

SECTION 7, CHAPTER 4

HEAVY DUTY STEAM CLEANING PLANT

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Introduction

1. The heavy duty steam cleaning plant (Fig. 1) provides a jet of steam at high pressure for removing contaminants such as dirt, oil and grease from metal surfaces. The plant is mounted on a three-wheeled chassis for manual towing and is suitable for cleaning M.T. vehicles, heavy machinery, engine parts, ground equipment and the bilges of marine craft.

2. The plant embodies an electrically-driven duplex pump which supplies a mixture of water and degreasing solution to a steam coil. Here, wet steam is generated, which then passes through flexible hoses attached

to the steam coil outlet and so to the two cleaning guns.

3. The steam coil is heated by the combustion of kerosine. The kerosine is first pumped to a combustion chamber; here it is ignited in the burner assembly, and fed with air from a small blower that is driven by the electric motor which drives the duplex pump.

4. The electric motor requires a 230–250 volt, a.c., single phase power supply. Water for the plant can be taken from any mains source, a water softener being incorporated to prevent the formation of scale on the inside of the system.

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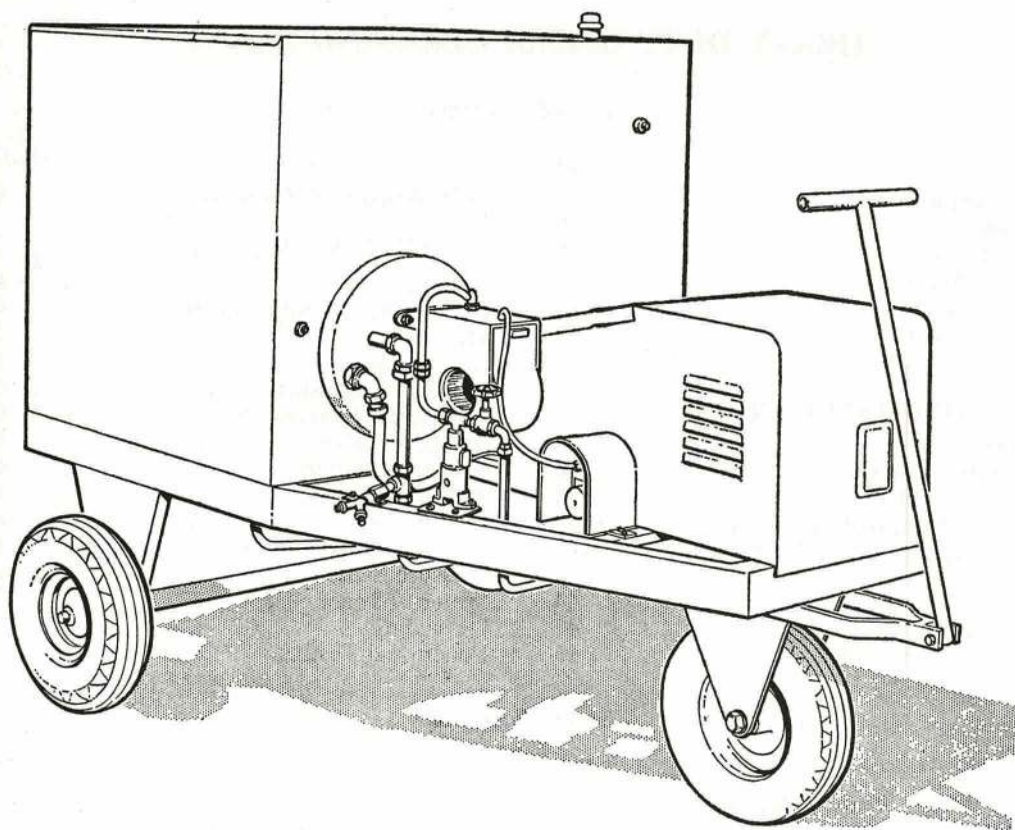


Fig. 1. HEAVY DUTY STEAM CLEANING PLANT—TYPE A

5. The plant can be divided broadly, into three main parts: a chassis, a water system and a steam system. Common to both the water and steam systems are the electric motor and the duplex pump.

Chassis

6. The chassis (Fig. 2) consists of a framework of steel channel sections upon which are mounted the water and steam systems, the electric motor and the duplex pump. Two pneumatic-tyred wheels rotate on an unsprung axle which is attached to the underside of the chassis. A swivelling fork is attached to the underside of the front end of the chassis. The fork accommodates a wheel and axle, and the attached draw-bar enables the plant to be positioned easily by hand.

7. **Cowling.** On earlier plants a sheet metal cowling encloses the front end of the chassis and protects the plant. The top of the

cowling hinges upwards, and there are two hinged doors at the front; these provide access to the interior for starting and general servicing purposes. The side cowling members have apertures to permit the free entry of air for cooling purposes. On later plants the front end of the chassis is not enclosed, but a sheet metal cover is fitted over the driving belts, electric motor, pressure switch and magneto. An additional panel, hinged to the top of the cover and secured to the chassis by a spring-loaded fastener, provides protection for the duplex pump.

Water System

8. The water system (Figs. 2 and 3) which consists essentially of a water softener, a water tank and a degreasing-solution tank, supplies a flow of soft water and degreasing solution to a duplex pump where the liquids are mixed and fed to the steam coil. The rate of flow of the degreasing solution is regulated by a hand-operated control valve.

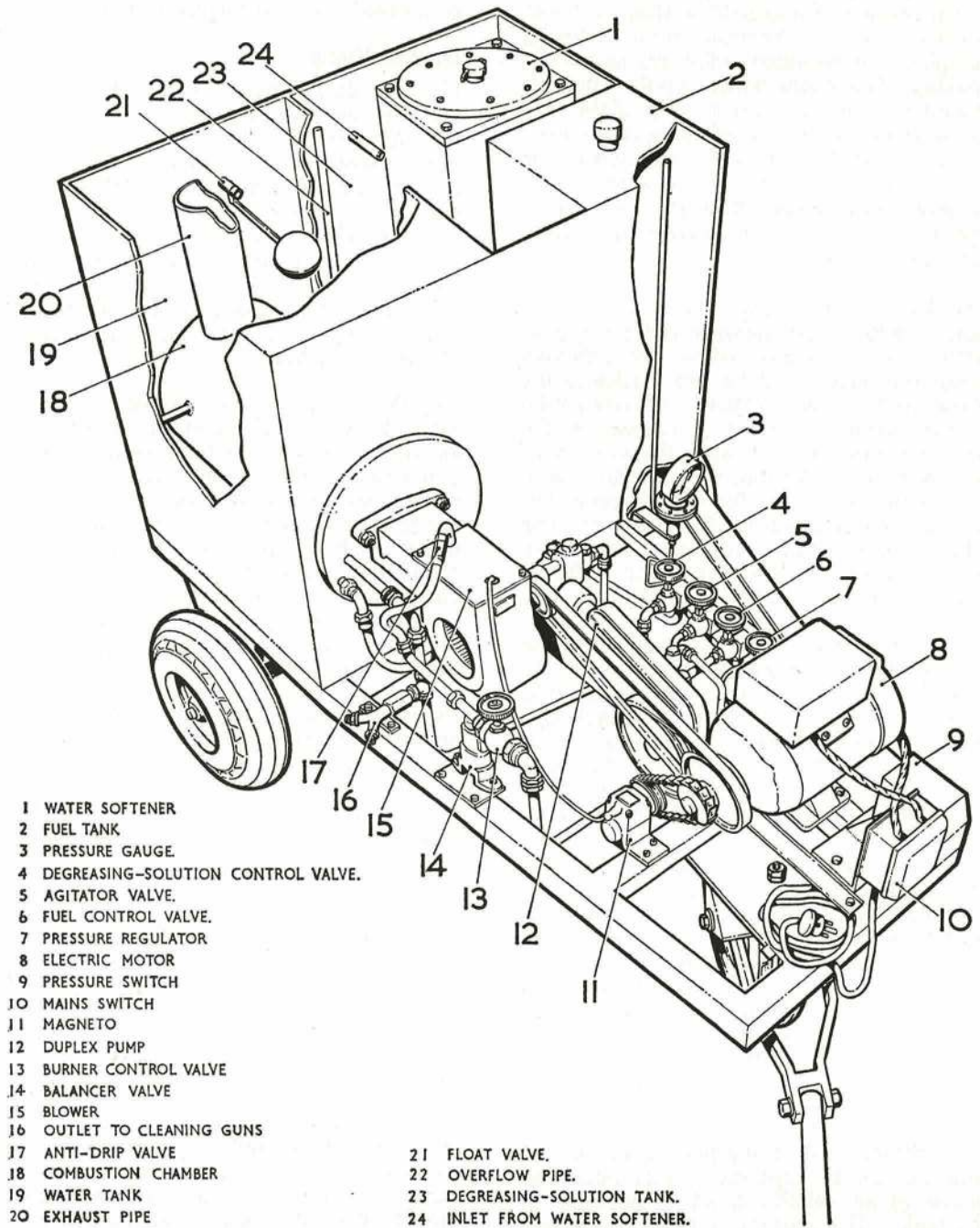


Fig. 2. LOCATION OF COMPONENTS

9. Water Softener. The water softener, which consists of a cylindrical steel container packed with a chemical water-softening compound, is mounted at the rear end of the chassis. The mains water supply enters at the inlet connection near the top of the container and passes to the softening compound; it then passes through the compound to the outlet at the bottom of the container, which supplies soft water through two hand-operated valves to the degreasing-solution tank and the water tank.

10. Back-flushing Valve. Because the direction of flow in the softener is from top to bottom, after a period of use the softening compound tends to settle and harden in the lower part of the softener. Consequently, during servicing, water is passed in the opposite direction, i.e. from the bottom of the softener to the top, in order to loosen the compound. It is for this purpose that the back-flushing valve is fitted in a pipeline which connects the mains water inlet valve to the outlet line from the water softener; it is a simple hand-operated needle valve.

11. Water Tank. This is mounted at the side of the degreasing-solution tank at the rear end of the chassis and, when full, contains 70 gallons of water. The tank also accommodates the combustion chamber and steam coil. A float valve, fitted to the inside of the tank, automatically controls the flow from the water softener to the water tank.

12. Degreasing-solution Tank. The degreasing-solution tank contains 45 gallons of a solution of degreasing compound and soft water. The soft water enters the tank through a hand-operated inlet valve, and the solution is made up by adding the requisite quantity of degreasing compound to the water. As it leaves the tank, the solution is filtered by a wire mesh filter which covers the tank outlet, and its flow to the water pump is controlled by a hand-operated valve.

13. Mixing. When the plant is in use, the solution can be kept thoroughly mixed by means of an agitator fitted in the base of the tank. The agitator consists of a length of steel tubing, perforated by a number of $\frac{1}{8}$ in. diameter holes, which is connected to the steam coil outlet. Fitted in the pipeline to the agitator is a valve which, when open, allows steam to enter the solution tank through the holes in the agitator. As the

steam mixes with the solution, the solution is agitated and thoroughly mixed.

Duplex Pump

14. The duplex pump (Fig. 4) is, in effect, two separate pumping units. It consists of two horizontally opposed cylinders, one slightly larger in diameter than the other, a plunger that is common to both cylinders and a connecting rod. Both pumps are bolted to a frame mounted on an adjustable bearer. The smaller diameter pump, which has a capacity of 35 gallons per hour, is the fuel pump; the larger diameter pump is the water pump, and this has a capacity of 95 gallons per hour.

15. Both pumps incorporate a suction valve, a delivery valve and, on earlier plants, an air vent cock; on later plants the fuel pump only is fitted with a vent cock. The water pump is also provided with two non-return valves which prevent the back flow of water to the degreasing-solution tank, and degreasing-solution to the water tank, when the pump is stationary. In each pump, leakage of fluid past the plunger is prevented by two gland rings retained in position by a gland nut.

16. Operation. The operation of both pumps is the same. The crank arm, driven through a pulley and belt drive by the electric motor, is joined to one end of the connecting rod. The other end of the rod is connected to the centre of the plunger by a wrist pin. As the crank arm rotates, the connecting rod causes the plunger to reciprocate in the two cylinders. On the suction stroke of the plunger in the fuel pump, the suction valve opens and fuel is drawn into the cylinder. On the delivery stroke the suction valve closes, the delivery valve opens and fuel is pumped through the delivery valve to the combustion chamber. On the suction stroke of the plunger in the water pump, the suction valve and both non-return valves open and a mixture of degreasing-solution and water is drawn into the pump cylinder. On the delivery stroke the suction valve and non-return valves close, the delivery valve opens and the mixture is pumped through the delivery valve to the steam coil.

Electric Motor

17. The plant is fitted with a standard 230-250 volts, 50 cycles, repulsion induction,

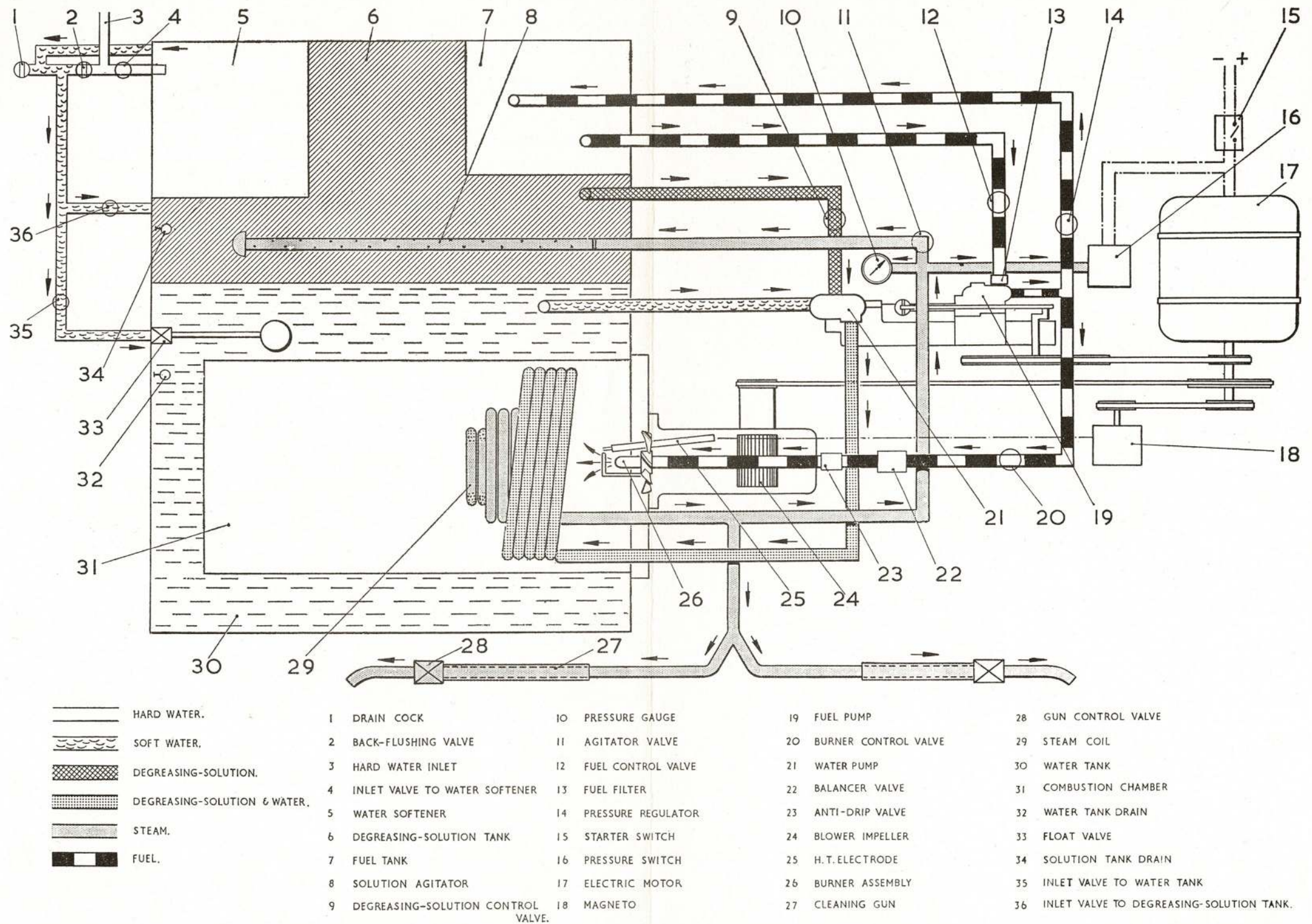


Fig. 3. DIAGRAMMATIC LAYOUT

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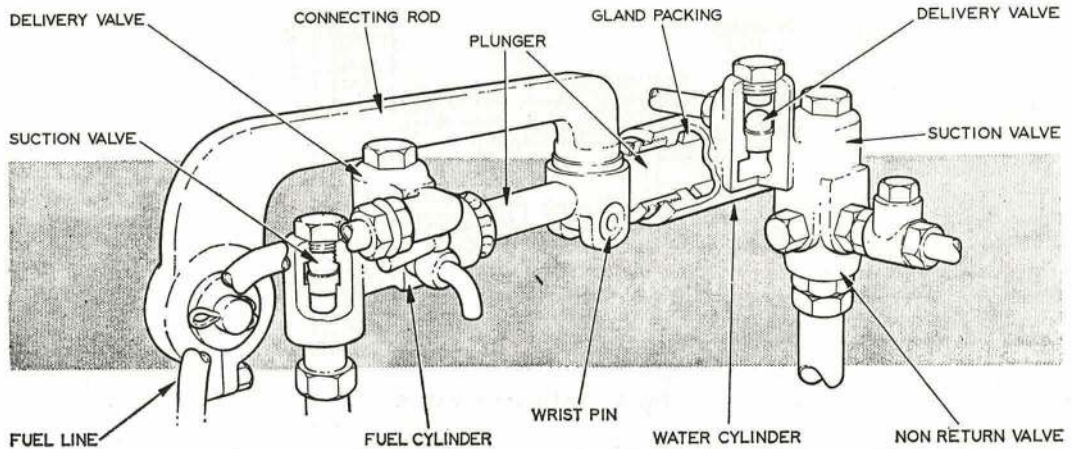


Fig. 4. DUPLEX PUMP

a.c. electric motor which develops $\frac{3}{4}$ H.P. at 1,440 r.p.m. Three pulleys are mounted on an extension shaft which is screwed on to the end of the armature shaft; these transmit the drive through flexible driving belts to the magneto, the blower and the duplex pump. Each pulley is locked in position on the armature shaft by a grub screw.

Steam System

18. The mixture of water and degreasing solution pumped into the steam coil is converted into steam by the combustion of kerosine in the combustion chamber. The components which comprise the steam system are as follows:—

- (a) Fuel tank.
- (b) Fuel pump.
- (c) Balancer valve.
- (d) Pressure regulator or automatic metering valve.
- (e) Anti-drip valve.
- (f) Blower.
- (g) Fuel burner assembly.
- (h) Magneto.
- (j) Combustion chamber and steam coil.
- (k) Cleaning guns.
- (l) Pressure switch.

19. **Fuel Tank.** The fuel tank has a capacity of 15 gallons, and supplies kerosine through a hand-operated control valve and a filter to the fuel pump.

20. **Fuel Pump.** The fuel pump is the smaller of the two pumps which comprise the duplex pump described in paragraphs 14 to 16.

21. **Balancer Valve.** The balancer valve (Fig. 5) is fitted to damp out the fluctuations in pressure of the fuel delivered to the pump, and to maintain an even flow of fuel to the combustion chamber. It is located in the fuel pipeline between the pump and the combustion chamber. The valve consists essentially of a spring-loaded plunger that is housed in a valve body, and guided in its movement by a guide plate bolted to a flange at one end of the body. The valve spring fits over the stem of the plunger and is located between the guide plate and a shoulder on the plunger. Leakage of fluid past the plunger is prevented by a synthetic-rubber gland packing, which is retained in position by a gland nut screwed into the valve body.

22. **Operation.** On the delivery stroke of the pump, fuel delivered at high pressure into the pipeline enters the balancer valve and forces the plunger along the valve body against the action of the compression spring. The valve then becomes a reservoir of fuel under pressure, which is fed back into the pipeline during the pump's suction stroke when the pressure in the pipeline would otherwise fall; this ensures a steady flow to the combustion chamber.

23. **Steam Pressure Regulation.** Regulation of the steam pressure is effected on

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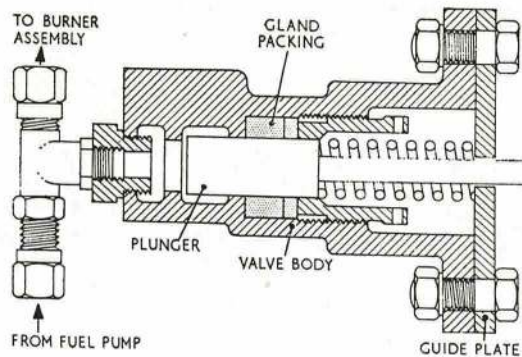


Fig. 5. BALANCER VALVE

early versions of the plant by means of an automatic metering valve, and on later plants by a pressure regulator. Both components achieve their purpose by control of the supply of fuel to the combustion chamber.

24. Automatic Metering Valve. The valve (Fig. 6) is a simple spring-loaded ball valve, seating on one end of an adapter screwed into the valve housing. The other end of

more or less fuel to the tank. The regulator comprises a body, a spring-loaded disc-valve, a screwed valve spindle with a hand-wheel, and a Tufnol plunger. The valve is held on a seating in the body by a spring, the loading of which is governed by the position of the valve spindle. The plunger, which has a tapered slot cut along its length, is free to slide in a guide on the inlet side of

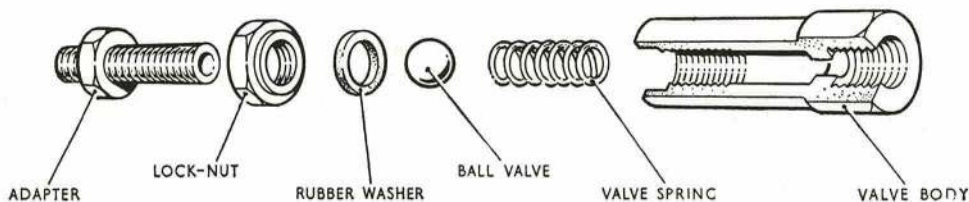


Fig. 6. AUTOMATIC METERING VALVE

the adapter is connected to the fuel delivery line from the pump. When the fuel pressure in the delivery line exceeds the spring pressure, the valve opens and allows fuel to return to the tank. The tension of the spring, and therefore the amount of fuel by-passed by the valve, can be adjusted by screwing the adapter into or out of the valve housing.

25. Pressure Regulator. With the steam pressure at 100 lb per sq. in. (normal operating pressure), approximately 3 gallons of fuel are burnt per hour in the combustion chamber. The fuel pump, however, delivers 35 gallons per hour, and the pressure regulator (Fig. 7) is incorporated to by-pass the excess fuel back to the tank. Thus, if it is desired to lower or raise the steam pressure, the regulator is adjusted to by-pass

the body, and its upper end is held in contact with the underside of the valve by fuel pressure. When the fuel pressure exceeds the loading on the valve spring, the plunger opens the valve and fuel is metered through the slot in the plunger and is returned to the fuel tank. Clockwise movement of the handwheel increases, and anti-clockwise decreases, the quantity of fuel passing to the combustion chamber.

26. Anti-drip Valve. On later versions of the plant an anti-drip valve is fitted into the fuel pipeline at a point just above the burner plate. The valve is a spring-loaded ball which seats on the inlet side of the valve body; it is opened by fuel pressure and closed by the spring. When the electric motor cuts out, the fuel pressure drops below the spring-

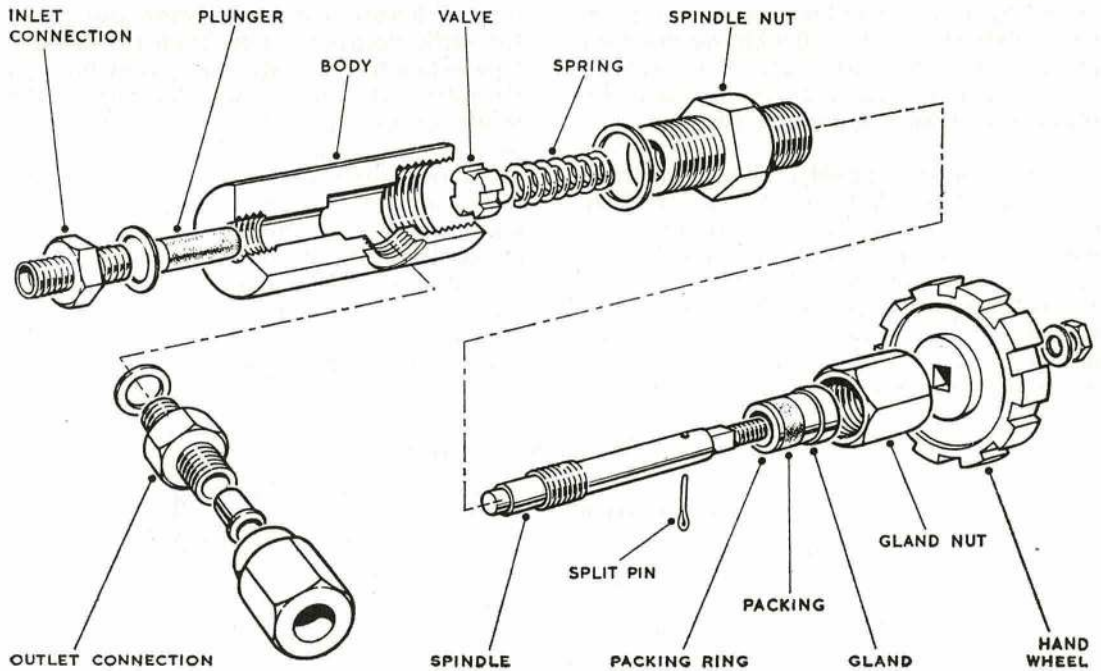


Fig. 7. PRESSURE REGULATOR

loading of the ball, which immediately seats and prevents any fuel in the pipeline from dripping into the combustion chamber.

27. Blower. A centrifugal type blower (Fig. 8) is fitted to provide a forced draught of air to the combustion chamber. It con-

sists of an impeller and a cast iron casing and is bolted to the combustion chamber cover plate. One side of the blower casing is open to atmosphere and provides the air inlet to the impeller. The other side incorporates a bearing for the impeller spindle, upon which is mounted a pulley that is

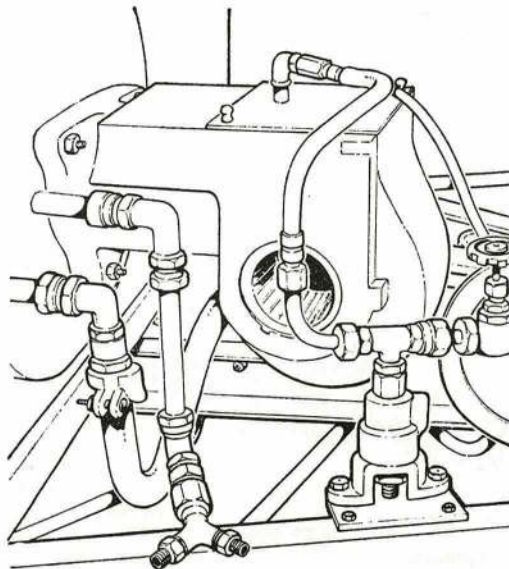


Fig. 8. BLOWER

driven by a belt from the electric motor. A cover plate at the top of the blower provides access to the fuel burner assembly which is mounted in the air passage between the impeller and the combustion chamber.

28. Fuel Burner Assembly. The fuel burner assembly, of which there are two versions (Fig. 9), atomizes and ignites the fuel delivered from the balancer valve to the combustion chamber. The high tension electrode on each type of burner is a porcelain-covered steel rod, one end of which is connected by a lead to a magneto which is driven by the electric motor. On the old

type of burner, the air deflector also forms the earth electrode. Fuel from the delivery pipe enters the jet body, and passes through the filter and holes in the filter cage to the inside of the cage. It then passes along slots in the whirler bush, through the whirler (which imparts a rotary motion to the fuel), and as it passes through the jet it is atomized and emerges as a fine spray. The purpose of the deflector is to break-up and whirl the air supplied by the blower. The air then mixes with the atomized fuel to form a combustible mixture which is ignited by the spark from the high tension electrode.

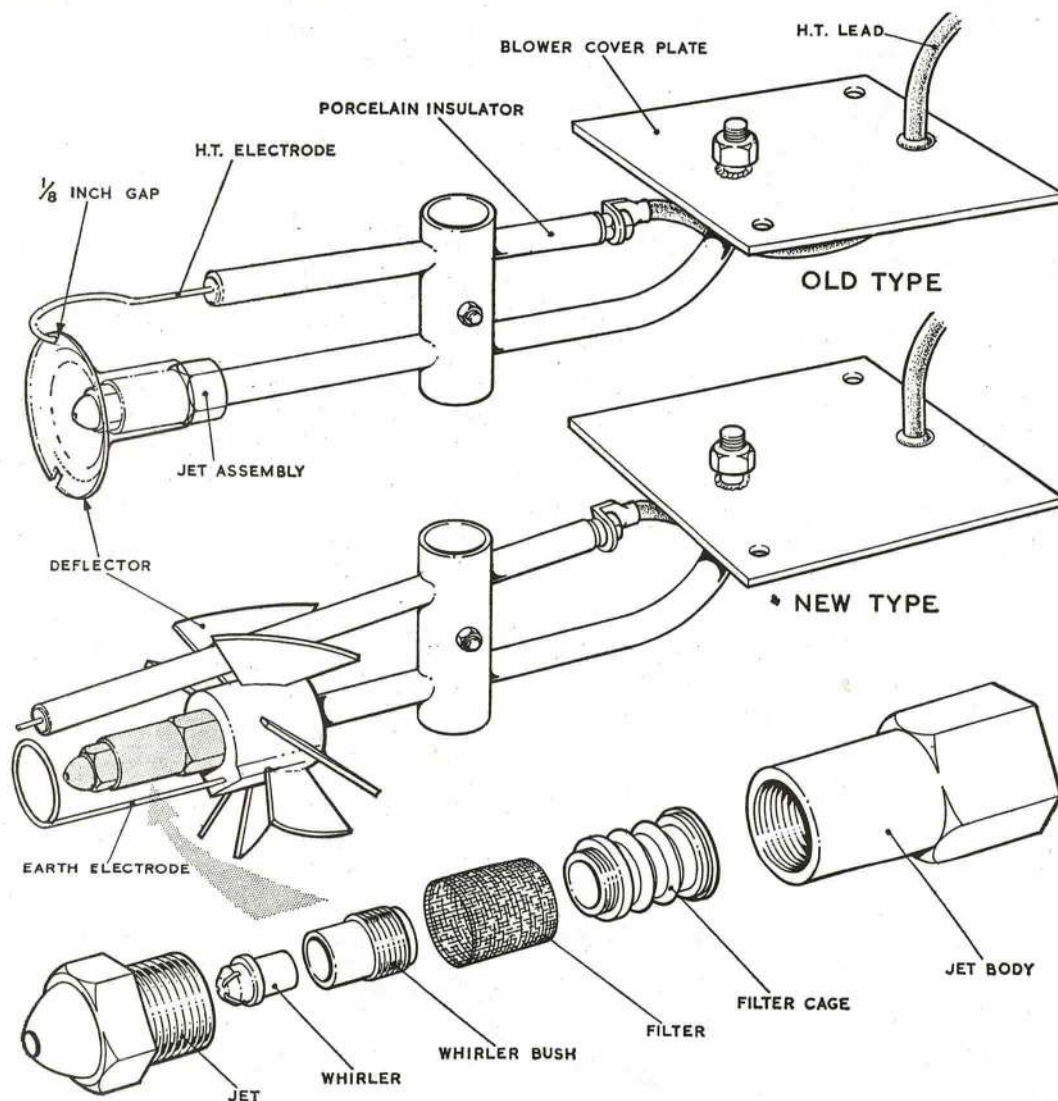


Fig. 9. FUEL BURNER ASSEMBLY

29. **Magneto.** Current for the high tension electrode is supplied by a Wico, Series A magneto, driven by the electric motor through a flexible driving belt to a flanged pulley which is keyed to the magneto rotor. The driving belt, which is made up of laminated links, can be shortened or lengthened as desired by the removal or addition of a link or links. It can also be repaired by renewing the defective portion.

30. **Combustion Chamber and Steam Coil.** The combustion chamber, which is a steel cylinder located inside the water tank, accommodates the steam coil (Fig. 10). The steam coil is a continuous length of steel tubing which is wound into three coils and positioned longitudinally inside the combustion chamber. The inlet end of the coil connects with the delivery pipe from the water pump, and the outlet connects with a Y-union mounted on the side of the chassis. When the plant is in operation, atomized fuel is sprayed by the jet assembly into the combustion chamber, where it is ignited by the high tension electrode. The heat generated is used to heat the coil, and to convert

the mixture of water and degreasing solution, pumped into the coil, into wet steam.

31. **Cleaning Guns.** Steam from the steam coil is led to a Y-union on the side of the chassis, whence it passes through flexible hoses to the two cleaning guns. Each cleaning gun (Fig. 11) consists of a length of $\frac{1}{2}$ -inch diameter steel tubing, insulated to enable it to be held by hand, a hand-operated control valve and a spray nozzle. Three different nozzles are provided for use with each cleaning gun as follows:—

(a) A $\frac{1}{4}$ -inch diameter round nozzle which is used for general cleaning.

(b) 2-inch and 4-inch flat nozzles which are used for cleaning large flat surfaces.

32. **Pressure Switch.** The purpose of this switch is to safeguard the plant from damage in the event of the operating pressure exceeding 150 lb per sq. in. It is automatic in action, and switches off the power supply to the electric motor when the steam attains a pressure of 150 lb per sq. in. The switch

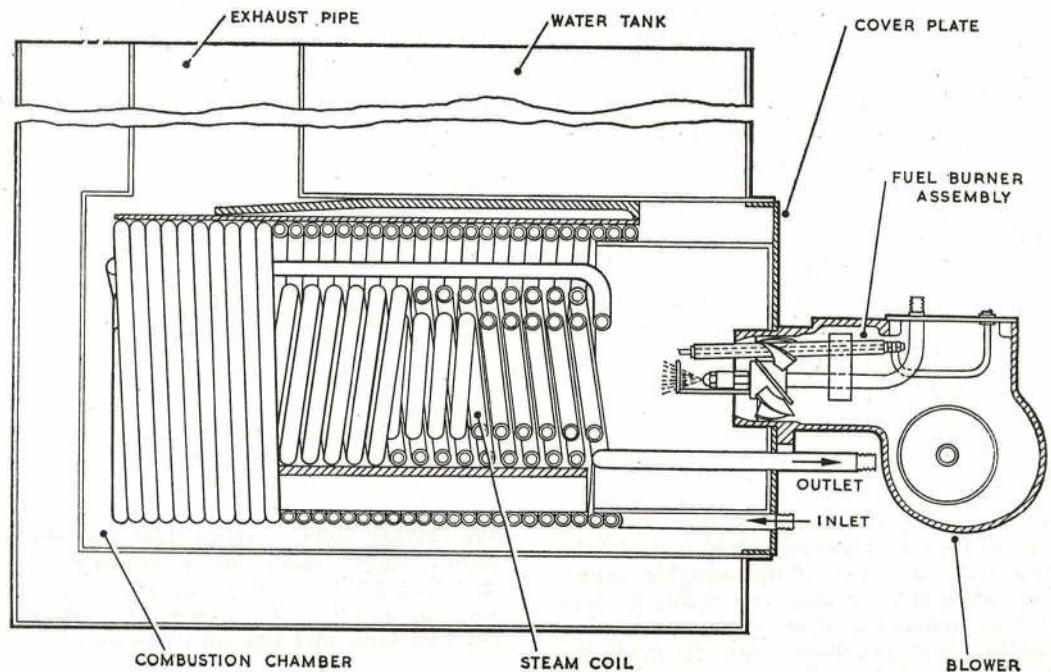


Fig. 10. COMBUSTION CHAMBER AND STEAM COIL

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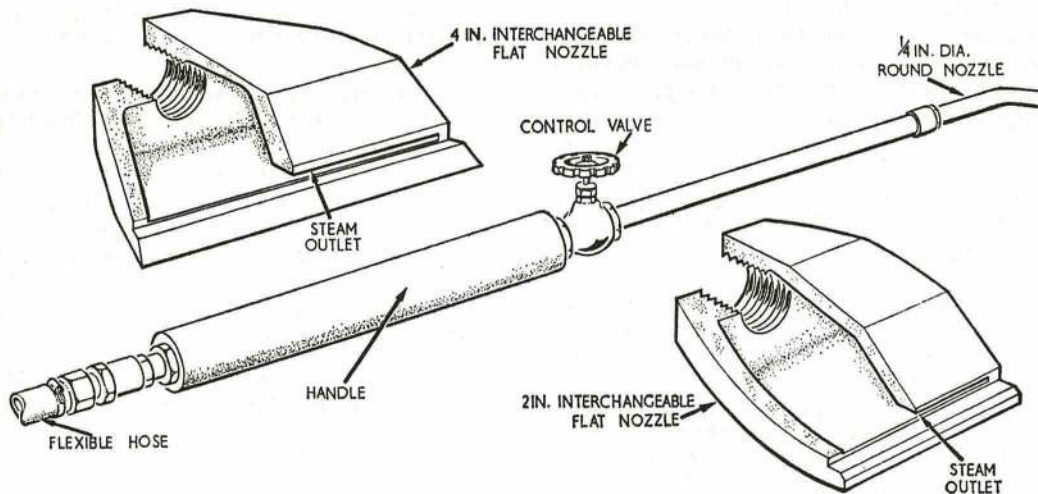


Fig. 11. CLEANING GUN

consists of a fixed and a moving contact which are in series with the power supply to the motor, and a spring-loaded diaphragm, one side of which is subject to the steam pressure and the other is attached to the moving contact. At the normal operating steam pressure the moving and fixed contacts are closed, and the circuit to the electric motor is complete. When the pressure on the diaphragm reaches 150 lb per sq. in., the diaphragm overcomes the spring tension and causes the moving contact to break the circuit, thus switching off the power supply to the motor.

Cleaning Compound

33. The cleaning compound at present approved and provisioned for use with the plant is the Type A, details of which are contained in A.P. 1464B, Vol. 1. The plant may, however, be used without the compound to supply wet steam for cleaning purposes.

OPERATING INSTRUCTIONS

General

34. When the plant is operated it must be level and on firm ground, preferably in the open and well clear of inflammable stores. If the plant is to be used in a building, there must be free access of air to the combustion chamber, and provision must be made for the removal of the exhaust gases to the outside of the building. If a chimney is used for this purpose, it should be at least 8 in. diameter and equipped with a hood (Fig. 12).

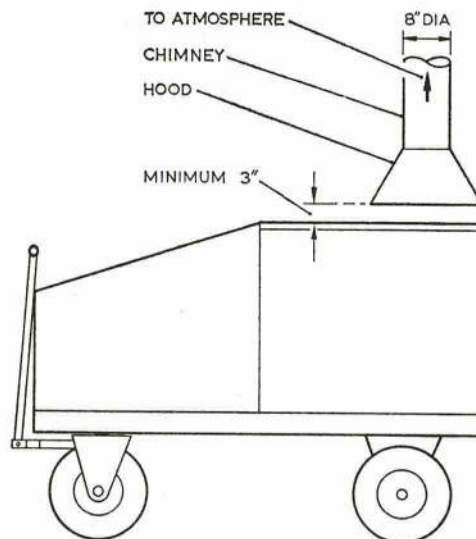


Fig. 12. ARRANGEMENT OF CHIMNEY

35. Before any attempt is made to use the plant, particularly if it has not been used for some time, ensure that it is serviceable. Check, and adjust if necessary, the tension of the driving belts. Ensure that the electric motor, duplex pump and magneto are secure, and that all water, degreasing solution and fuel unions are tight. Check the contents of the fuel tank and top up if required.

Preparation for Use

36. **Water System** (Fig. 13). Fill the water system as follows:—

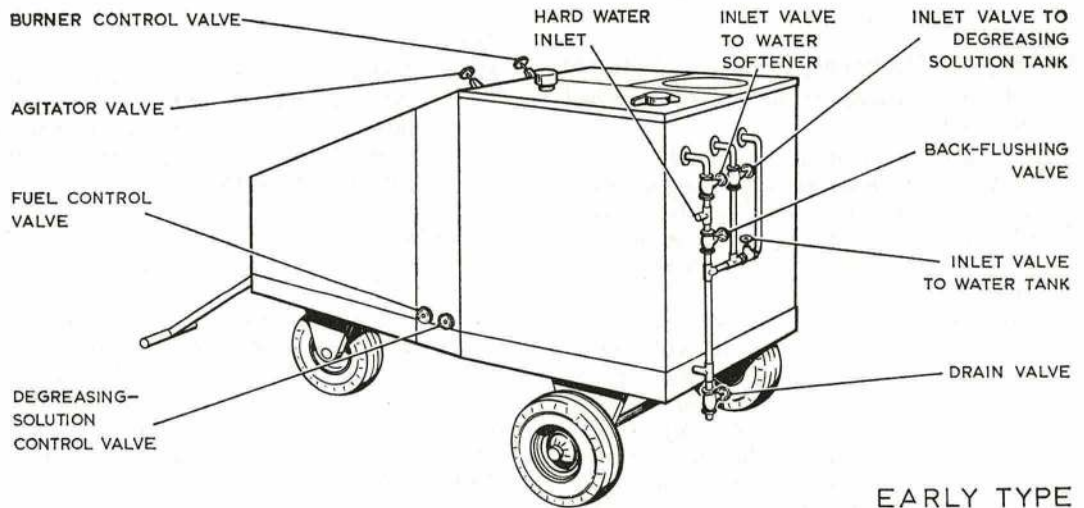
HEAVY DUTY STEAM CLEANING PLANT

- (a) Connect the mains water supply to the hard water inlet connection and open the inlet valve to the water softener.
- (b) Close the back-flushing valve.
- (c) Close the drain valve.
- (d) Open the inlet valves to the degreasing-solution tank and the water tank.
- (e) Turn on the mains water supply.
- (f) When the level of the water in the

degreasing-solution tank is 4 in. from the top, close the inlet valve to the tank

Note.—The float valve will control the flow of water into the water tank, and will automatically close when the tank is full.

37. Cleaning Guns. Screw the appropriate spray nozzle on to the end of each cleaning gun and open the cleaning gun control valves.



EARLY TYPE

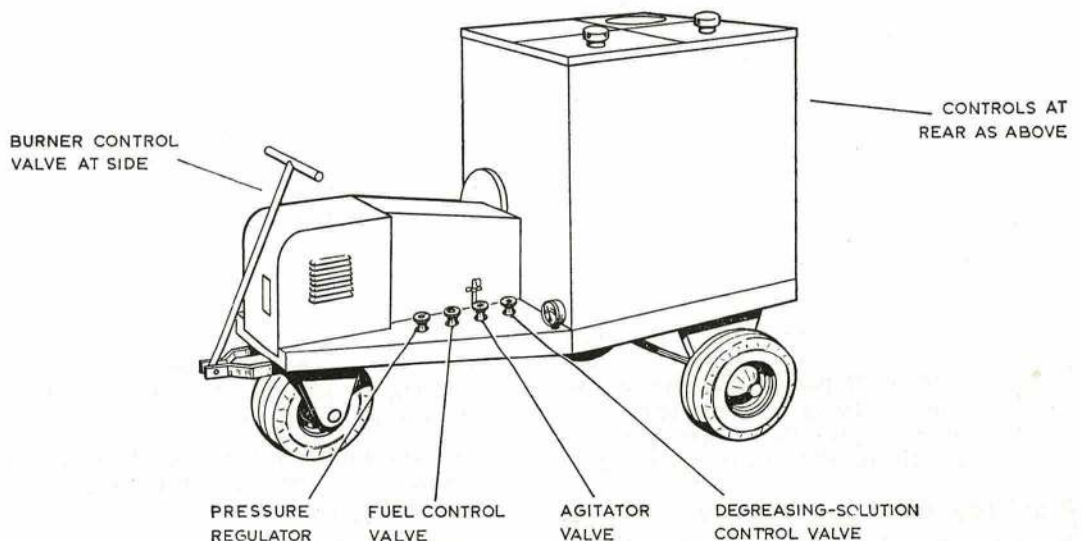


Fig. 13. LOCATION OF CONTROL VALVES

Starting the Plant (Fig. 13)

38. When it is required to start the plant, proceed as follows:—

- (a) Open the fuel control valve.
- (b) Open the degreasing-solution control valve.
- (c) Switch on the electric motor.
- (d) When water issues from the cleaning guns, open the burner control valve.
- (e) As soon as the steam pressure reaches 100 lb per sq. in., mix the degreasing solution (para. 39).

Mixing the Degreasing Solution (Fig. 13)

39. To mix the degreasing solution, proceed as follows:—

- (a) Start the plant as described in paragraph 38 and close the degreasing-solution control valve. As soon as the steam pressure reaches 100 lb per sq. in., add the cleaning compound to the water in the degreasing-solution tank.

Note.—The amount of cleaning compound to be added to the water will depend on the particular cleaning requirement. For normal use, a 2½% solution (1 gallon of compound to approximately 40 gallons of water) should suffice, but for heavy contamination the concentration may be increased to 5%.

- (b) Close the cleaning gun control valves.
- (c) Open the agitator valve.
- (d) When the solution is thoroughly mixed, open the cleaning gun control valves, close the agitator valve, open the degreasing-solution control valve and, when the cleaning guns are passing steam, reduce the pressure to 50 lb per sq. in.

Note.—If necessary, the steam pressure may be increased to 75 lb per sq. in., but it should not be increased beyond this figure as it may then drive the contamination into the underlying paint. If, however, the plant is being used to supply wet steam only, the steam pressure should be 100–110 lb per sq. in.

Regulating the Steam Pressure

40. The method of regulation of the steam pressure depends upon whether a pressure regulator or an automatic metering valve is fitted.

41. **Pressure Regulator.** To increase the steam pressure, turn the handwheel in a clockwise direction; to decrease the steam pressure, turn the handwheel anti-clockwise.

42. **Automatic Metering Valve.** When this component is fitted instead of a pressure regulator, the steam pressure is altered by altering the position of the adapter in the valve housing. To increase the steam pressure, screw the valve adapter in a clockwise direction; to decrease the pressure screw the adapter in an anti-clockwise direction. After the adjustment has been made, tighten the locknut.

Note.—The automatic metering valve is fitted into the return pipeline to the fuel tank. It is located on the right-hand side of the back-plate beneath the top control panel.

Cleaning

43. For general cleaning, use the round nozzle and apply it about 3 in. from the surface to be cleaned. For cleaning large flat surfaces, use either of the flat nozzles and apply it, with the slot downwards, directly on to the surface. Carefully move the nozzle forward and backward (not sideways) to cover all the surface. After being cleaned with the degreasing solution, the cleaned surfaces should be washed liberally with clean, cold water.

Safety Precautions

44. The following precautions must be observed when the plant is in use:—

- (a) Never idle the machine with the cleaning gun control valves closed for longer than two minutes.
- (b) Do not direct the steam on to rubber or fabric components.
- (c) Ensure that the degreasing solution is kept thoroughly mixed.
- (d) Do not refill the fuel tank nor remove the filler cap while the plant is in use.
- (e) Do not place tools or other articles on the top of the plant.
- (f) Do not allow the hands to come into contact with the exhaust gases from the combustion chamber.

Stopping the Plant

45. To stop the plant proceed as follows:—

- (a) Close the burner control valve.

(b) Close the degreasing-solution control valve.

(c) Allow the electric motor to continue running until there is a steady flow of water from the cleaning guns.

(d) Switch off the electric motor.

Note.—On no account should the motor be switched off before the burner control valve is closed as, on plants not fitted with an anti-drip valve, this will allow fuel to collect in the combustion chamber.

Procedure After Use

46. When the plant is out of use, all valves should be closed and the steam hoses wound into coils and placed on top of the plant. If the plant is expected to be out of use for some considerable time, it should also be disconnected from the mains water supply and then completely drained as follows:—

(a) Open the drain valves at the base of the water tank and the degreasing-solution tank, and allow the tanks to drain.

(b) Switch on the electric motor and open the burner control valve.

(c) When the water ceases to issue from the cleaning guns, close the burner control valve and switch off the motor.

(d) Close the drain valves.

(e) Close the fuel control valve.

Cold Weather Precautions

47. If, during cold weather, the plant is expected to be out of use for more than 24 hours, it should be drained completely as detailed in the previous paragraph.

GENERAL SERVICING

General

48. The permissible repairs to the plant are mainly those which involve the renewal of unserviceable components. Care should be taken to ensure that nuts, bolts, screws, etc., are secure, and that the plant is always kept in a clean condition. There should be no leakage of fluid from unions and components of the water and steam systems. The driving belts must be kept free from oil and grease which, in addition to causing slip on the

pulleys, have a detrimental effect on the rubber content of the belts.

Driving Belts—Adjustment

49. It is essential for the efficiency of the plant that the driving belts are correctly tensioned. Slack belts will slip on the pulleys; tight belts will impose excessive bearing loads. The driving belts should therefore be checked regularly and adjusted as necessary. The blower driving belt should always be the first to be checked and, if necessary, adjusted. The reason for this is that this adjustment entails movement of the electric motor, and consequent alteration of the tension of both the magneto and the duplex pump driving belts.

50. **Blower Belt.** To adjust the tension of the blower driving belt, loosen the four bolts which secure the electric motor to its mounting on the chassis, and move the motor in relation to the blower until the tension is such that a reasonable pressure exerted by hand on the top run of the belt, at a point midway between the blower and the motor, causes a deflection of the belt of approximately 1 in. at that point. When the motor has been re-positioned, tighten the retaining bolts and re-check the tension of the belt.

51. **Magneto Belt.** The magneto driving belt should be adjusted so that when a reasonable pressure is exerted on one run of the belt, at a point midway between the magneto and the electric motor, there is about $\frac{3}{4}$ in. movement of the belt. To tighten the belt, remove one or more of the laminated links.

52. **Pump Belt.** The tension of the pump driving belt should be adjusted so that when a reasonable pressure is exerted on the top run of the belt, at a point midway between the pump and the motor, there is about $\frac{3}{4}$ in. deflection of the belt at that point. To adjust the tension of the belt, proceed as follows:—

(a) Loosen the two bolts which secure the pump bearer to its mounting (Fig. 14).

(b) To increase the tension of the belt, unscrew the adjusting screw locknut and turn the screw in a clockwise direction until the tension of the belt is correct; tighten the locknut and bearer bolts.

(c) To loosen the belt, unscrew the adjusting screw locknut and turn the screw in

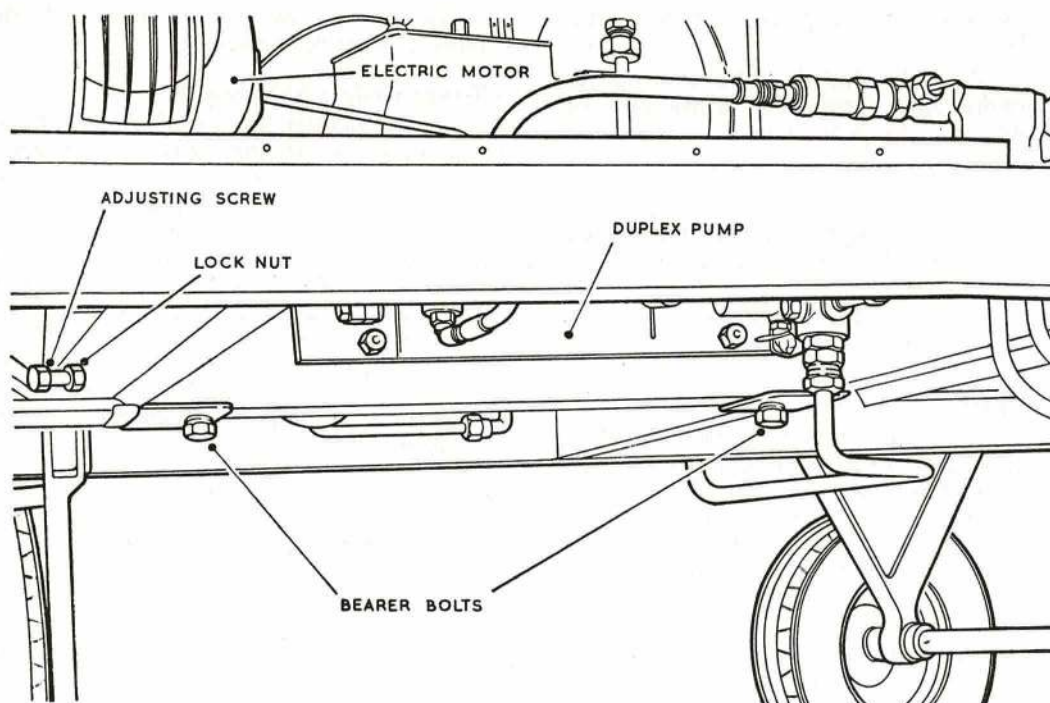


Fig. 14. PUMP BELT ADJUSTMENT

an anti-clockwise direction, at the same time pushing the pump bearer towards the electric motor until the tension of the belt is correct; tighten the locknut and bearer bolts.

(d) After adjustment has been made, recheck the tension of the belt.

Magneto

53. If the contact breaker points are found to be pitted, dirty or uneven, they should be cleaned and refaced with an equalizing file or a small abrasive stone. After they have been refaced, use a clean cloth moistened with gasoline to remove all traces of dirt from the points.

54. To adjust the contact breaker points, proceed as follows:—

(a) Disconnect the high tension lead from the magneto.

(b) Unclip and remove the contact breaker cover, and turn the magneto driving pulley until the contact points are fully open.

(c) Slacken the fixed-contact clamping screw, and turn the adjusting screw in the required direction until the gap between the contact points is 0.012 to 0.015 in.

Tighten the clamping screw and recheck the gap.

(d) Refit the contact breaker cover and the high tension lead.

Duplex Pump

55. Servicing of the duplex pump includes venting the fuel pump, lubricating the wrist pin and crank arm bearings, adjusting the gland packings to prevent leakage of fluid from the pump cylinders, and adjusting the lift of the ball valves.

56. **Venting the Fuel Pump.** When it is suspected that air may be trapped in the pump, and after refitting the pump following servicing or repair, the pump should be vented. To do this, open the fuel control valve and the fuel pump vent cock. When a steady flow of fuel that is free from air bubbles issues from the pump, close the vent cock.

57. **Lubrication.** To lubricate the wrist pin of the pump connecting rod, gently raise the felt pad which covers the small end of the rod and pour oil OMD-40 into the wrist pin housing and on to the felt pad. When the housing is full and the felt pad is soaked thoroughly, lower the pad into position and

wipe off any excess oil which flows on to the pump plunger. The crank arm bearings are packed with grease by the makers and should not normally require to be lubricated. If, however, the bearings become dry, a small amount of grease LG-280 should be forced into the bearings by hand.

58. Pump Glands. If a fluid leak occurs from one of the plunger glands, the gland nut should be turned in a clockwise direction until the leak ceases. Check that after the nut has been tightened the plunger is free to operate without binding. If, after tightening a gland nut the gland still leaks, a new packing must be fitted. To do this the pump must be partly dismantled; when doing this it is advisable to renew the water and fuel pump glands, even though one gland only may be leaking. The procedure for renewing the glands is as follows:—

- (a) Slacken both gland nuts.
- (b) Disconnect the pipelines from the water pump, remove the securing bolts and withdraw the pump from the plunger.
- (c) Remove the wrist pin from the plunger and connecting rod, and withdraw the plunger from the fuel pump.
- (d) Remove the gland nut and packing from each pump.
- (e) Fit a new packing to each pump.

Note.—Each packing comprises two rings; a thick ring with a concave surface on one side, and a thin ring with a convex surface on one side. The thick ring is inserted first and the concave and convex surfaces must abut.

- (f) Refit but do not tighten the gland nuts, and insert the plunger into the fuel pump gland. Refit the wrist pin.
- (g) Refit the water pump.
- (h) Tighten the gland nuts on to the packings, and then slacken them about $\frac{1}{32}$ in. to allow for expansion of the packings when the pump is running.
- (j) Run the plant and check the glands for leaks. Make any necessary adjustment to the gland nuts.

59. Capacity Testing. To check the capacity of the water pump, proceed as follows:—

- (a) Close the fuel valve and the degreasing-solution valve, and open the control valve on one of the cleaning guns.

(b) Switch on the electric motor and, when water issues from the cleaning gun, adjust the control valve on the gun to give a water pressure of between 80 and 100 lb per sq. in.

(c) Obtain a container of known $1\frac{1}{2}$ gallons capacity and check the time taken to fill it with water from the gun. If the time taken is longer than one minute, the output of the pump is below the required capacity.

(d) If the output of the pump is below the requirement, check the gland packing for leakage and adjust as in paragraph 58; also check the lift of the delivery ball valve and adjust as in paragraph 60.

60. Adjusting Valve Lift. To adjust the lift of the pump ball valves, proceed as follows:—

- (a) Unscrew the concerned valve cap-nut and remove the packing shims.
- (b) Using a soft metal drift, tap the ball valve on to its seating and, without shims, refit the cap-nut.
- (c) Screw down the cap-nut until it seats on the ball and then, using feeler gauges, measure the gap between the facing flange of the cap-nut and the face of the valve housing.

Note.—If, through wear of the valve seat, the cap-nut does not seat on the ball, a depth gauge should be used to measure the distance between the face of the valve housing and the top of the ball. The difference in measurement between the depth of the cap-nut and the ball should then be ascertained and the necessary clearance obtained as described in sub-para (d).

(d) Remove the cap-nut and fit shims to take up the clearance obtained by measurement of the gap, adding extra shims to allow for $\frac{1}{16}$ in. to $\frac{3}{32}$ in. lift of the ball.

Note.—The thickness of each shim is $\frac{1}{32}$ in.

- (e) Tighten the cap-nut.
- (f) Repeat operations (a) to (e) to set the other valves.

Pressure Regulator

61. If the pressure regulator fails to control the steam pressure, the cause may be traced

(A.L. 15, Oct. 63)

to a defect in the operation of the Tufnol plunger or to dirt under the valve. To service the regulator, proceed as follows:—

(a) Remove the handwheel from the valve spindle, and disconnect the inlet and outlet pipelines from the body. Remove the regulator from its mounting.

(b) Remove the split pin from the spindle, slacken the gland locknut and unscrew the spindle nut. Remove the assembly complete with the valve and spring from the body.

(c) Remove the inlet connection at the base of the body, and use a pencil to push the plunger from the body.

(d) Wash the components in kerosine and examine them for wear. Use a small piece of wood to clean the slot in the plunger, and ensure that the plunger slides freely in its guide.

Note.—Do not use an abrasive to clean the plunger and its guide, and take care not to enlarge the slot in the plunger.

(e) Check that the packing gland is serviceable by tightening the gland nut and turning the spindle. If the gland does not grip the spindle, remove the gland nut and gland and withdraw the packing by unscrewing the spindle from the spindle nut.

(f) Remove the gland packing and wash the spindle and spindle nut in kerosine. Inspect the spindle for wear and, if necessary, obtain a new one.

(g) Screw the spindle into the nut and ensure that the packing ring is seated squarely in the gland housing. Repack the housing with graphited asbestos string, allowing sufficient space for the gland to just enter the housing.

(h) Lightly compress the gland assembly by tightening the gland nut.

(j) Assemble the components in the reverse order to dismantling, ensuring that the plunger is fitted so that the small end of the slot is towards the valve.

(k) Refit the regulator to its mounting, fit the handwheel and reconnect the pipelines.

(l) When the plant is running, adjust the regulator as in paragraph 41 and check the gland for leakage.

Automatic Metering Valve

62. Failure to produce sufficient steam pressure on earlier plants may be due to a

fault in the automatic metering valve. To service the valve, proceed as follows:—

(a) Disconnect the fuel pipeline from the valve adapter and unscrew the valve body from the elbow on the fuel tank.

(b) Unscrew the locknut one complete turn.

(c) Unscrew the adapter from the valve body and withdraw the ball and valve spring. Remove the rubber washer from the adapter.

(d) Use kerosine to clean the ball, the valve spring and the valve seat.

(e) Fit a new rubber washer to the adapter and assemble the valve spring, ball and adapter, in that order, into the valve body.

(f) Start the plant and adjust the valve as described in paragraph 42.

Balancer Valve

63. If a fuel leak occurs from the balancer valve gland packing, provided it is not excessive, the gland nut should be turned clockwise until the leak ceases. It is advisable to use a light hammer and a copper drift to turn the gland nut. Do not use a steel drift, and take care not to over-tighten the gland nut. If this treatment does not stop the leak, the gland packings should be renewed as follows:—

(a) Unscrew and remove the two bolts which secure the guide plate to the valve body, and remove the guide plate from the plunger spindle.

(b) Remove the spring from the plunger spindle, and unscrew and remove the gland nut.

(c) Withdraw the plunger and remove the gland packings from the valve body.

(d) Fit new gland packings into the valve body, insert the plunger and screw the gland nut into the valve body.

(e) To ensure free movement of the plunger in the valve body, tighten the gland nut on to the gland packings and then slacken the nut about $\frac{1}{8}$ in.

(f) Fit the spring and the guide plate over the plunger spindle, and bolt the guide plate to the valve body.

Burner Assembly

64. To service the burner assembly, proceed as follows:—

(a) Disconnect the high tension lead from the magneto, and unscrew the fuel delivery

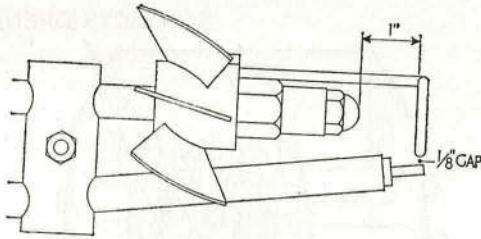


Fig. 15. BURNER SPARK GAP SETTING

pipe from its union at the top of the blower cover plate.

(b) Unscrew and remove the wing nuts which secure the blower cover plate to the blower and remove the cover plate, complete with the burner assembly.

(c) Unscrew the jet assembly from the burner pipe.

Note.—On old type burner assemblies the air deflector must first be removed. This is done by turning the deflector until its slot is in line with the h.t. electrode.

(d) Unscrew the jet from the jet body and the filter cage from the jet; remove the filter from the filter cage.

(e) Unscrew the whirler bush from the jet and remove the whirler from its bush.

(f) Use kerosine to clean each component of the jet assembly, and a hardwood probe to clean the jet orifice. On no account should a piece of wire or steel be used as this will damage the wall of the orifice.

(g) Clean the h.t. electrode and the porcelain insulator with kerosine, and dry them thoroughly.

(h) Scrape the carbon deposit from the deflector.

(j) Fit the whirler into its bush and screw the bush into the jet.

(k) Fit the filter over the filter cage and screw the filter cage into the jet.

(l) Screw the jet into the jet body and then screw the assembly on to the burner pipe. On old type burners, refit the air deflector.

(m) Adjust the earth and h.t. electrodes to the positions shown in Fig. 15. Do not bend the h.t. electrode to obtain the $\frac{1}{8}$ in. gap.

Note.—On old type burners, position the air deflector so that its edge is $\frac{1}{8}$ in. from the h.t. electrode. On new type burners the earth electrode is secured to the air deflector by means of an Allen screw.

(n) Slide the burner assembly into the blower casing and secure the blower cover plate by means of the two wing nuts. Connect the h.t. lead to the magneto and reconnect the fuel pipeline to the burner assembly.

Anti-drip Valve

65. To service the anti-drip valve, proceed as follows:—

(a) Disconnect the fuel pipe from the valve body, and unscrew the valve adapter from the burner pipe.

(b) Unscrew the adapter from the valve body, and remove the spring and the ball valve.

(c) Use kerosine to clean the components and then dry them thoroughly.

(d) Replace the ball in the body, and, using a soft metal drift, lightly tap the ball on to its seating. Fit the spring and the adapter.

(e) Fill the body and the adapter with clean kerosine and check the ball valve for signs of leakage.

(f) Refit the assembly to the burner pipe and reconnect the fuel pipe to the valve body.

Fuel Filter

66. The fuel filter in the delivery line to the fuel pump is serviced as follows:—

(a) Disconnect the fuel pipe from the filter assembly and unscrew the filter assembly from its mounting.

(b) Unscrew the adapter from the filter casing and remove the filter. Dismantle the filter and clean the components in clean kerosine. If necessary, renew the felt packing fitted inside the filter sleeve.

Note.—On early filters only a single gauze filter is fitted.

(c) Assemble the copper and asbestos washer on to the adapter and, after fitting the filter, screw the adapter into the filter casing.

(d) Screw the filter assembly into its mounting and connect the fuel pipe to the filter.

Electric Motor and Pressure Gauge

67. These components are serviced by electrical and instrument tradesmen respectively.

Pressure Switch

68. If the switch (Fig. 16) fails to operate when the steam pressure reaches 150 lb per sq. in., or operates before the pressure reaches 140 lb per sq. in., the switch setting will require adjustment. This is done by slackening the locknut and turning the adjusting nut; anti-clockwise decreases, clockwise increases, the loading on the diaphragm spring. After adjusting the setting the locknut must be securely tightened.

69. Faulty functioning of the switch may be caused by dirty contacts. These can be cleaned in situ by the careful use of an equalizing file.

Water Softener

70. **Back Flushing.** Before regeneration and at the periods specified in the servicing schedules, the water softener should be back-flushed as follows:—

(a) Close the inlet valve to the water and degreasing-solution tanks, and open the back-flushing valve.

(b) Close the drain valve and the inlet valve to the water softener, and remove the filler cap at the top of the water softener.

(c) Turn on the mains water supply and, for a period of ten minutes, allow the water to pass through the water softener and to overflow from the filler orifice. Do not allow the water to flow too rapidly, otherwise some of the base exchange compound will be carried away.

(d) Turn off the mains water supply, close the back-flushing valve, and open the inlet valve to the water softener, the degreasing-solution and water tanks. Refit the filler cap.

71. **Regeneration.** To maintain its water-softening properties, the base exchange compound in the water softener should be periodically regenerated as follows:—

(a) Turn off the mains water supply.

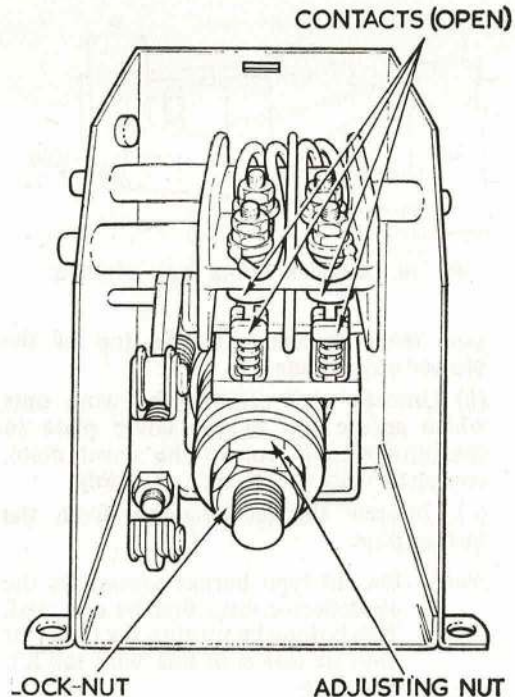


Fig. 16. PRESSURE SWITCH

(b) Close the back-flushing valve and the inlet valves to the water and degreasing-solution tanks.

(c) Remove the filler cap at the top of the water softener, pack 8 lb of common salt into the softener and refit the filler cap.

(d) Open the drain valve and the inlet valve to the water softener, and turn on the mains water supply.

(e) Allow water to flow through the softener and through the drain valve.

(f) Wash through until the water is soft again, then close the drain valve and turn off the mains water supply.

De-scaling

72. **General.** After a period of use, which depends largely on the degree of hardness of the local mains water, mineral scale will have formed inside the steam coil, the pump and the water pipelines to such an extent as to result in a reduction in efficiency of the plant. At such a time the plant should be de-scaled with the aid of de-scaling fluid as described in paragraph 74.

73. Precautions. The de-scaling fluid is a highly corrosive acid, and personnel must not allow their hands or clothing to come into contact with the fluid. Adequate supplies of clean water should be available for rinsing purposes and personnel should be instructed to wash at once any part of the skin that has been in contact with the fluid. Protective clothing and rubber gloves and boots should be worn and, if there is a risk of the fluid splashing into the face, goggles must also be worn. It is recommended that prophylactic ointment be applied to the hands and face before de-scaling of the plant is commenced.

74. De-scaling Instructions. To de-scale the plant, proceed as follows:—

- (a) Thoroughly drain and clean out the water tank. Ensure that all traces of sludge are removed from the bottom of the tank.
- (b) Open the cleaning gun control valves and place each gun, with its nozzle downwards, into the water tank.
- (c) Dilute 1 gallon of de-scaling fluid with 4 gallons of water, and pour the mixture into the water tank.

WARNING

When mixing the de-scaling fluid, always pour the fluid into the water; never pour water into the de-scaling fluid.

- (d) Disconnect the high tension lead from the magneto.
- (e) Close the burner control valve and the degreasing-solution control valve.
- (f) At one-minute intervals, for a period of ten minutes, alternately start and stop the electric motor, and then allow the motor to run for one hour.
- (g) Switch off the electric motor, remove the cleaning guns from the water tank, and allow the de-scaling fluid to remain in the system for 30 minutes.
- (h) Drain the fluid from the water tank and fill the tank with water. Start the motor and flush the system with water until the tank is empty. Repeat the flushing operation at least three times to ensure

that all traces of de-scaling fluid are removed from the system.

(j) Connect the h.t. lead to the magneto.

Functional Testing

75. To test the plant after repair or reconditioning, and to make any necessary adjustment to the pressure regulator or pressure switch, proceed as follows:—

- (a) Fill the plant with water as described in paragraph 36.
- (b) Switch on the electric motor and check that the water capacity is correct as described in paragraph 59.
- (c) Open the fuel and burner control valves.
- (d) Allow the plant to run until the steam pressure rises to 100 lb per sq. in. and then open the gun controls. Make any necessary adjustment to the pressure regulator or, on earlier plants, the automatic metering valve to obtain this pressure.
- (e) If the desired pressure cannot be obtained by adjustment, close the burner control valve, switch the motor off, and dismantle and clean the burner jet assembly as described in paragraph 64.
- (f) Set the plant to operate at 100–110 lb per sq. in. pressure (with both cleaning guns open), by turning the handwheel of the pressure regulator down to its maximum position as governed by the split pin in the valve spindle.

Note.—If a new pressure regulator has been fitted or if a new valve spindle has been fitted to the old regulator, adjust the handwheel to give 100–110 lb per sq. in. pressure and then drill the spindle and fit a $\frac{1}{8}$ -in. split-pin to prevent further clockwise movement of the spindle.

- (g) Close one of the cleaning guns and allow the steam pressure to build up.
- (h) Check the operation of the pressure switch. This should stop the plant when the steam pressure reaches 140–150 lb per sq. in., and restart the plant when the steam pressure drops to approximately 95–100 lb per sq. in. If necessary, make any adjustment as described in paragraph 68 to ensure that the plant does not operate in excess of 150 lb per sq. in.

FAULTS — CAUSES — REMEDIES

Fault	Possible Cause	Remedy
1. Plant fails to operate.	Fuel tank empty. Incorrect starting procedure. Magneto c.b. points dirty or incorrect gap. Magneto serviceable but no spark at h.t. electrode gap. Loose magneto driving belt. Burner jet assembly blocked.	Refill fuel tank. Check starting procedure. Service c.b. points. Check wiring to h.t. electrode Clean h.t. and earth electrodes and reset spark gap. Adjust tension of belt. Dismantle and clean jet assembly.
2. Plant generates insufficient steam pressure.	Fuel tank empty. Dirty fuel filter in outlet line from fuel control valve. Dirty filter in burner assembly. Partial blockage in jet assembly. Low voltage to electric motor. Faulty pressure regulator. Faulty automatic metering valve (early plants). Water or steam system scaled up. Loose blower driving belt. Loose pump driving belt.	Refill fuel tank. Remove and clean filter. Clean the filter. Dismantle and clean jet assembly. Check wiring. Dismantle and clean regulator. Dismantle and clean valve. De-scale plant. Adjust belt tension. Adjust belt tension.
3. Plant generates dry steam.	Improper starting procedure. Faulty delivery valve in water pump. Air leak on suction side of water pump.	Check starting instructions. Check lift of ball valves. Check pipe unions for tightness.
4. Plant generates sufficient pressure but gun discharge is poor.	Orifice in connection to hose Y-piece scaled-up.	Remove Y-piece and clean orifice.

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