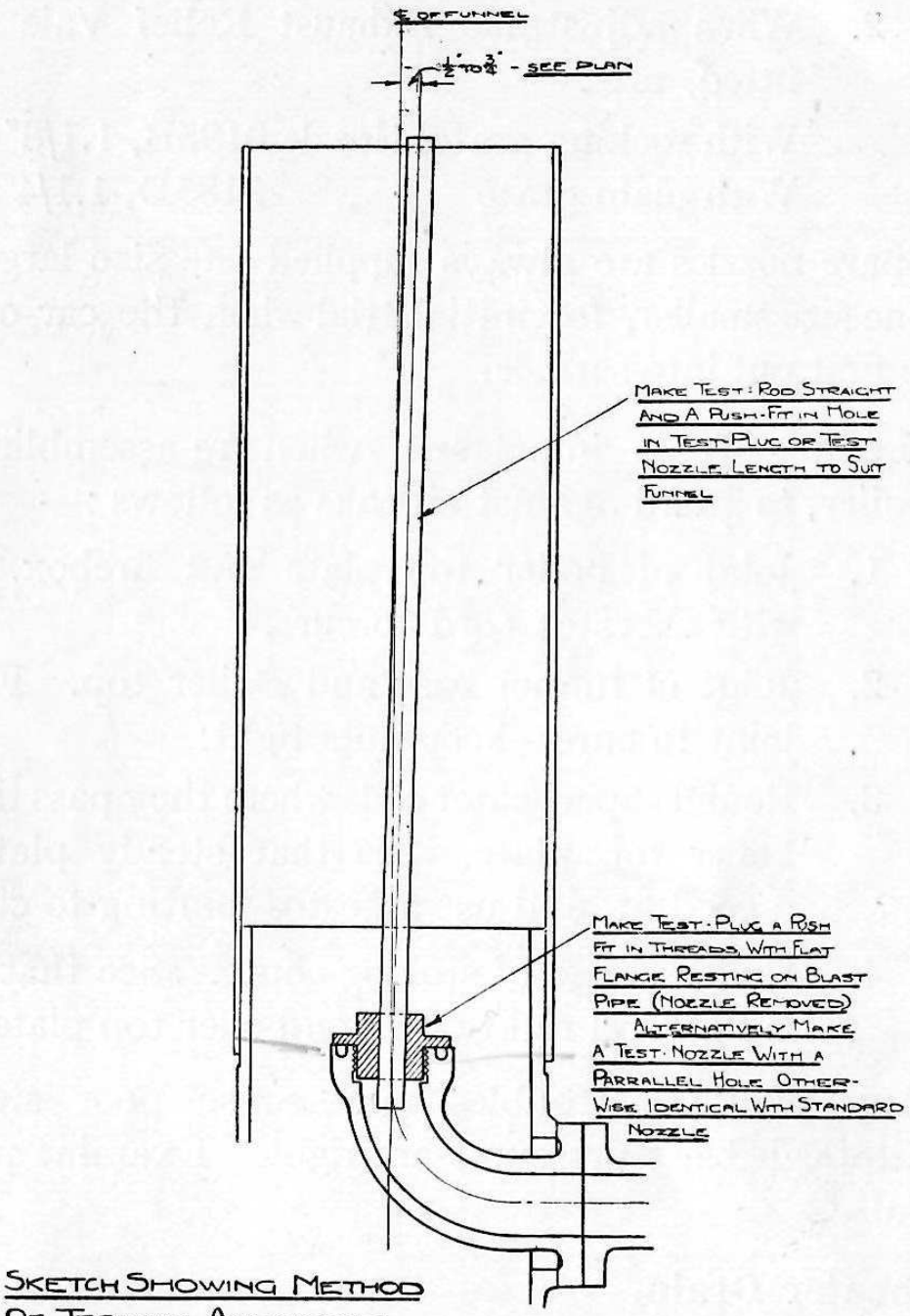
2. When adjustable Exhaust Relief Valve is not fitted, use :—

   With rocking grate, Nozzle 9184C 15/16″ dia.
   With plain grate ,, 9184D 1″ dia.

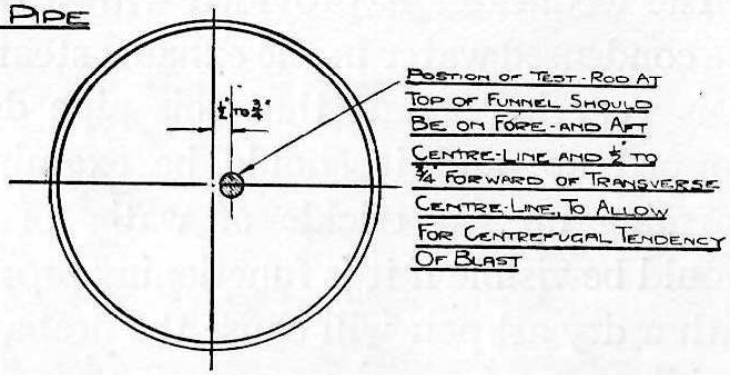
(*b*) Single throated funnels.

1. When adjustable Exhaust Relief Valve is fitted, use :—

   With rocking grate, Nozzle 9184D, 1″ dia.
   With plain grate ,, 9185A, 1.1/16″ dia.



SKETCH SHOWING METHOD OF TESTING ALIGNMENT OF BLAST PIPE



2. When adjustable Exhaust Relief Vale is not fitted, use :—

   With rocking grate, Nozzle 9185B, 1.1/8″ dia.
   With plain grate ,, 9185D, 1.1/4″ dia.

Spare nozzles are always supplied one size larger and one size smaller, for initial trial when the car or loco. is first put into service.

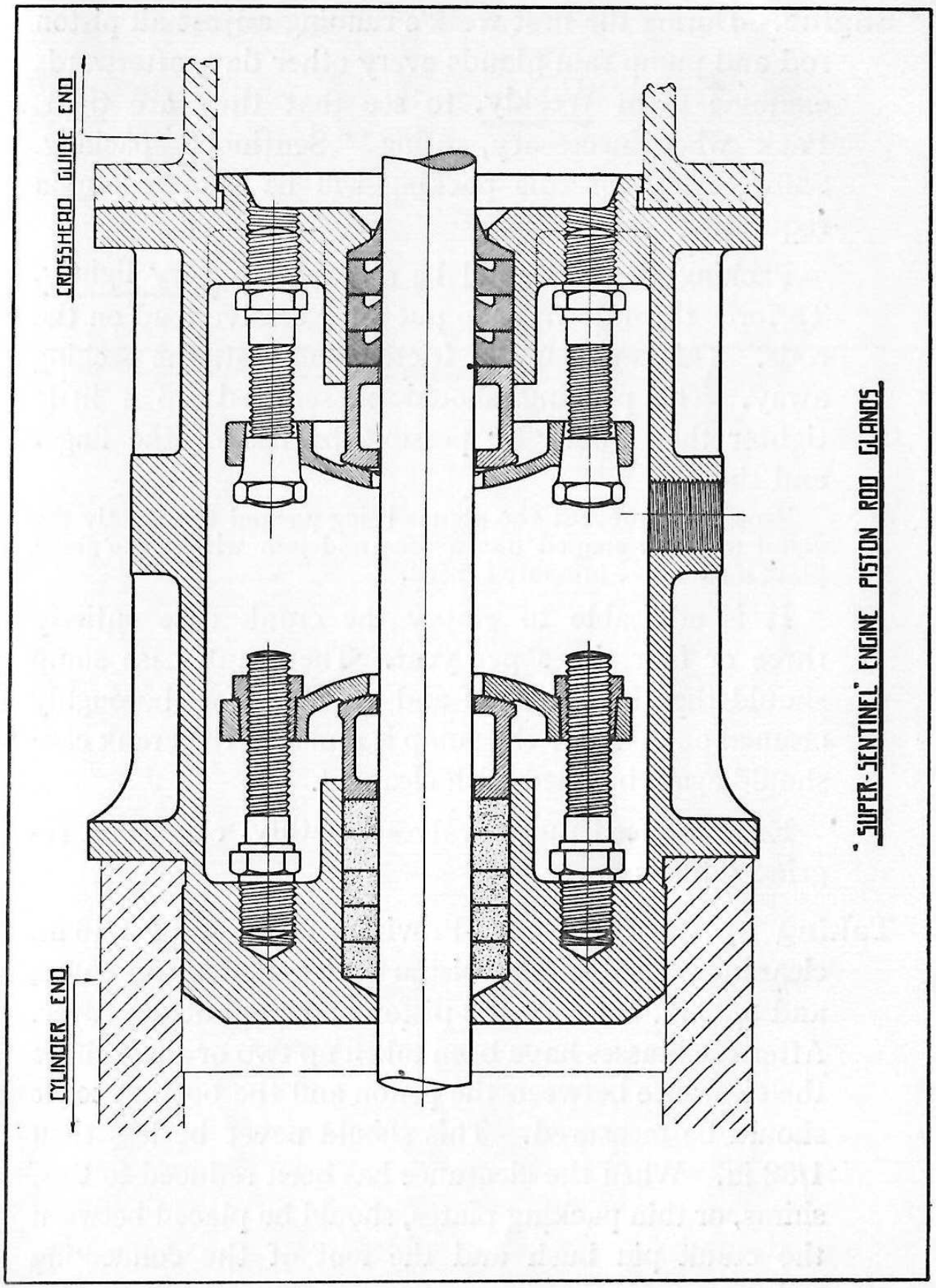
Air Leaks.—It is important, when re-assembling the boiler, to guard against airleaks as follows :—

1. Joint of boiler top plate and firebox. Pack with asbestos cord to cure.
2. Joint of funnel base and Boiler top. Fit new joint to cure—keep nuts tight.
3. Round superheater coils where they pass through boiler top plate. See that steady plates are a good fit, and use asbestos jointing to cure.
4. Under flange of stoking chute. See that flange is flat, and right down on boiler top plate.

Any of these troubles may cause poor steaming although blast pressures are right. Examine periodically.

Feedheater Drain.

The feedheater is provided with a drain to conduct the condensed water in the exhaust steam to the ashpan. It is very important that this pipe does not become stopped up, and it should be examined Daily when warming up ; a trickle of water or blow of steam should be visible if it is functioning properly. Running with a dry ashpan will cause the firebars to burn away rapidly.



'SUPER-SENTINEL' ENGINE PISTON ROD GLANDS

Engine.—During the first week's running adjust all piston rod and pump ram glands every other day, afterwards examine them Weekly, to see that they are tight. Pack when necessary, using "Sentinel" packing. Sample rings of this packing will be supplied upon request.

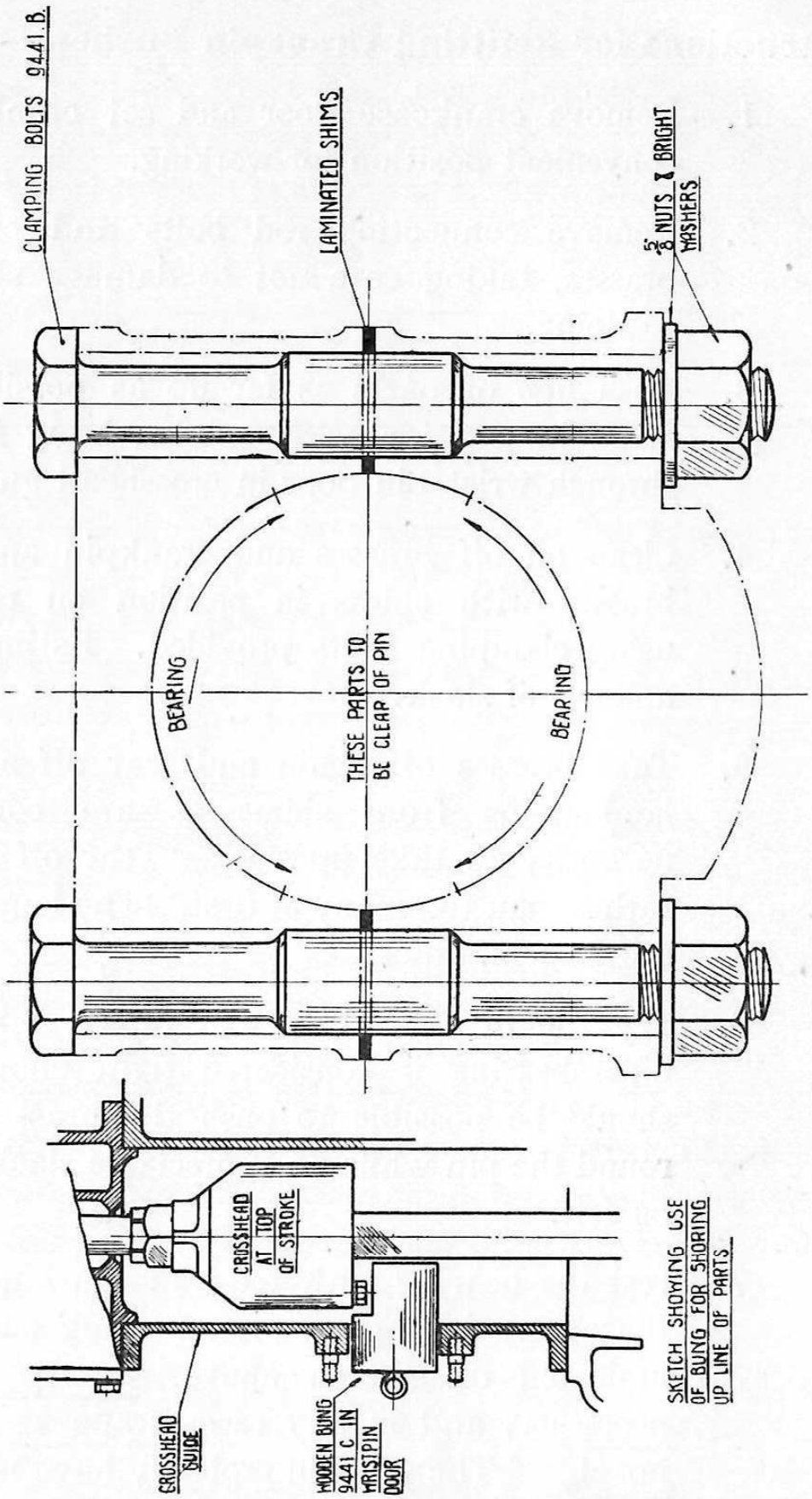
Packing glands should be screwed up very lightly. To force them down is to put an excessive load on the rods. This causes undue friction and tears the packing away. The packing should be screwed up a little tighter than would be possible by use of the finger and thumb.

NOTE.—To prevent the glands being packed too tightly the gland nuts are shaped like a cone and jam within the gland plate if excessive pressure is used.

It is advisable to empty the crank case entirely three or four times per year. The crank case sump should then be taken off and the chamber thoroughly cleaned out. After the sump is replaced the crank case should again be filled with clean oil.

Examine feed pump valves Monthly, clean and re-grind if necessary.

Taking up the Brasses.—Provision is made of 1/16 in. clearance between the piston and cylinder top cover, and 3/32 in. between the piston and the bottom cover. After the brasses have been taken up two or three times the clearance between the piston and the bottom cover should be measured. This should never be less than 1/32 in. When the clearance has been reduced to this, shims, or thin packing plates, should be placed between the crank pin bush and the foot of the connecting rod.


CLAMPING BOLTS 9441.B.
LAMINATED SHIMS
⅝" NUTS & BRIGHT WASHERS
BEARING
THESE PARTS TO BE CLEAR OF PIN
BEARING
CROSSHEAD AT TOP OF STROKE
CROSSHEAD GUIDE
WOODEN BUNG 9441.C IN WRISTPIN DOOR
SKETCH SHOWING USE OF BUNG FOR SHORING UP LINE OF PARTS

Instructions for Refitting Crankpin Bushes.—

1. Remove crankcase door and set crankpin in convenient position for working.

2. Remove connecting rod bolts and crankpin brasses, taking care not to damage shims in so doing.

3. Push line of parts as far up as possible and shore in position with wooden bung inserted through wrist pin door in crosshead guide.

4. Clean oil off brasses and crankpin and place brasses with shims in position on crankpin using clamping bolts provided. Estimate the amount of slack.

5. Take brasses off again and tear off as many laminations from shims as are considered necessary to take up slack. Tear off too few rather than too many at first. The laminations are .003 in. thick.

6. Try the brasses again and repeat operations until bearing is considered tight enough. It should be possible to push the brasses easily round the pin while no appreciable slack should be felt.

7. Test the bearing with red-lead marking to see that there is a good even bearing surface as indicated on sketch above. Scrape only if necessary, and in any case scrape as little as possible. The pin will probably have made the best possible bearing for itself.

8. When a satisfactory bearing has been obtained replace everything as it originally was, oiling pins and brasses well.
9. If possible run the engine for a while with chains off, or in neutral gear.

NOTE.—When brass begins to show through white metal re-metal the brasses.

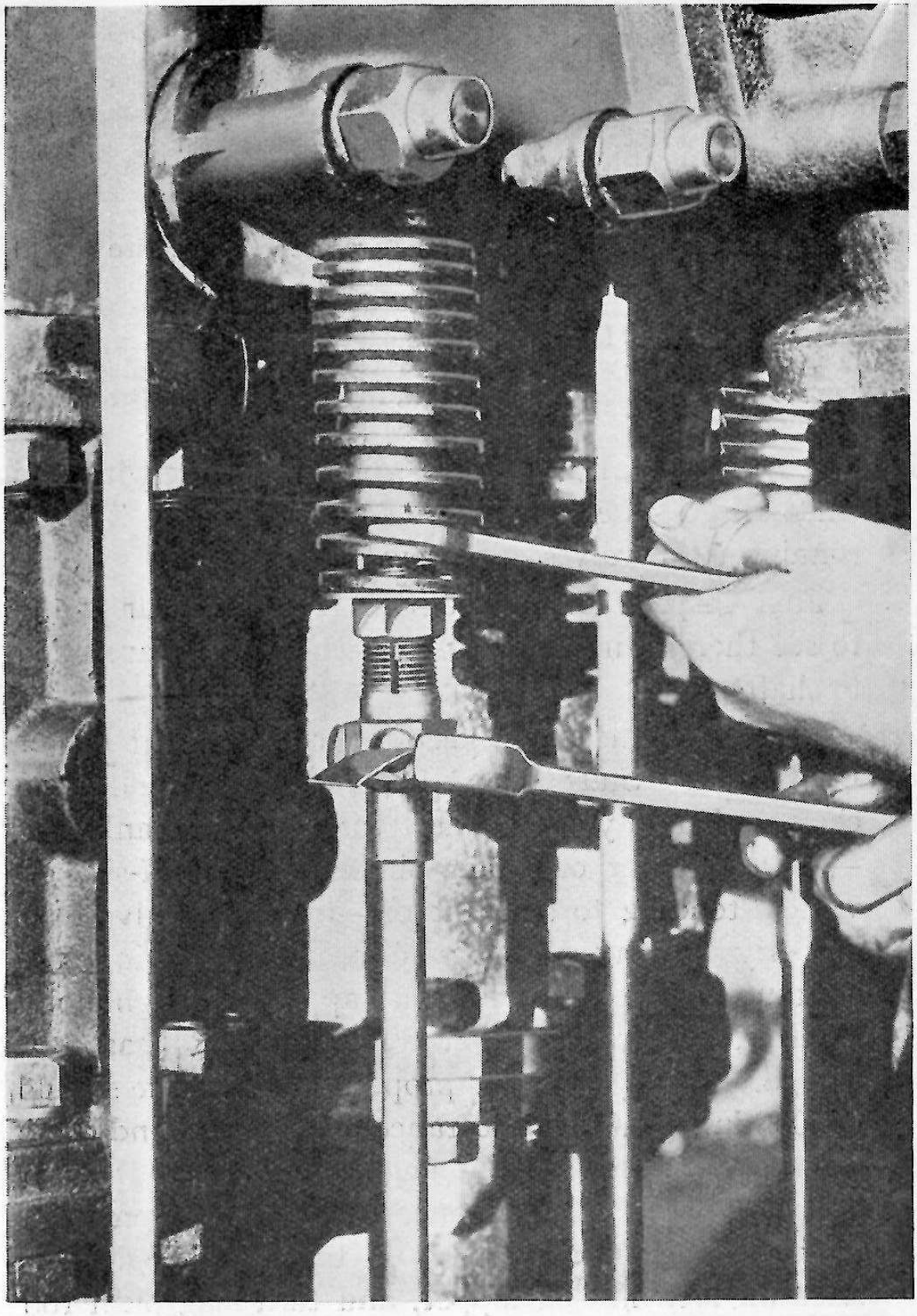
NOTE.—Older engines are fitted with plain brasses without shims. The joint faces of these must be filed to take up slack in the ordinary way. In most cases white-metalled and shimmed brasses can be supplied, interchangeable with those in older engines.

Testing Engine Valve Setting.—Do not meddle with this while all goes well, but if the engine " thumps " when running, test valves as follows :—

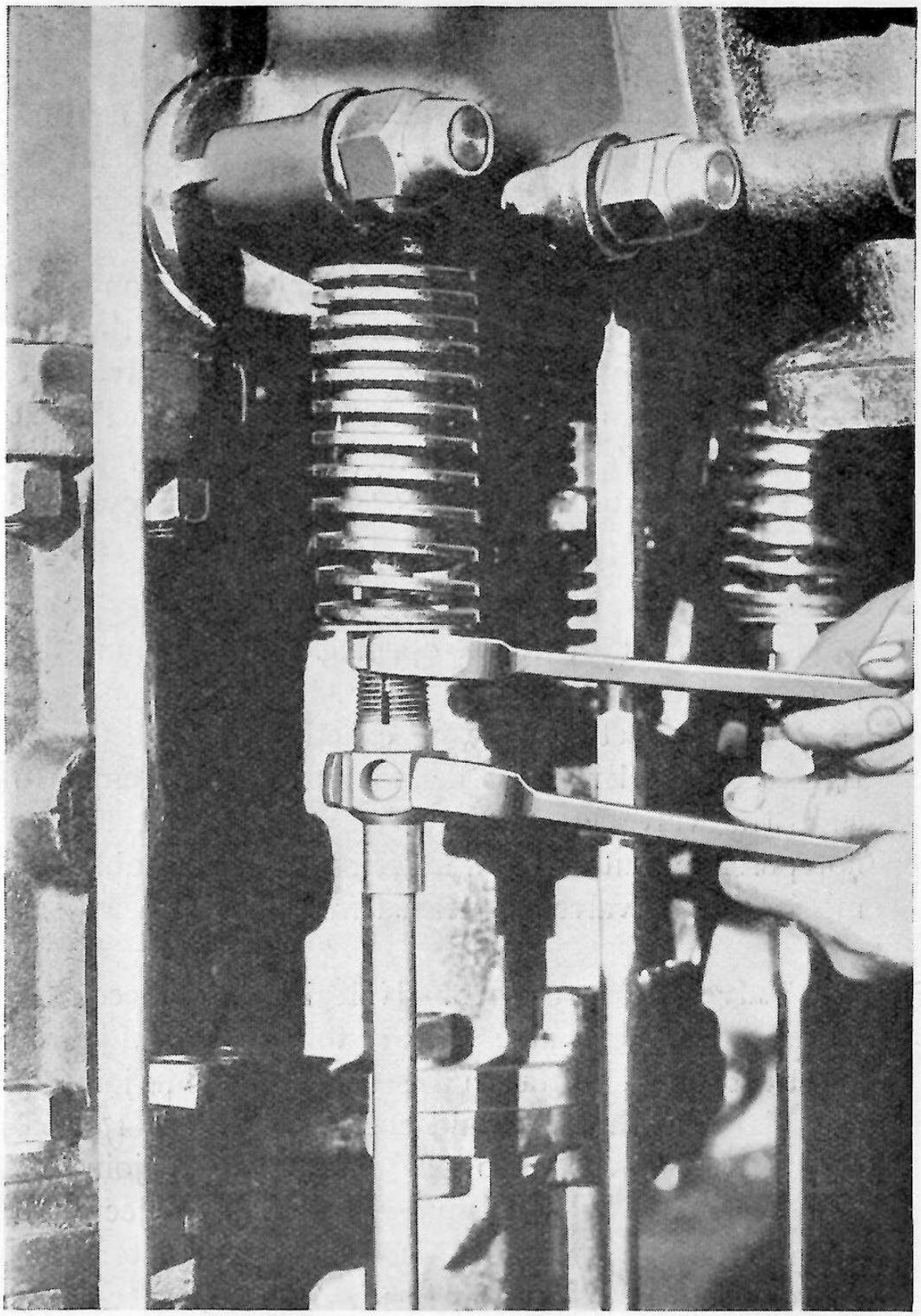
First inspect and tighten all reversing gear joints to see there is no play here, or where levers are fixed to shafts.

To time engine valves keep reversing lever at Power Unit end in " ~~Start~~ FAST " notch and remove engine driving chains. While your assistant turns engine crankshaft —by a spanner on chain pinion nut on off-side of vehicle tending to screw it on—try if all valves are properly seating. This is done by observing the clearance between valve stem tappets, through holes in latter, when cam follower is as far into crankcase as it will go. When a valve is properly seated there should be .006 in.* to .010 in. clearance between the end of its stem and tappet when the engine is cold. If there is too much or too little clearance this should be remedied by the adjustment provided on tappets. To do this slack off lock nut on tappet, and turn long push rod

*NOTE.—A feeler gauge of correct thickness will be found inside back cover of this book.



Adjusting Valve Tappets to give Correct Clearance (Railcar and Loco.)

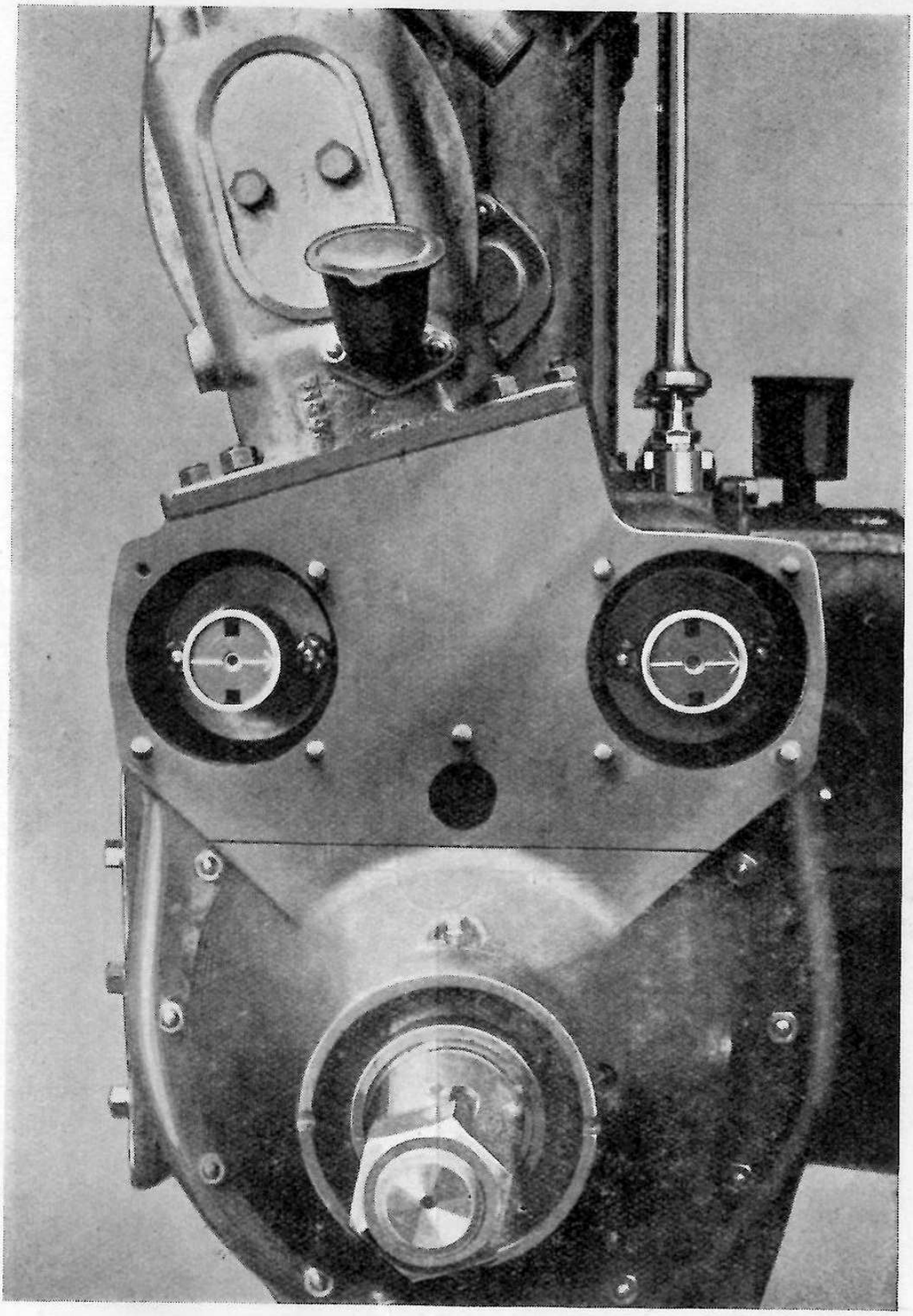


Locking Valve Tappets after securing Correct Clearance (Railcar and Loco.)

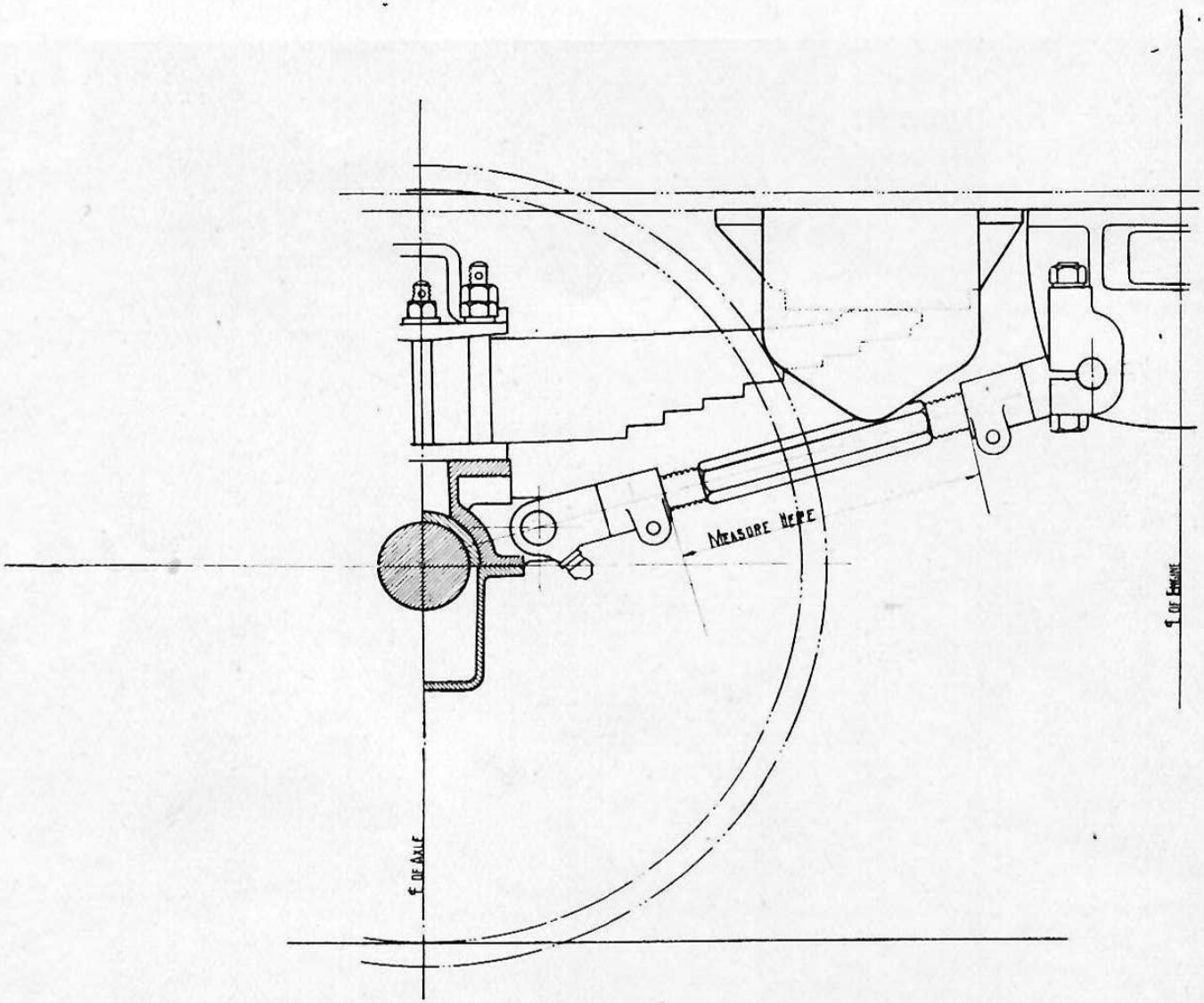
until clearance is correct, then tighten lock nut, holding long push rod by a spanner on flat provided. Make quite sure that cam follower is not being held up by cam before attempting to adjust. Having seen that all valve clearances are correct, remove near side trunk door, and while your assistant slowly turns crankshaft (still tending to screw on pinion nut, right hand) watch piston rod. As it nears the top dead centre, the top steam valve (the outer valve that side) should open. If engine be cold, steam valve should open from 1/16 in. to 1/8 in. before end of stroke while the exhaust valve at opposite end of cylinder should open approximately 1/2 in. before end of stroke.

The moment of valve opening can be found by placing a feeler strip of .001 in. or .002 in. between valve stem and tappet and noting exactly when the tappet tightens on feeler. Another method is to attempt to turn the valve by its spring. When closed this is not possible, but a slight movement is obtainable immediately the valve is released from its seat.

Fitting Valve Chest Joints.—If it is found necessary either to fit a new valve chest or to re-make the joints, great care should be taken to see that only thin jointing material is used. It should not be more than 1/32 in. thick. It is as well to use a fairly hard jointing. Soft material is likely to squeeze out when subjected to the heat of steam, and this is liable to distort the cylinders. Once the chest has been off it is necessary to check over the valve clearances as there is 1/16 in. clearance in the stud holes which fix these chests.



View showing Arrows on ends of Camshafts (Railcar and Loco.)



Showing method of testing for Axle Alignment (Railcar and Loco.)

Cam Shafts.—A definite stop is provided in the engine for each end of the cam shaft. When adjusting reversing gear connections, it is only necessary to see that the cam shafts are hard against one stop when reversing lever is in the " forward start " ; and hard against the other one when the reversing lever is in the " reverse start " position.

In order to make the setting of the valve gear as easy as possible each of the two cam shafts is marked with an arrow on the gear end. When re-timing after an overhaul or when fitting new cam shafts, it is only necessary to turn the crankshaft so that the left-hand crank (nearest arrows) is on lower or crank end dead centre, and then set the cam shafts so that both arrows are pointing vertically upwards when the engine is in a horizontal position. When the engine is placed vertically these arrows will both lie horizontally and point to the right. The cam shaft driving wheels may then be slid into mesh. See page 55.

NOTE.—There are two slots or key-ways in the ends of the cam shafts (for manufacturing reasons), but only one of these is of sufficient depth to take the driving key, so that no mistake can be made.

Chain Adjustment.—The adjustment of the driving chains is carried out by means of the left and right hand screws on radius rods. Great care must be taken that each two radius rods on the same axle are adjusted exactly alike. This is best determined by measuring the distance between the inside faces of the radius rod sockets as shown in the illustration on page 56.

When correctly adjusted the chain should have a total up and down movement of about 2 in. in the

middle of its slack side. Do not run with the chain too slack as this rapidly increases the wear. Too tight a chain on the other hand will tend to cause over-heating of bearings.

NOTE.—When connecting up Radius Rods after overhauling, the Rods must be entered simultaneously into their respective right and left hand threaded sockets.

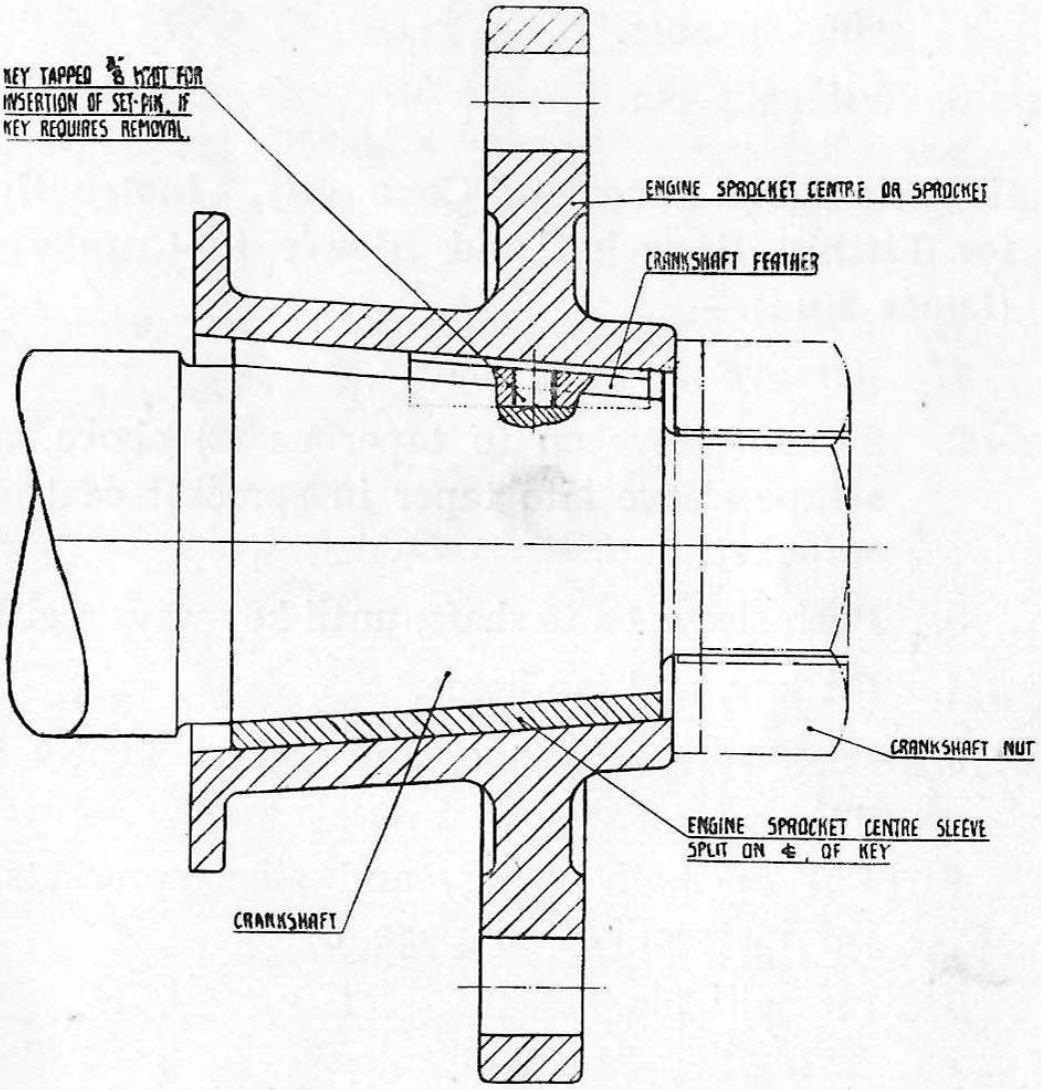
Adjusting Double Drive to one Axle.—In the more recent railcars, and in double-engined locos, two chains drive one axle. When this is so, the sprocket at one end of the crankshaft is keyed on in the ordinary way, while that on the other end is "loose," being mounted on a split bush, which is keyed to the crankshaft taper (see illustration). To adjust such chains for equal tension, proceed as follows :—

1. Put both chains on, leaving the "loose" sprocket nut slightly slack.
2. Tighten the radius rod equally on both sides until both chains are as tight as they can be.
3. Tighten and split-pin the "loose" sprocket nut.
4. Slack off the radius rods equally until the correct amount of slack is present in the chains.

Check the even tension of the chains from time to time, following the above procedure.

All Locos and Cars. Instructions for Fitting Sprocket to Crankshaft (Keyed End).—

1. Remove key from shaft.
2. Scrape sprocket on to taper, using fine emery powder, until sprocket seats perfectly for full length and diameter (test in usual way with red marking).


KEY TAPPED 3/8 W.S.F. FOR INSERTION OF SET-PIN, IF KEY REQUIRES REMOVAL.
ENGINE SPROCKET CENTRE OR SPROCKET
CRANKSHAFT FEATHER
CRANKSHAFT NUT
ENGINE SPROCKET CENTRE SLEEVE SPLIT ON ℄ OF KEY
CRANKSHAFT

3. Refit key in shaft.
4. Push sprocket on and tighten lightly home with nut. Remove nut and ensure that a .008 in. feeler can be pushed above key for its whole length.
5. Replace nut, tighten, and hammer up with ring spanner.
6. Fit split pin.

Single Axle Drive Locos and Cars only. Instructions for Fitting Sprocket and Sleeve to Crankshaft (Loose End).—

1. Remove key from shaft.
2. Scrape sleeve on to taper as (2) above, also scrape sleeve into taper in sprocket centre or sprocket.
3. Push sleeve on to shaft, until key-ways register.
4. Fit key, and tap home.
5. Push sprocket home, and tighten lightly with nut.
6. Put on both chains, and align sprockets as per instructions on page 57.
7. Fit split pin.

Adjustments.—Each week-end see that no nuts are working loose.

All bolts and pins in the under-frame brakework, lighting, bogies, pivots, etc., and all structure bolts should be overhauled frequently. The bolts taking axles and journals should also be examined.

Adjustment of Vacuum Control.—The vacuum control cylinder to which the ejector is bolted has a steam and an air valve operated by a lever provided with two adjusting screws.

Set the control wheel at the " brake off " position. The bottom of the steam valve should be then just in contact with its adjusting screw.

Next move the control wheel to the intermediate stop between " brake off " and " steam off " and test the air valve which should be just in contact with its adjusting screw.

Between those positions both valves should be shut and the vacuum held in the pipes. In this position a feeler should be able to pass between both valve stems and their respective adjusting screws.

In the " steam off " position of the control wheel the air valve will then be open and the brakes released.

Adjustment of Vacuum Brake.—A gauge (indicated below) should be fitted in the slot of the Vacuum Brake Cylinder piston ; then the handbrake is applied

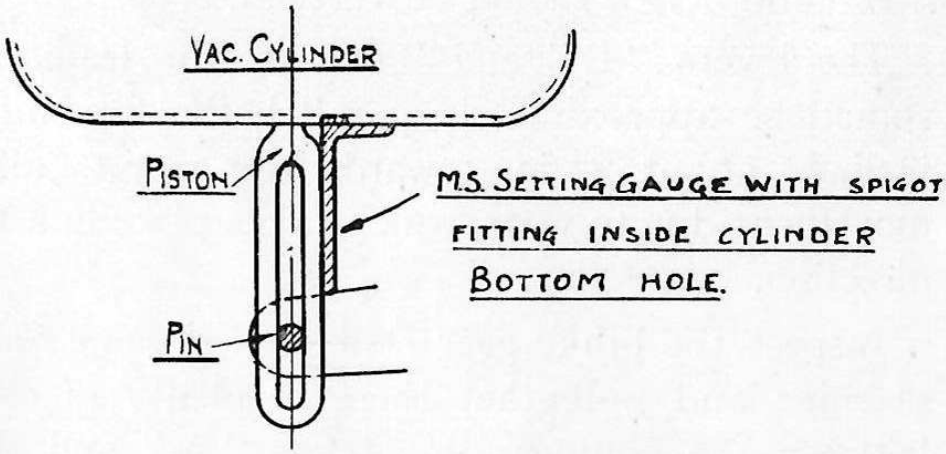


FIG. 10

until this stop is held tightly by the lifted piston pin ; the turn-buckle on the long pull rod should then be screwed up until all the brake blocks are hard on the wheels, the brake will then be found to have been accurately adjusted. The gauge referred to is supplied with the tools.

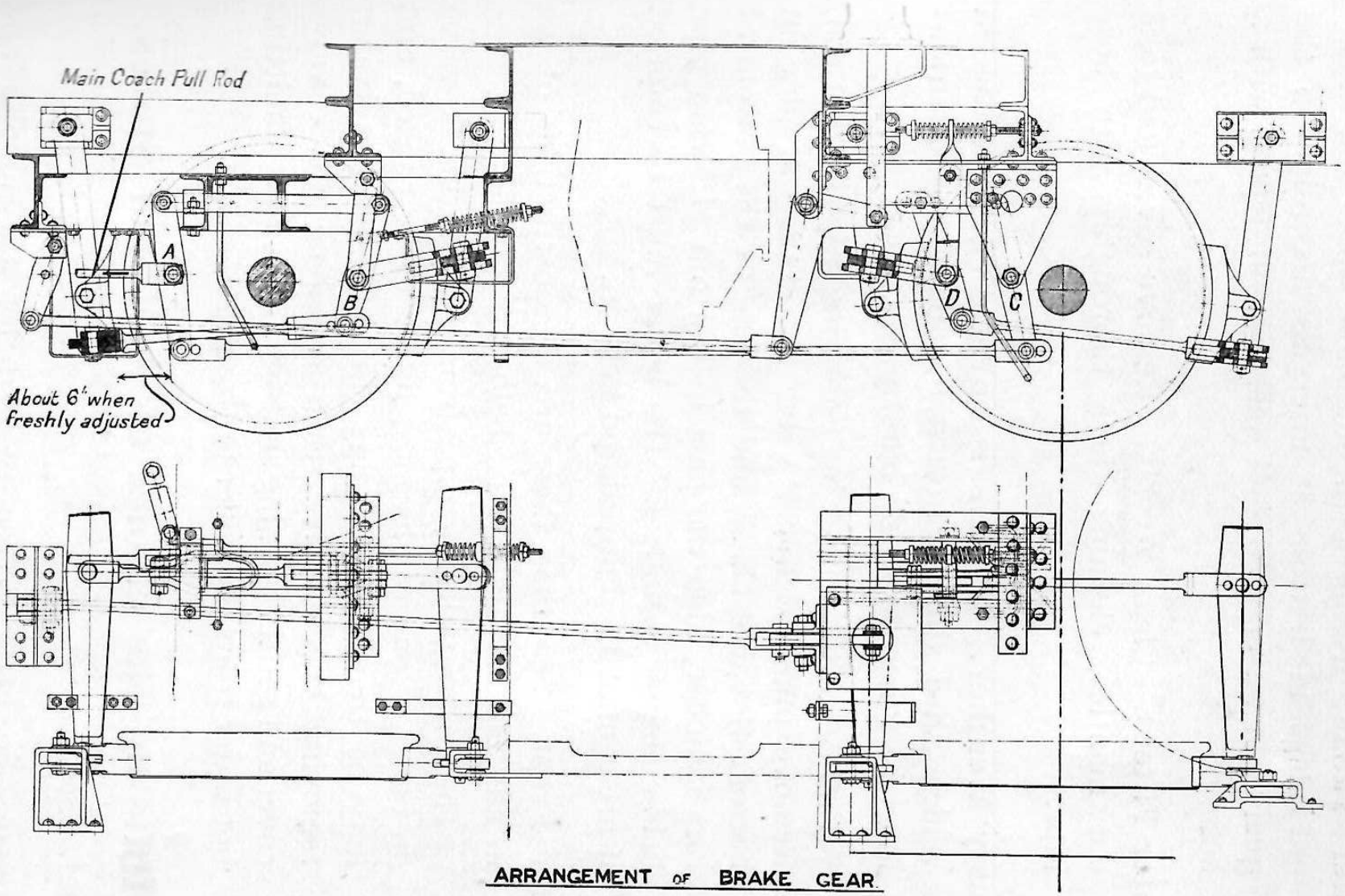
Adjustment of Brake Gear on Power Unit.—The pull from the vacuum cylinders is taken on the centre of a compensating lever " A " at the rear end of the bogie, and is transmitted from thence to the front and rear wheels. See accompanying illustration on page 63.

When freshly adjusted lever " A " should be back close to the pivot frame, the lower end sloping forward, so that there is a space of about 6 in. between the lever and the rear brake beam. This allows for a wear of $\frac{1}{2}$ in. per block, before the rods require taking up on the adjusting holes.

The brake lever " B " should slope forward towards the top so as to give it plenty of room to pull backwards as the blocks wear. The swing links supporting levers " B " and " D " should be vertical.

The levers " C " and " D " at the leading wheel should be approximately parallel, the top ends being inclined about $2\frac{1}{2}$ in. towards the rear to allow for movement due to wear, which takes place in a forward direction.

Inspect the brake gear Daily when going round the machine and note that there is plenty of clearance between the compensating lever " A " and the rear brake beam.



Railcar Power Unit.

Water Tanks.—Remove the manhole doors and wash-out plugs in bottom at intervals according to the quality of water used, and wash out all deposit with a hose.

Water Filters.—Clean Weekly. Remove covers and take out mantles, cleaning these thoroughly with hose pipe.

Frosty Weather.—If there is no heating apparatus in vehicle shed during frost the following precautions must be taken to avoid burst pipes, etc.

Empty water tanks by removing plug in bottom. Remove pump delivery valve and take out plug in bottom of valve chest, and the one at the bottom of ram cylinder, also the plug in bottom of steam pipe below engine cylinders. The boiler must be emptied if fire cannot be damped and kept in.

After Frost.—See that there are no obstructions of ice in any pipes, valves, etc., before restarting.

The water delivery pipe from feed to check valve on boiler is one of the most likely to be choked, and may be thawed by closing shut-off valve on boiler, removing check valve, then replacing check valve cover and gently opening shut-off valve, thus admitting hot water from the boiler to this pipe.

Hints on the Choice of Fuel and Stores.

Fuel.—See page 8.

Grease.—So little grease is used for the nipples and stauffers of the "Sentinel-Cammell" Car or

" Sentinel " Locomotive that it is false economy to use cheap stuff. We use a good quality vaseline, which we can supply in $\frac{1}{2}$cwt. kegs.

Lubricating Oil.—The " Sentinel-Cammell " Car and " Sentinel " Locomotive having nearly all parts running in oil baths are kept well lubricated with far less trouble than other vehicles, but the oil used must be good and suitable.

The safest way to avoid all troubles, and the cheapest in the end, is to use " Sentinel " oil, which we can supply in 40 gallon casks. This oil is made specially for us, and it is the result of much experiment and research. If condensed steam leaks into this oil the mixture still forms a good lubricant, entirely free from acid or anything which would injure the surface of the metals.

Clean Oil and Grease Necessary.—It is of the utmost importance that for all purposes your oil and grease should be perfectly free from grit and chips. Keep the vessels containing lubricant closely sealed, and when drawing off oil allow it to run through a strainer before using on the vehicle.

Electric Lighting.

This subject is dealt with in a separate booklet, which can be obtained on application to the " Sentinel " Waggon Works, Ltd., Railway Dept., 20, Iddesleigh House, Caxton Street, Westminster, London, S.W.1.

Running Hints.

Examine Blast Nozzle periodically and clean out carbon deposit. If this is allowed to accumulate excessive back pressure is set up in engine with consequent loss of power. Watch Pressure Gauge on Feedheater.

Examine tappet clearances periodically and always ensure that correct clearances are allowed when engine is cold.

Do not allow feed pump check valves excessive lifts.

Make certain that the firebars in boiler suit your particular fuel. The following sizes are obtainable : $\frac{3}{8}$ in., $\frac{5}{8}$ in., 1 in. and $1\frac{1}{4}$ in. air spacings.

Fire Boiler frequently with small amounts of fuel rather than infrequently with large amounts.

Prime feed pump before starting if Car has been standing considerable time in shed.

Remove Boiler Hand hole door carefully and thus save cost of new joint.

If hot axle-box trouble is encountered ensure that adequate clearance is provided where axle passes through back of box, also see that sufficient end-play is allowed in journal for brass. This should be 1/8 in.

Make certain that foot release valve is not leaking and that piston rod glands are not blowing.

Time spent on ensuring clean boiler furnace and tubes is time saved in service.

When fitted, test if Water Lifter Valve is leaking by feeling if copper steam pipe from valve to tank ejector is hot.

Leaking Water Lifter Valve increases temperature of feed water in tank which often prevents Boiler Injector functioning.

Cheap lubricating oil is false economy.

Make certain that ashpan contains water. Examine drain pipe from feed heater frequently to see that it is not choked.

Drivers should carefully note " beat " of engine as it exhausts up the funnel. In this way an imperfectly seating engine valve can be detected. To test this, Car or Locomotive should be driven slowly, and, if engine valves are seating properly, an appreciable silent pause will be noted between the engine exhaust strokes.

After grinding in valves always test whether they are seating properly by cleaning thoroughly, applying light film of " Raddle " or other suitable marking to valve face, reinserting valve in chest and turning valve slightly on seat. If the valve is seating correctly the valve seat should show an unbroken film of marking.

It is always advisable to examine valve tappet clearances after engine valves have been ground in.

Make intelligent use of the Adjustable Exhaust relief valve when it is fitted. It will reduce your coal consumption, and assist you in keeping steam.

If you require further information, write The " Sentinel " Waggon Works, Ltd., Railway Dept., 20, Iddesleigh House, Caxton Street, London, S.W.1., England.

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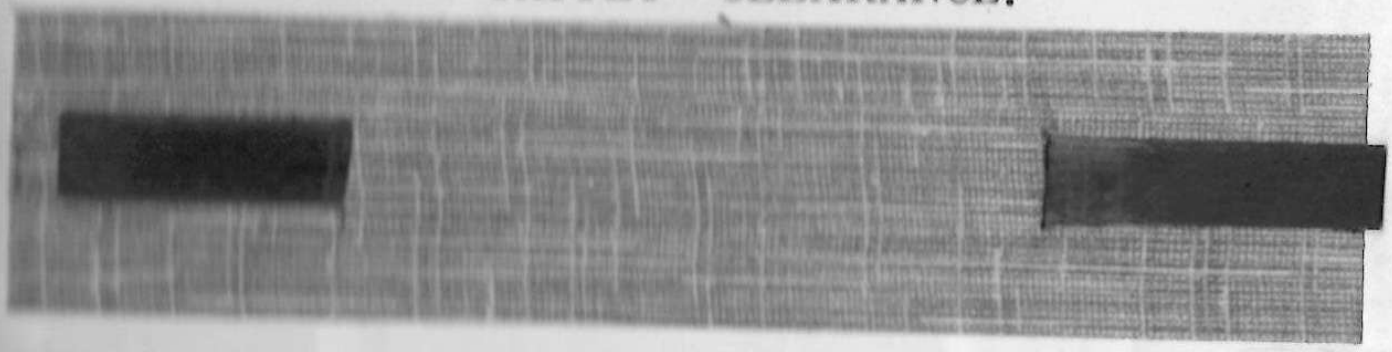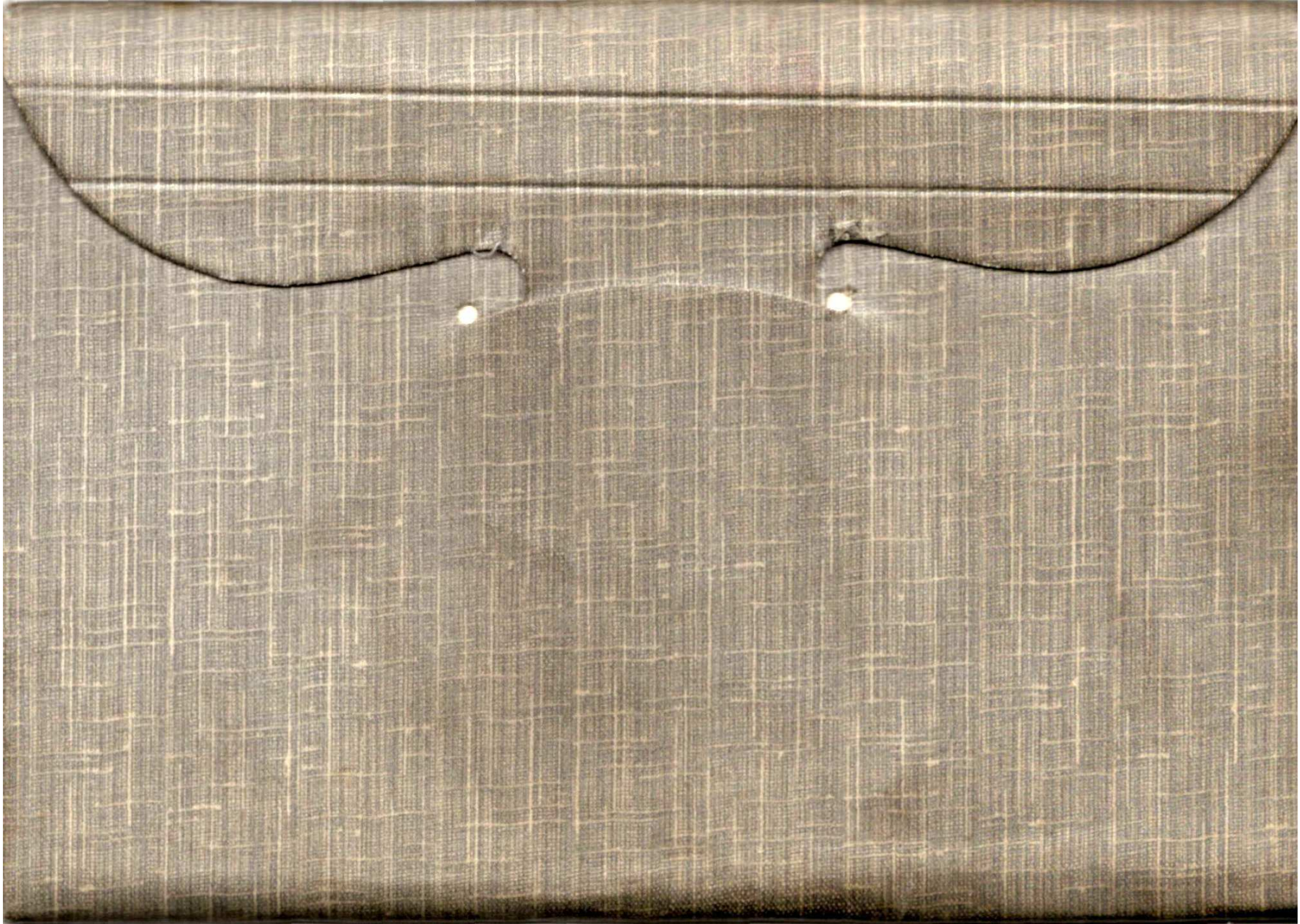
FEELER FOR TESTING CORRECT VALVE TAPPET CLEARANCE.