THE SERVICING, MAINTENANCE & OVERHAUL OF MULTIPLE-UNIT DIESEL TRAINS

BRITISH UNITED TRACTION LTD.

HANOVER HOUSE, HANOVER SQUARE, LONDON, W.1.

DIESEL TRAIN MAINTENANCE

THE SERVICING, MAINTENANCE & OVERHAUL OF MULTIPLE-UNIT DIESEL TRAINS

MULT-O
(Registered Trade Mark)

TO OPEN - twist bottom levers clockwise slightly as you press them.

TO CLOSE - press top levers.

NITED TRACTION LTD.
USE, HANOVER SQUARE, LONDON W.1

PRINTED IN ENGLAND

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We are pleased to acknowledge the assistance given by the following:

Shell Petroleum Company Limited
Shell-Mex & B.P. Limited
Leslie Hartridge Limited
"Diesel Railway Traction"

INTRODUCTION

1. The life of a lightweight multiple-unit diesel train is very definitely dependent upon the standards of maintenance to which it is subjected.

2. The high-speed diesel power unit and its associated transmission system have been designed and produced to the highest standards attainable in present day mechanical and electrical engineering, and providing certain basic maintenance operations are carried out at fixed periods, it has been proved that this equipment is not only the most economical Motive Power system on rail to-day, but is also extremely rugged and dependable.

3. It is the intention of BRITISH UNITED TRACTION LIMITED in producing this brochure to indicate certain minimum standards of maintenance, as well as outline an ideal maintenance system around which a railway operator can evolve a highly efficient service.

4. The mileages quoted throughout this brochure have been obtained by experience on particular operations, and therefore can be modified by the further experience of subsequent operators. However, it should be remembered that visual examination of parts does not always give an indication of their condition, and therefore, before making drastic alterations to maintenance schedules, controlled and thorough investigations should be carried out. The Service Department of BRITISH UNITED TRACTION LIMITED is always willing to assist operators with maintenance problems of this nature, and maintains a staff of highly trained engineers to give on the spot advice to C.M.E. and Motive Power staff.

5. Preventive maintenance in lightweight diesel traction is of utmost importance and will pay handsome dividends although, at the time the systems are inaugurated, they may appear onerous.

PART 1. - BASIC REQUIREMENTS

6. The operation of lightweight diesel trains can be basically divided into two sections - maintenance and overhaul. The demarcation between the two depends upon the number of cars operated in an area, and the type of maintenance staff available at the various depots.

7. Maintenance can be sub-divided into two sections:-

(a) Daily servicing and running repairs.

(b) Mileage examinations.

8. Overhaul can also be sub-divided into two sections:-

(a) Top overhaul and light dock.

(b) Major overhaul.

(a) is determined by the life of valves and piston rings, and (b) by the re-grind life of the crankshaft.

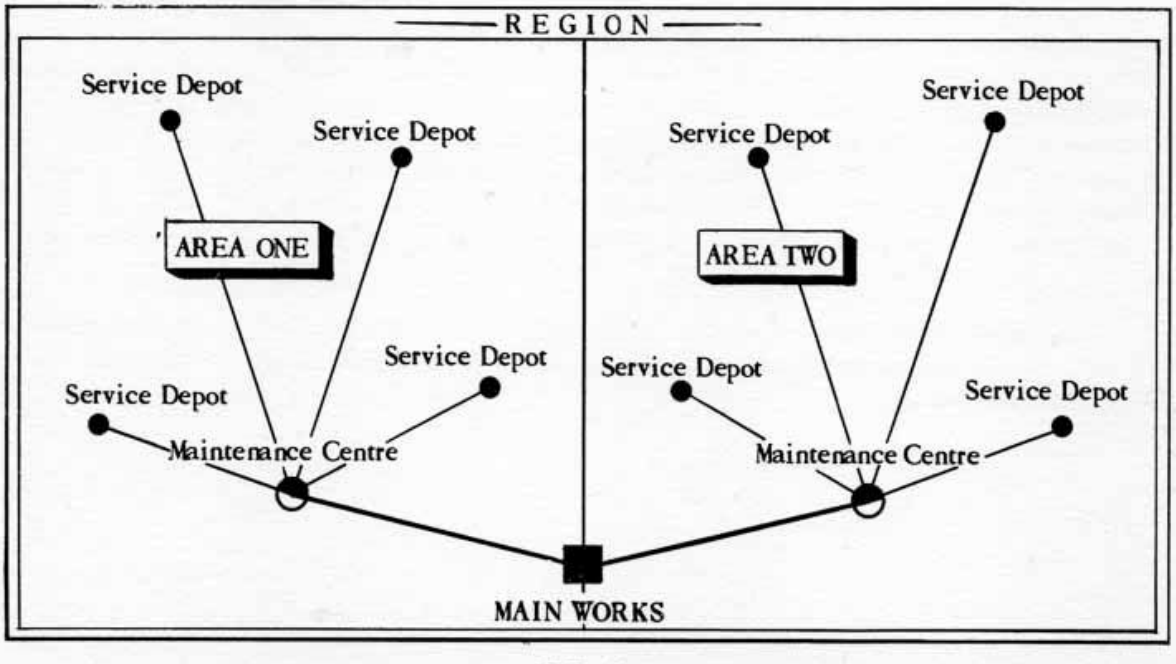

FIG. 1.

9. From the above it is possible to evolve a depot system to suit any given area or region. For example, daily servicing and minor running repairs along with the less complicated and skilled mileage examinations, can be carried out at service depots where the cars are stabled. The more complicated mileage examinations and top overhauls can be carried out at area maintenance centres, and finally major overhauls can be carried out regionally or at Main Works. (See figure 1.).

10. In certain regions it may be more economical to omit some of the maintenance centres and reduce the work carried out by them by a carefully controlled system of unit exchange from Main Works.

11. From a careful analysis of the maintenance schedules outlined later in this brochure, and giving consideration to the availability of skilled staff and facilities, it should be possible to evolve a system to suit any particular operation.

12. With regard to staff, it cannot be over emphasized that their basic training should be sound and thorough, and where staff are employed who were previously used to steam locomotive maintenance, they must be taught that meticulous cleanliness and rigid adherence to maintenance schedules are imperative to the satisfactory operation of a diesel. One of the finest incentives in this particular field is the provision of well designed premises and adequate facilities.

PART II - SERVICING AND SERVICE DEPOTS

13. The following points are of pre-eminent importance at service depots, as distinct from maintenance centres:-

Complete protection from the elements.

Rapid and efficient removal of waste water and oil, i.e. drainage.

Adequate natural lighting.

Complete and up-to-date artificial lighting, both fixed and portable.

Provision of power points in sufficient numbers and at correct spacings.

Thorough fire protection arrangements.

Proper methods for the dispensation and metering of lubricants and fuel.

Light workshop facilities.

Storage provision for field-service kits of spares.

Service literature, including servicing and fault-finding charts should be available to the members of the staff who are carrying out this work.

Wall charts and coloured diagrams of all descriptions should be prominently displayed so that staff can refer to whatever type of unit they are working on.

Graphic service records illustrating periodical tasks and work actually done, together with 'target' pointers for items outstanding.

14. Daily servicing is the "out-post" through which those responsible for maintenance receive regular reports of mileage, fuel and lubricant consumption, and the flow of vital performance reports on which most maintenance schedules are based. Any untoward happeningsare also reported through these channels. This is the yard stick by which mechanical maintenance programmes are initiated and if unit changes are to be made is a constant source of advance information as individual units near their replacement mileages.

15. In figure 2 there is illustrated a service depot with adequate facilities for the type of work which will be outlined in the following paragraphs. It should, however, be borne in mind that there can be two distinct types of service depot. Firstly, the type of premises where diesel cars are merely stabled and at which daily examinations are carried out, the mileage examinations being undertaken at a maintenance depot. Secondly, there is the type of service depot which includes facilities normally applicable to a maintenance depot, i.e. the provision of inspection pits.

FIG.2

TYPICAL SERVICING DEPOT (Open Type)

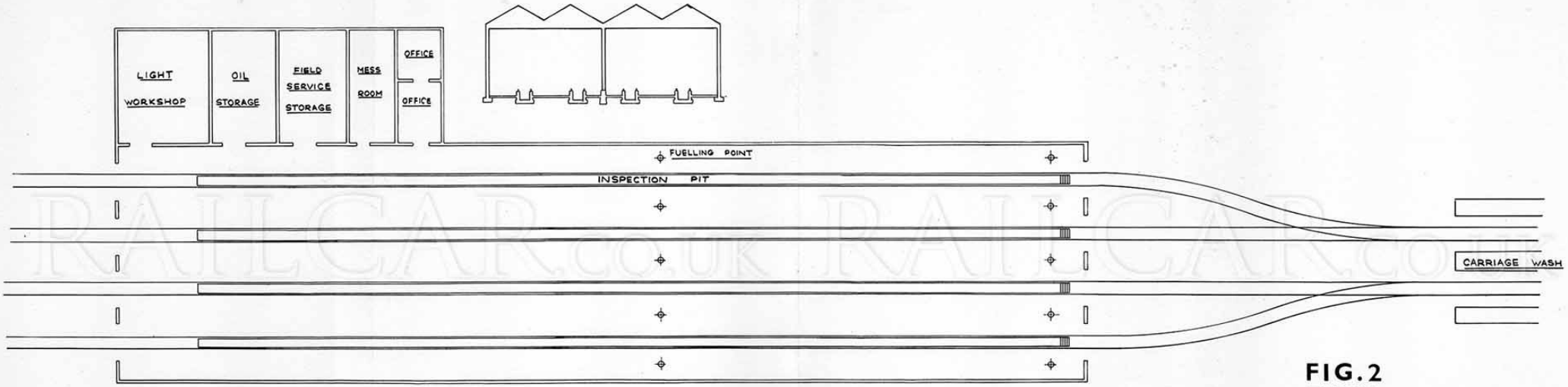

FIG. 2

TYPICAL

SERVICING DEPOT (OPEN TYPE)

ONE TWO THREE OR FOUR ROADS

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16. Facilities should always be provided to enable water to be taken from existing water columns by the provision of an ordinary tap and hose pipe, and this should apply throughout routes where diesel cars and multiple-unit trains operate. The small amount of work entailed by plumbing in such a connection is amply repaid when one considers the labour involved and delays experienced when the use of water cans has to be resorted to. Most water columns have a standard tap already fitted and the provision of a hose with a suitable connection only is required.

CLEANLINESS

17. The importance of strict cleanliness cannot be over-emphasized, and this applies to the handling of equipment as well as tools and premises in use. Injection equipment of diesel rail cars is precision made to thousandths of an inch and cleanliness of almost hospital standards is essential in dealing with many of the constituent parts. It will be apparent, therefore, that premises of new design and revised standards must be provided, differing entirely from those previously used in connection with the maintenance of other forms of motive power.

18. The provision of many small items of service equipment plays a large part in maintaining a standard of cleanliness, and attention to the supply of such items as injector nozzle protection caps, racks for keeping fuel injection and other components above bench level, together with paraffin baths and drainers assists to a large degree.

19. Experience has proved that the siting of diesel service tracks, bays and shops away from steam locomotive premises is well worth while, but this should not result in the diesel installation being placed close to coaling or ash plants. Complete segregation is the only answer to this problem. Cleanliness tends to be overlooked if the floor provided at a service centre is of the traditional motive power type (i.e. wooden blocks) and a smooth, easily washable surface is necessary, together with the provision of adequate refuse bins in prominent locations. Where fuels and lubricants are concerned, the same theme of rigid cleanliness must be followed.

20. As regards the vehicles themselves a thorough break-away from steam engine procedure must be made, and the undercarriage with its power transmission and allied equipment should be kept in first-class state of cleanliness. Only in this way can leakages from the fuel, cooling and lubrication systems be quickly and easily traced and action taken to rectify them. As is well known, apparently insignificant leaks, which on steam locomotives may be ignored, can lead to serious troubles and possibly failures with machines of the high standard employed in diesel rail traction. In addition, the possibility of fire due to an accumulation of grease and coal dust, bonded together with oil, must not be overlooked, and regular vigorous washing down and wire brushing should be carried out at frequent intervals. It is <u>not</u> sufficient that regular cleaning be applied only to the bodies of diesel rail cars but that methods must be employed to maintain the condition of the underframe equipment to prevent collection of dirt and oil.

21. It is unreasonable to expect staff to carry out proper examinations and to trace faults or suspected fractures, leaks, etc., on equipment which is coated with the

peculiar composition which is collected on the under-parts of rail vehicles. Neither must it be expected that the equipment itself will function as desired or give of its best unless it is maintained in a clean state. The obvious time to apply such measures is from the beginning - at the very introduction of diesel cars in a particular area, and it is doubtful if efficient working results can otherwise be obtained.

PRECAUTIONS

22. Where an assembly of fuel oil, lubricating oils and i.c. engined vehicles is encountered, fire precaution measures should be taken, and this applies both to the vehicles themselves and to the premises which they use. At specified locations throughout the area fire appliances of the foam and CO2 types should be made easily available, although it is pointed out that unless the staff are properly instructed in their use, the presence of such equipment will be largely unavailing when an emergency arises.

23. No naked lights, such as flare-lamps, candles or wax tapers, commonly used in motive power depots, should be allowed in the diesel premises or in the vicinity of a diesel car. Notices to this effect should be prominently displayed, and lead lights protected against breakages provided for the close examination of units.

24. It is, of course, essential that provision be made for the disposal of waste oils from sites at which diesel cars are serviced and it is not sufficient that these waste fluids be accumulated in a sump pit. They must be removed from the vicinity, and to do this effectively adequate drainage channels, gratings and gulleys are required. In addition, regular daily hosing - down of all the passages referred to is of paramount importance and accumulations of fuel-oil or grease, no matter how small, must be dealt with rapidly and effectively - the staff concerned should be instructed to act at once in this matter.

25. In view of the high standard of construction of the traction equipment, no unskilled person should be allowed to handle components or make adjustments, and none other than authorised personnel should be allowed to move a diesel railcar.

FUELLING FACILITIES

26. If availability figures are to be kept at a high level, it follows without question that the storage accommodation for fuel-oil must be ample at all times. In this connection, it is recognised practice to ensure that a reserve of at least two weeks' supply is maintained over and above the normal weekly usage. Two separate bunkers are preferable to a large one, providing that each is able to hold a complete consignment of fuel. This arrangement enables full advantage to be taken of the "settling" process and is employed with most large installations. The twin tanks may be connected for filling purposes through a single orifice providing that stop cocks are arranged in order to secure necessary isolation.

27. Fuel-oil storage tanks should be elevated above the ground but only to a minor degree, and they should be well protected from the vagaries of the climate. Brick cradles are best for mounting and a downward inclination towards the draincock end of half-an-inch per foot length is suitable. Welded cylindrical tanks of the horizontal type are

preferable, and pains should be taken to ensure that the internal surfaces are cleaned thoroughly immediately before initial use. The external surfaces can be protected by three or four coats of bituminous paint. These storage tanks should conform in all aspects to B.S. No. 799.

28. Man-holes should be provided not less than 18 in. in diameter if round, or 18 in. by 16 in. if oval, to comply with Section 27 of the 1937 Factories Act, and it is important to ensure that the man-hole covers are equipped with serviceable gaskets and well bolted down. A vent pipe (not smaller in bore than the filler pipe) from the top of each tank usually in direct connection with the dip-pipe should be provided and this should terminate at a point higher than that of any part of the tank itself. The vent pipe outlet should be in the open air and located where overflows will not cause damage. A wire cage must be provided over the vent pipe extremity and under no circumstances should fine gauze be used for this purpose. A brass dipstick is best provided for calibrating the amount of fuel contained in the tank and the dip-orifice should be located on top of the vessel at a central position. The dip-stick should be thoroughly cleaned before each dipping.

29. A supply outlet connection is best located at the higher end of the storage vessel and should not be less than 3 in. above the tank's bottom. In this way provision is made for a space in which residue and water can settle and be removed through the medium of a drain valve situated at the opposite end of the tank (i.e. at the lowest point). The drain valve must be of adequate size to be effective and before the tank is filled must be opened for drawing off water and residue no matter how minute the quantity may be.

30. It is imperative that a well designed filter of the enclosed pattern be included in the outlet supply arrangements and the filtration element needs to be of fine mesh in order to be effective (120 mesh per-linear inch is suggested). This filter unit must receive regular cleaning and consequently should be of readily accessible design and location. In order to avoid fuel being spilt whilst filter cleaning is taking place, the filter should be so mounted that it can be completely isolated. An alternative is a duplex-type filter which has the added advantage of enabling the delivery of filtered-oil to be maintained whilst cleaning is undertaken.

31. All pipe line connections should be constructed with steel tubes and fittings and welded joints are preferable. Galvanized metals, zincs, lead and soft alloys of copper and

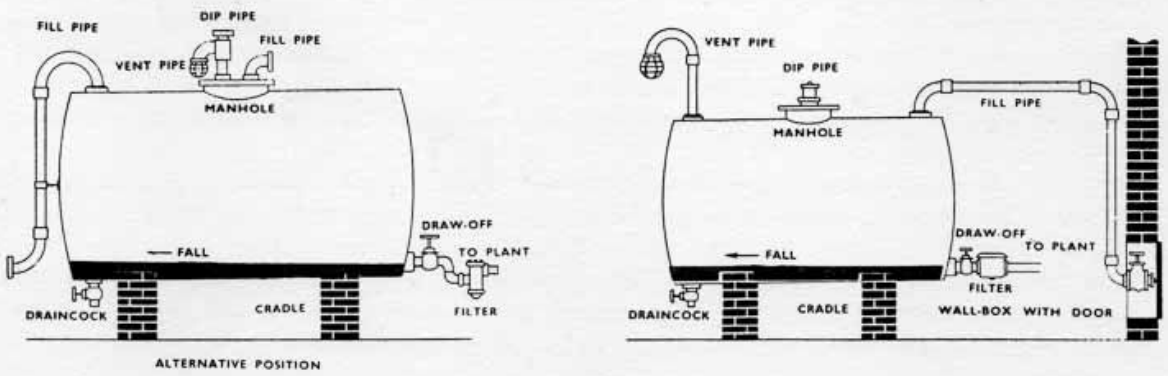

Fig. 3. Installation of bulk fuel oil storage tank.

zinc should not be used on any portion of the fuel-oil installation likely to come into contact with oil. Adequate provision for prevention of fires must be made in accordance with modern practice and the display of warning notices etc. arranged (see paragraphs 22 and 23 of these notes).

32. Quick and efficient methods are available for the dispensing of fuel into the tanks of diesel cars and re-fuelling points should be provided on both sides of each track where cars are serviced. These points must be adequately protected from the action of the elements, and in particular from airborne coal dust etc. Nowhere is scrupulous cleanliness more necessary than in matters relating to fuel oil and injection equipment. The hose nozzles in particular should be kept closed at the ends and hung well away from the ground or possible contamination by other sources and must be wiped scrupulously clean before each delivery is made. Flowmeters should be provided and should be of the large-dial pattern which is easy to read and arranged for illumination. This type of equipment can be obtained with devices for dispensing a pre-determined quantity of fuel.

LUBRICANTS

33. The choice of lubricants for B.U.T. equipment is governed by specifications formulated after extensive research by the manufacturers and oils and greases which comply with these specifications are officially approved. Only approved lubricating oils and greases which comply with B.U.T. specifications should be employed.

34. Of equal importance to the above is the question of storage and handling of lubricating oils with which of course must be included dispensing. A first essential is to ensure that lubricants have not been impaired by contamination or the effects of poor storage conditions. Freedom from pollution or injury is entirely the responsibility of the operator. It is by no means generally appreciated to what extent careless handling or improper storage of lubricants can lead to damage and marked attention must be given if a high standard is to be achieved.

35. On the assumption that lubricating oil is delivered in drums the primary object should be to reduce the handling to a minimum. Filled drums are usually of such weight that they cannot be easily handled by one or two employees and as a result they are frequently dropped, turned on their sides or allowed to roll unchecked down sloping surfaces. In turn rough handling causes leaking seams and obliterated brand markings, which may possibly lead to wrong application or the entry of water which, in the case of certain lubricating oils containing compounding agents and additives, can have disastrous results.

36. Drums of lubricating oil incorrectly stored in the open can become contaminated with water due to being stood on end and subject to rain water collecting in the recessed tops. Such water is drawn into the drums through the medium of the bungs due to the slight vacuum created by temperature drop over-night. To avoid this, drums should be stored on their sides or tilted slightly to avoid water accumulation in the vicinity of the bungs, and the bungs themselves arranged to lie on the lateral diameter.

Fig. 4. Illustrating method of storing lubricants in drums.

Fig. 5. Method of handling lubricating oil drums by hand trolley.

37. The presence of dirt, coal dust, sand and other abrasive elements in a lubricant can lead to the most serious troubles and extremely small quantities are sufficient to cause major failures. It is therefore obvious that the site for storage and the methods of handling lubricants must be such as to avoid even the slightest possibility of contamination. Drums should be stored on their sides or bilge rings and furthermore, placed on wood baulks in order that they may be kept clear of the ground and rusting prevented. Under no circumstances should drums be placed directly on a clinker surface such as is met with at motive-power depots, as this is highly corrosive to the metal. Where it is not possible to avoid the storage of drums in the open they must always be covered with tarpaulins in addition to the precautionary measures given above and regular examination is essential.

38. Storage provision for oil and grease under cover must be sited so that it is away from any installation producing dust and should be subject to a high standard of safety regulations. Where bulk storage for lubricating oils is provided the vessels should be emptied and cleaned every nine to twelve months and the same precautions are necessary with hoses as mentioned in paragraph 32. The oil store should be well lighted naturally and a high standard of ventilation arranged, whilst the floors should be formed of non-porous and anti-slip material. Drains from the oil store should be so arranged as to pass through an interceptor unit to prevent the waste lubricants reaching the normal drainage system.

39. Employees often tend to use whatever type of lubricating oil happens to be closest to hand and in this connection an essential part of the system should be strict control from delivery through storage right up to the point of application. Clearly marked tabs and notices should be provided at all points and used in conjunction with lubrication charts (which themselves should be permanently displayed under glass) close to the point of distribution. A lubrication chart thus displayed is useless at night unless brightly illuminated. Colour coding can be resorted to so that an appropriate colour marked on the chart is applicable to a particular brand of oil shown under the respective colour at the dispensing point.

40. There are several methods of dispensing oil from drums but the pump system is by far superior and less likely to result in contamination. Any system however, will

Figs. 6 & 7. Portable dispensers for lubricating oils.

deteriorate unless containers used to carry the oil to the diesel-car are maintained in a scrupulously clean condition and it should be particularly noted that it is at this point that the entry of foreign and abrasive matter invariably takes place. In order to avoid the possibility of the ingress of foreign matter a portable tank on wheels fitted with a pump and delivery hose will yield good results providing the floors over which it is expected to operate are reasonably smooth (see Figs. 6 & 7.). For larger installations such as those at diesel-car repair centres, centrally located lubricating-oil tanks with several dispensing points and hoses are preferable. The ultimate aim should always be - no handling between storage and application to the machine concerned.

41. Among the most mishandled products is grease which, as it does not flow by gravity, requires special equipment for distribution. A practice which must be avoided at all costs is that of the open grease drum, for here the danger of contamination is high. The provision of properly designed grease dispensing equipment is of paramount importance in connection with diesel railcar servicing and portable plants are available operated by compressed air, which enable the lubricant to be dealt with from delivery to dispensing without handling.

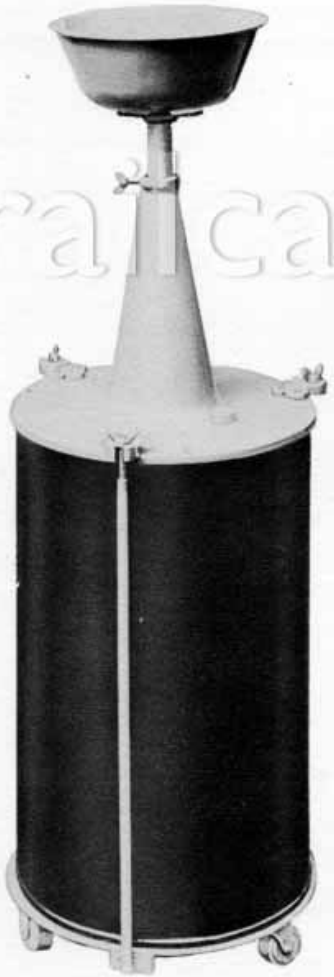

FIG. 8

42. Waste lubricating oils should be drained direct into portable containers (see Figure 8). Where larger depots are concerned, a system should be employed providing for the pumping of oil directly out of the crankcases and circulating systems into a common sump, from whence it is routed through centrifugal purifiers for subsequent storage, settling and re-use in less arduous forms of service (e.g. protective coatings to chains and couplings in store).

SERVICING PREMISES

43. As previously mentioned, the premises at which only diesel servicing is undertaken need consist of little more than a number of covered tracks with facilities for the storage and dispensation of fuel-oil, lubricants and grease, together with simple bench arrangements and a light workshop. They may or may not include inspection pit facilities, depending largely on whether or not a maintenance centre is reasonably close by. A first essential is that complete protection from the elements be provided and that arrangements for the removal of waste oil and water, as mentioned in the foregoing paragraphs, be efficient. Lighting should be from the best possible natural and artificial sources as working will undoubtedly be undertaken on a 24-hour basis.

44. The minimum fixed equipment required for the light workshop is as follows:-

(a) Modern strong steel benches, with cabinets and drawers.

(b) Bench power drill, with capacity up to ½-inch - ⅝-inch.

(c) Dust-proof compartment for the testing of fuel injectors.

(d) Paraffin bath for cleaning minor components.

(e) Small turret-type electrical grinder and buffer.

(f) Racks for special spanners and keys.

(g) Small store for the retention of field service kits of spares.

45. An important provision should be the display of servicing and trouble-finding charts, and accessible storage of service manuals and other relevant literature. Among the items of portable equipment considered necessary are a portable electric drill of the double-handled pattern, together with a high-speed pistol drill, a portable trolley for the acceptance of waste lubricants, and suitable rubber-tyred trolleys for the conveyance of both fuel-oil and lubricating oil in drums. Provision must also be made for packing blocks and hydraulic jacks to facilitate emergency repairs.

46. Servicing and maintenance tasks included in this brochure are based on the following division:-

		Short Title
1 ...	Engines	Engines
2 ...	Lubricating-oil System ..	Lub. oil System
3 ...	Cooling-water System ...	Cooling System
4 ...	Fuel-oil System ...	Fuel System
5 ...	Fuel-injection Equipment	Injection Equipt.
6 ...	Auxiliary Drives ...	Aux. Drives
7 ...	Fluid Couplings ...	Fluid Couplings
8 ...	Gearboxes	Gearboxes
9 ...	Final Drives	Final Drives
10 ...	Transmission Shafts ...	Trans. Shafts
11 ...	Compressed Air System .	Air System
12 ...	Vacuum System ...	Vac. System
13 ...	Electrical	Electrical

DAILY ROUTINE

47. All operations are dependent on the human factor and the over-riding influence of skilled supervision is necessary at all times. Daily servicing operations should comprise routine checks to ensure that all components are functioning correctly and that the fuel, lubricating oil and the water systems have been replenished. Together with correction of minor defects these can be divided into two distinct activities:- (A) Replenishment of fuel, water and lubricating oil, together with checks of the mechanical, air, vacuum and electrical systems. (B) Attention to minor defects recorded on drivers' reports. (This work must be undertaken at each point where diesel railcars are stabled and operated).

48. Dealing first with Operation "A", this should comprise the following work:-

OPERATION A (Daily)

Job No.	Unit	Description
A1	Engines	Start and ensure operating correctly.
A2	Lub-oil Systems	Examine oil level in each sump by means of the dip-stick provided (which should first be withdrawn, wiped clean and re-inserted to obtain a correct reading) and make good any loss.
A3	Cooling Systems	Check level of water in the header tanks and make good any loss (using anti-freeze in correct proportion to water during the Winter).
A4	Fuel System	Replenish tanks as necessary and ensure that filler caps are adequately secured.
A5	Injection Equipt.	——
A6	Aux. Drives	Examine drive belts for soundness and tension.
A7	Fluid Couplings	Rotate engine until one of the filler plugs is in the top position, unscrew plug, check the oil level and top up if necessary. Refit the plug and repeat operation on opposite engine. This may be extended to weekly intervals in the light of experience gained.
A8	Gearboxes	Remove dip-stick, wipe clean, reinsert and examine oil level. Top up if required.
A9	Final Drives	

Job No.	Unit	Description
A10	Trans. Shafts	Ensure that shafts are free from all tools, leadlights, rag, etc.
A11	Air System	Start engine, drain reservoirs, close drains and check pressure on gauge in cab and observe whether there is any appreciable fall-off of pressure.
A12	Vacuum System	Start engine, create vacuum and test for leakage.
A13	Electrical	Ascertain whether code lamps and tell-tale lights are operative, and that generator output is correct. Operate controls when maximum air pressure is available by moving throttle control through all positions whilst someone observes whether the engine runs in accordance with the throttle control. Move gear controller through all positions whilst a mate observes whether the free-wheel shaft stops as each gear is selected.

49. In addition the following work should be undertaken:-

OPERATION B (Daily)

Carry out attention to minor defects reported by enginemen on repair cards

FIG.9

COMBINED MAINTENANCE CENTRE & SERVICE DEPOT.

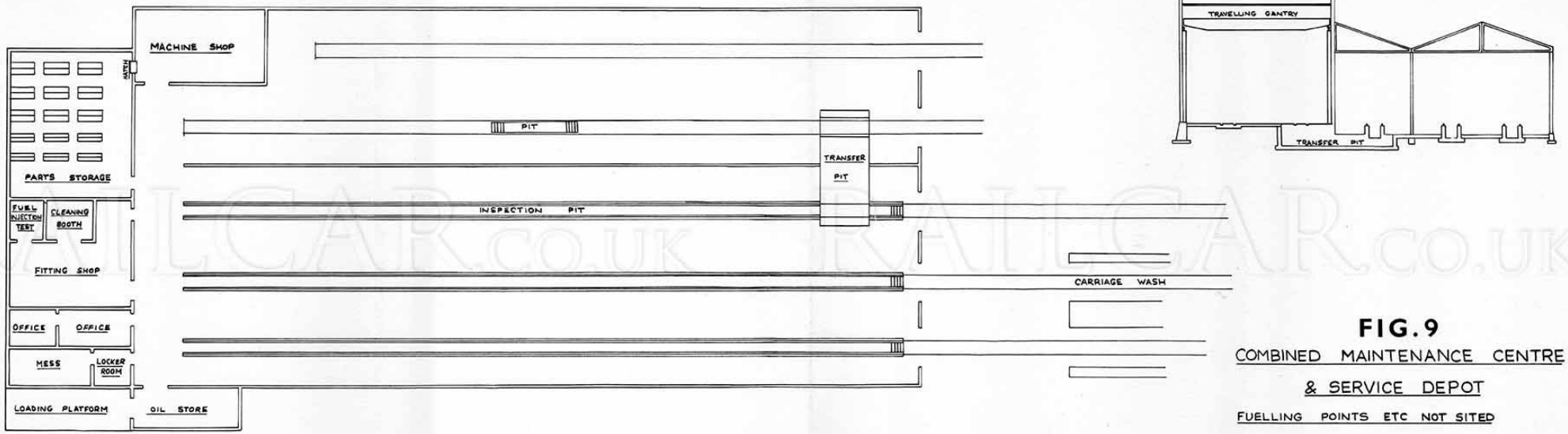

FIG. 9

COMBINED MAINTENANCE CENTRE & SERVICE DEPOT

FUELLING POINTS ETC NOT SITED

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PART III - MAINTENANCE AND MAINTENANCE DEPOTS

50. The maintenance centres which would normally undertake mileage examinations and light repairs should be of similar lay-out to that shown in Figure 12 and the staff on these centres will be mainly responsible for undertaking operations "D", "E" and "F" (see further paragraphs of these notes), as well as being called upon to carry out the duties tabulated in Operations "A", "B", "X" and "C".

51. These premises should have a glazed roof of modern factory type, preferably with north lights and maximum possible window space provided. Horizontal folding doors as opposed to the roller type have been found less vulnerable to damage, and they should be of fire-proof pattern, power-operated if possible. A problem exists regarding the damage to structural work, steel or concrete through the medium of diesel exhausts, and one answer to this is the provision of exhaust trunking with flexible connections for coupling to the exhaust pipes of the diesels. A more costly but efficient method is the installation of air-conditioning. The floor of a maintenance centre should be of dust-free concrete or asphalt, sloped gently to permit hosing down.

52. All pits and service roads should be served by water, compressed air and electric power with frequent outlets. Compressed air connections must be made available for cleaning and for pneumatic tools and at frequent intervals plug points should be provided for inspection leads.

53. Fuel-oil facilities should be provided from a separate bulk storage fuel-oil station linked with a pump-house employing centrifugal purifiers. Lubrication arrangements should be such as to reduce to a minimum the labour and time involved. It is important that water and fuel points be so located that no excessively long hoses are called for. Such items create a danger to personnel, and are quickly damaged.

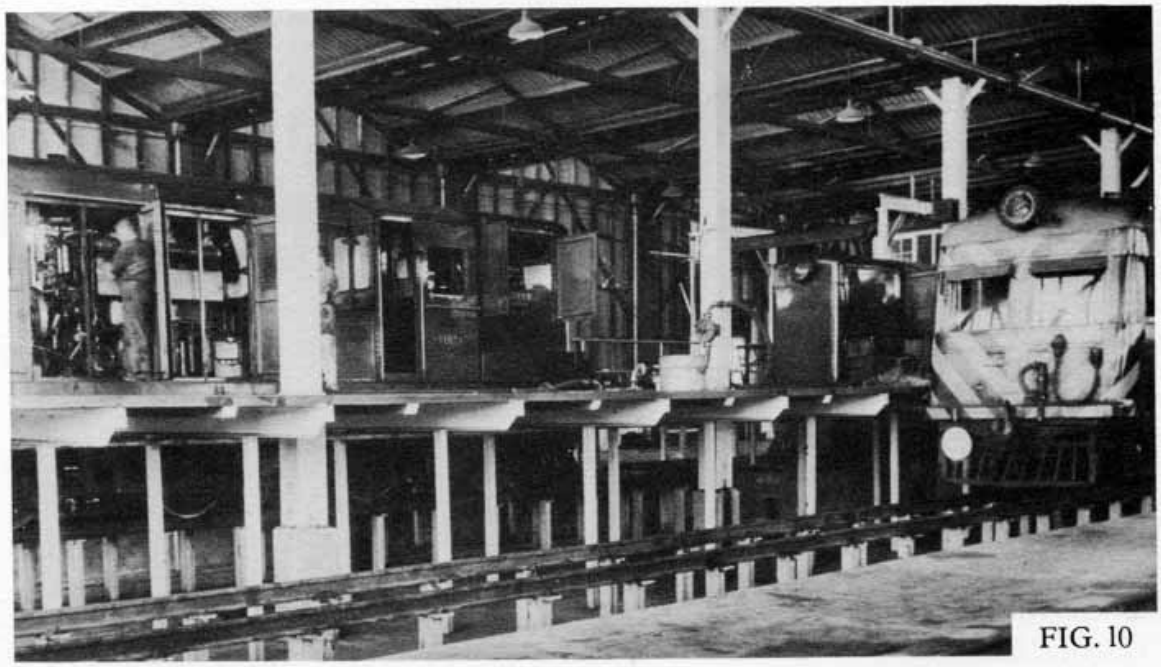


FIG. 10

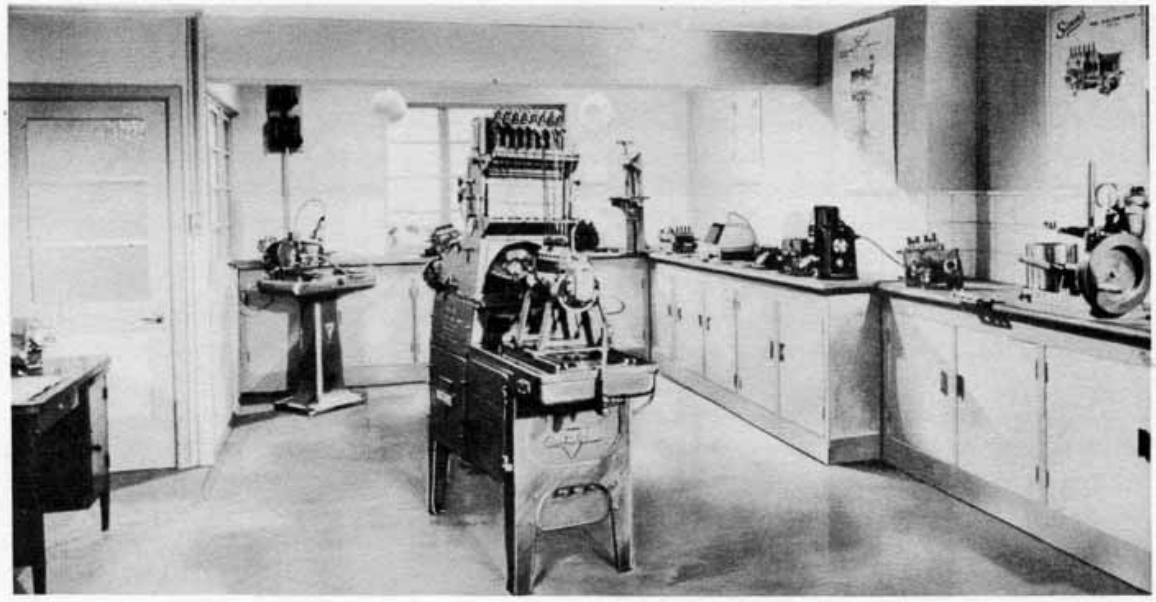
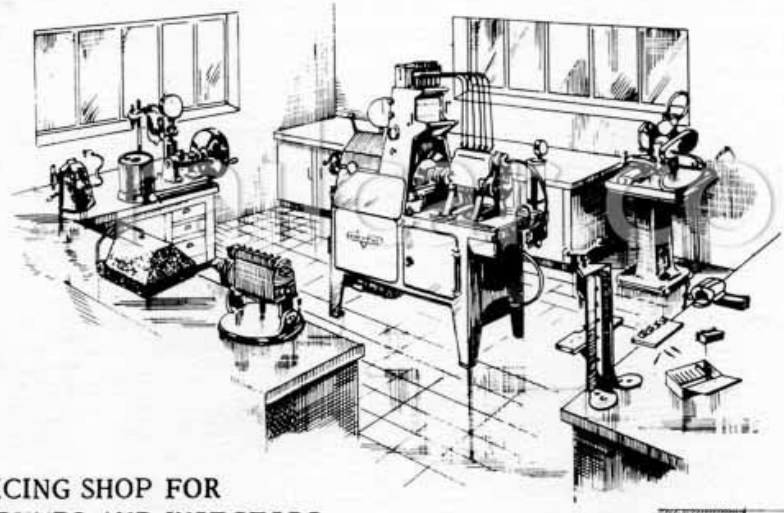
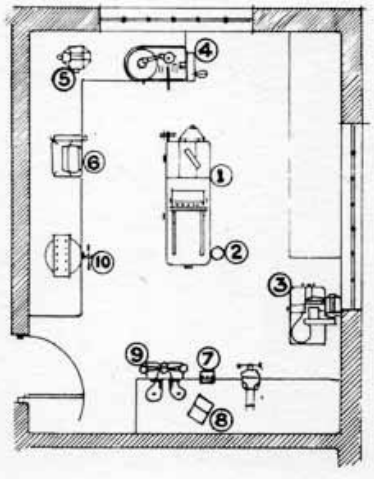


Fig. 11. A typical fuel injection shop.



SERVICING SHOP FOR
FUEL PUMPS AND INJECTORS



1. Test Bench with Accessories.
2. Feed Pump Tester.
3. Nozzle Grinding & Lapping Machine.
4. Bench Nozzle Tester.
5. Universal Nozzle Microscope.
6. Nozzle Pressure Cleaning Cabinet.
7. Nozzle Dismantling Jig.
8. Injector Cleaning Kit.
9. Puller Press.
10. Fuel Pump Vice.

54. As shown in Figure 12 a washing plant, which will be easy of access by all trains, must be included, consisting of a well-drained floor, accommodating a wash rack fitted with facilities providing a hot cleaning solution under pressure for under-frame equipment, together with revolving leathers at either end.

55. Other ancillary equipment includes an incinerator for disposal of rubbish and a degreasing outfit which should adjoin the workshop and where small components can be loaded into metal baskets during the process of degreasing. A battery shop, so arranged as to connect directly with the workshop, is provided and this with the degreasing plant should be equipped with an independent ventilation system.

56. Generally, the length of the premises will be such as to accommodate a complete multiple-unit train of whatever maximum length is used in general service, and thus avoid unnecessary uncoupling.

57. Shadowless lighting for night operations should be installed both in the main shop at various levels, and the pits. Rails should be carried on pre-stressed concrete piers or girders to enable traction equipment to be worked on at eye level, but provision must also be made through the means of rail-level floors for the removal of engines. As illustrated in Figure 10 open pits and a sunken floor, together with elevated platforms at passenger-platform level, are an ideal arrangement for diesel m.u. trains and locomotives. The Superintendent's or Foreman's office can be elevated above the highest working level. Thus providing a full view of all workshop activities.

58. The fuel injection shop at this particular maintenance centre is arranged so as to service the whole range of injection equipment, including injection pumps, lift pumps and injectors (see Figure 11). Throughout the premises each fitter and electrician has his own bench with adequate working space.

MILEAGE EXAMINATIONS

59. In these notes the term "Maintenance" is used to describe all work necessary apart from daily service and overhauls. To ensure satisfactory operation of diesel mechanical traction equipment, it is considered essential that operational maintenance as well as major repairs should be administered from one source only. A maintenance scheme based on divided authority invariably results in incompetence, bottle-necks and obstruction.

60. The reliability of a diesel railcar is now almost entirely a question of efficient preventive-maintenance, which must be more thorough than that accorded to the steam locomotive and must be schemed so that it can be varied in the light of operating conditions and subsequent experience.

61. Maintenance operations which take place between overhauls will include the items mentioned later, and it must be borne in mind throughout these notes that items of non-B.U.T. supply (e.g. Code Lamps, Interior Lights, Combustion Heaters, etc.) are not included in the schedules.

62. New cars entering service for the first time need to have an extra operation carried out after the initial 1,000 miles has been run, and this operation also applies to cars which have been overhauled at Main Works.

OPERATION X (After initial 1,000 miles)

Job No.	Unit	Description
X1	Engines	Tighten down cylinder heads and adjust valve clearances.
X2	Lub.-Oil System	
X5	Injection Equipt.	
X8	Gearboxes	Drain and refill with fresh oil
X9	Final Drives	Drain and refill with fresh oil

63. It should be appreciated that all tasks tabulated in the mileage examinations must be conscientiously carried out, and the success of each operation is entirely dependent on the human factor. Consequently, the influence of skilled supervision is necessary at all times.

64. The first of the normal mileage examinations, Operation 'C' is as follows:-

OPERATION C (at 3,000 mile intervals)

Job No.	Unit	Description
C1	Engines	Clean oil-bath air cleaners. Lubricate controls, clevis pins, etc.
C2	Lub.-Oil System	Thoroughly examine all connections for leakage and rectify where necessary.
C3	Cooling Systems	Thoroughly inspect for leaks all hoses and connections. Ensure effectiveness of anti-freeze during Winter.
C4	Fuel System	Clean all filters and change elements where necessary, (except paper element type filters - which should be changed at not less than 12,000 miles). Thoroughly examine for leaks at connections and pipe lines.
C5	Injection Equipt.	Run engines and test injectors by cutting out each one individually.
C6	Aux. Drives	Lubricate. Examine thoroughly, adjust belt tensions. Test tightness of coupling bolts and security of locking devices.
C7	Fluid Couplings	Examine for leakage from bellows-glands and periphery joints. Make good loss of oil.
C8	Gearboxes	Drain off water.

Job No.	Unit	Description
C9	Final Drives	Check oil level.
C10	Trans. Shafts	Examine shafts, couplings and bolts thoroughly.
C11	Air System	Make thorough examination of all connections for leakage. Examine anti-freeze unit when in use and top up as necessary.
C12	Vac. System	Examine the vacuum separator oil level and top up as required.
C13	Electrical	Examine jumper connections for damage and looseness at pins and sockets Test starter motor connections and ensure tightness. Test water alarm devices.

65. At every 6,000 miles the following operation - 'D' - should be carried out, and it should be noted that in addition to this particular schedule all tasks in Operation 'C' should be included, as the latter fall due concurrently.

OPERATION D (At 6,000 mile intervals)

Note: Also carry out Operations C1 to C13 inclusive.

Job No.	Unit	Description
D1	Engines	Thoroughly wash down; Test cylinder-head nuts (and jack-nuts where fitted) with torsion wrench; Adjust valve clearances, check valve operating gear, thimbles, cotters and lubrication of rockers; ensure that valve covers and sump nuts are tight; start engine and examine exhaust for excessive smoke.
D2	Lub.-Oil System	Change oil, change filter elements, clean centrifugal type. Run engine at fast-idle for 5 minutes then, with engine stopped re-check oil level and top-up to FULL MARK on the dipstick.
D3	Cooling Systems	Examine radiators, clean elements externally; ensure air-ducting and screens are free of obstruction.
D4	Fuel System	Examine fuel lift-pump, suction, delivery and return lines for leaks and tightness at unions.

Job No.	Unit	Description
D5	Injection Equipt.	Examine injector dribble pipes and gallery for tightness and leaks; Examine injection pump control levers, pins and nuts.
D6	Aux. Drives	(Carry out operation C6).
D7	Fluid Couplings	(Carry out operation C7).
D8	Gearboxes	Examine suspension, pins and nuts.
D9	Final Drives	Examine torque-arm suspension, pins, nuts and locking devices.
D9 D10	Trans. Shafts	Check for play, lubricate couplings and splines.
D11	Air System	Lubricate throttle motors, check tightness of unions. Examine and clean delivery, reducing and unloader valves. Change unloader and divertor valve-felts if necessary.
D12	Vac. System	Examine thoroughly all connections for leaks.
D13	Electrical	Examine level of battery electrolyte and top-up if necessary; Clean batteries; Vaseline battery terminals.

66. At 12,000 mile intervals Operation 'E' should be carried out and the following work is included;

OPERATION E (At 12,000 mile intervals)

Note: Carry out Operations C1 to C13 and D1 to D13 inclusive at the same time.

Job No.	Unit	Description
E1	Engines	Test tightness of exhaust manifold holding-down nuts. Check exhaust pipes and silencers for leaks.
E2	Lub.-Oil System	Adjust oil pressure if necessary, with engine hot.
E3	Cooling System	Examine all drain-cocks for blockages.
E4	Fuel System	Test fuel-tank supports to ensure tightness. Examine fuel-tanks for leaks and filler caps for oversplash. Change paper-element filters.

Job No.	Unit	Description
E5	Injection Equipt.	Tighten injection pump holding-down bolts. Ensure that injection pump seals are intact. Test tightness of injection pump couplings and if slack, re-time pump. Test each injector and change if necessary.
E6	Aux. Drives	Thoroughly examine all belt drives and change belts if necessary.
E7	Fluid Couplings	Examine starter ring-gear teeth for wear.
E8	Gearboxes	Clean breather assembly.
E9	Final Drives	Test tightness of gland lock-nuts and banjo bolts; Examine air cylinder for leaks and clearances of reversing dogs.
E10	Trans. Shafts	(Carry out operation C10).
E11	Air System	Examine and clean compressor air filters and delivery valves.
E12	Vac. System	Drain excess oil from separator and clean filters.
E13	Electrical	Examine starter motor pinions for wear. Examine control relays, E.P. valves and ensure that control switch gear contacts are mating.

67. Operation 'F' is scheduled to be undertaken at intervals of 36,000 miles, and consists of the following tasks:

OPERATION F (at 36,000 mile intervals)

Note: In addition carry out tasks tabulated in Operations C1 - C13, D1 - D13 and E1 - E13 inclusive.

Job No.	Unit	Description
F1	Engines	Examine engine suspension thoroughly.
F2	Lub.-Oil System	Remove sump and oil grids, clean and replace.
F3	Cooling System	Steam out radiators.
F4	Fuel System	(Carry out Jobs C4, D4 and E4).
F5	Injection Equipt.	Change injectors.
F6	Aux. Drives	(Carry out Operations C6 and E6).

Job No.	Unit	Description
F7	Fluid Couplings	(Carry out operations C7 and E7).
F8	Gearboxes	Change oil. Examine band-linings for wear.
F9	Final Drives	Change oil. Examine operating cylinders and pistons; inspect axles.
F10	Trans. Shafts	(Carry out operations C10 and D10).
F11	Air System	(Carry out operations C11, D11 and E11).
F12	Vac. System	Change oil in exhauster reservoirs.
F13	Electrical	Clean all contacts. Check all fuses, switches and leads for insulation and contact. Clean generator and starter motor commutators and brush gear; renew brushes if necessary. Lubricate bearings. Oil starter pinion. Examine and check oil-pressure switches.

UNIT CHANGES

68. Providing unit re-conditioning facilities and arrangements are available, a scheme of unit changes can be initiated and will result in considerable saving of time. The provision of re-conditioned units may be arranged direct from the equipment manufacturers or through the medium of unit re-conditioning workshops, which can in themselves be an integral part of the Overhaul Shops (see Parts III and IV of these notes). It is possible to extend periods between major repairs if an efficient unit change scheme is in operation.

69. Units which can be included in the replacement operation are:-

(a) Engines, complete with fluid-coupling
(b) Cylinder heads
(c) Fuel-injection pumps
(d) Water circulating pumps
(e) Starter motors
(f) Generators
(g) Gearboxes
(h) Compressors
(i) Exhausters
(j) Final-drives
(k) Propellor shafts.

70. In order that such a scheme may be effective adequate provisioning of spare units must be instituted, not only to ensure rapid despatch of re-conditioned units to particular depots or maintenance centres, but to make certain that the unit re-conditioning staff at the Main Workshops are constantly and economically employed. This unit change system can be inaugurated between a Main Works and a Maintenance Depot, or between Main Works and a Maintenance Depot and Service Centre combined. Alternatively, diesel cars can be returned to Main Works for unit changes to be effected.

71. Cylinder heads are an item which, if consistently available, will conserve both time and labour that would otherwise be expended on top-overhaul operations. The effect is to bring this type of work to the point where an assembly of skilled labour and specialised equipment is available.

72. Special attention must be paid to the packing and protection of exchange-units for transport. For example, cylinder head faces must be adequately protected, so that they do not come into contact with materials which might cause damage. Engines and gearboxes should be "packaged" and minor components placed in small containers packed within the larger. Starters, injection-pumps, dynamos, etc., should never be sent loose and it is as well to remember that railway practice of sending unprotected components by passenger train must be avoided. For instance, it is normal for steam loco. spares to be despatched open in the brake-van of a train without ill effect, but diesel equipment can be easily damaged in this way, and a system of careful packing must be introduced from the beginning.

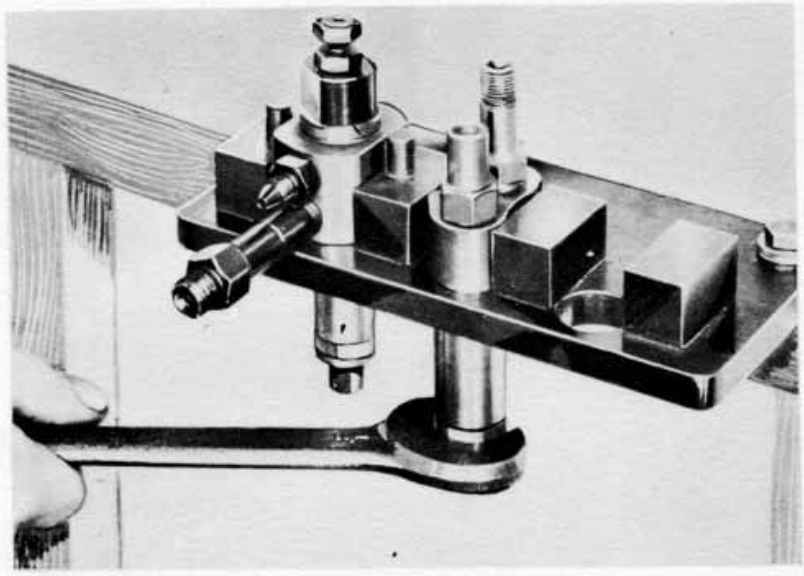


Fig. 11 (A) Bench jig for dismantling fuel injector nozzles. (See Fig. 11, item 7)

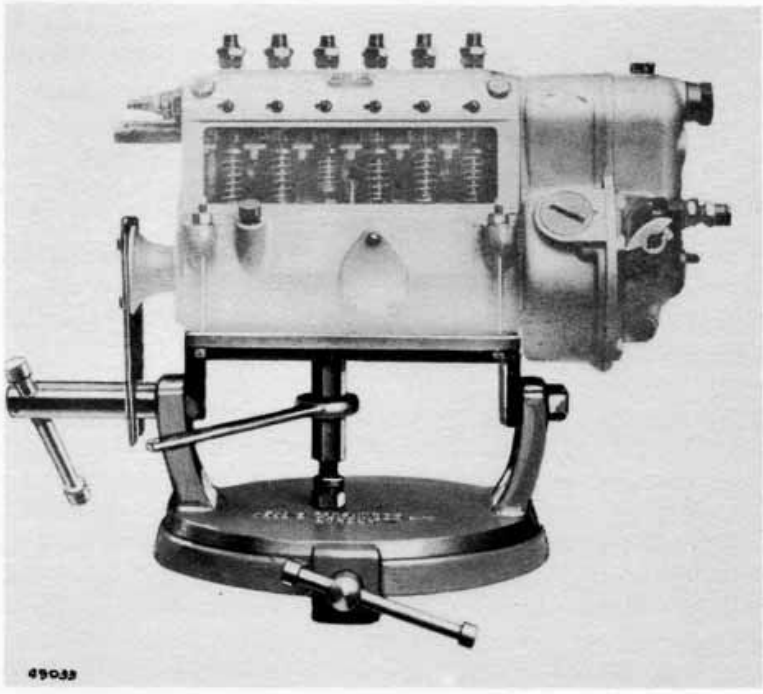


Fig. 11 (B) Bench vice for Fuel injection pump. (See Fig. 11, item 10)

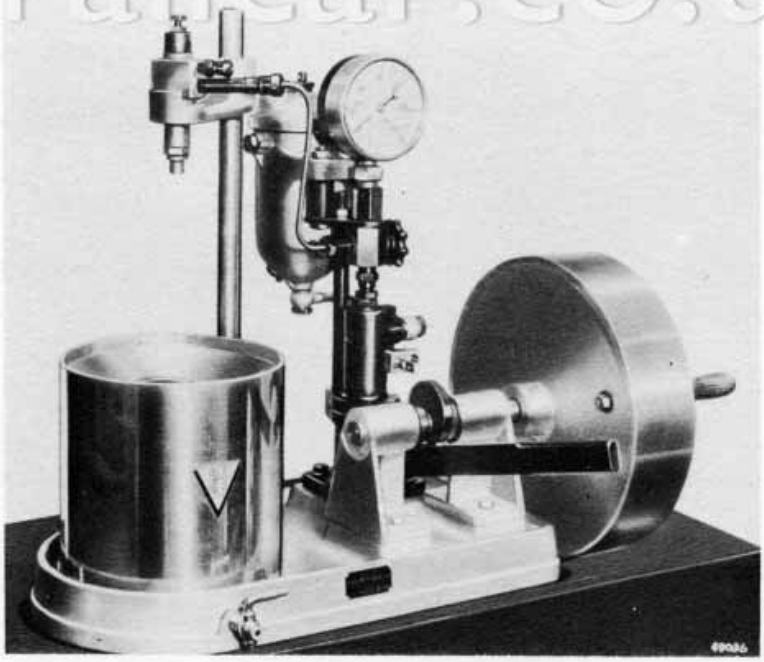
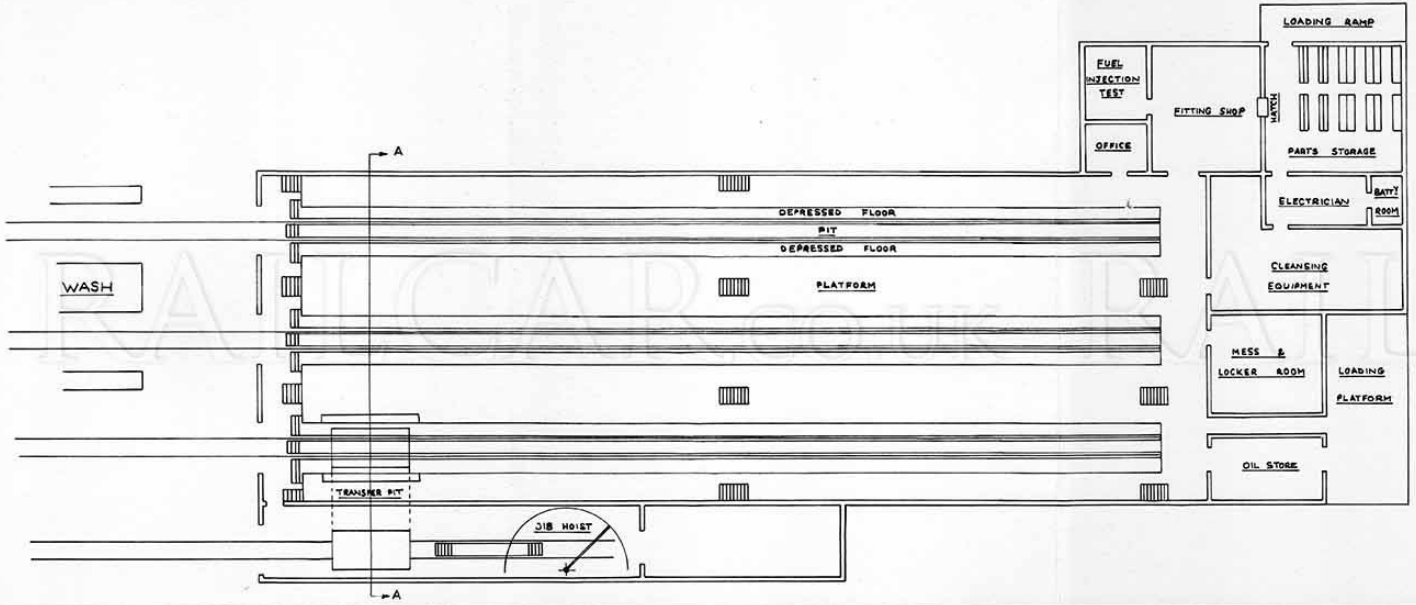
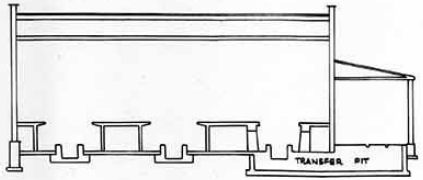


Fig. 11 (C) Bench Injector Nozzle Tester (See Fig. 11, item 4)

FIG.12
MAINTENANCE CENTRE OF THREE-LEVEL TYPE





SECTION AA

FIG. 12

MAINTENANCE CENTRE OF THREE-LEVEL TYPE

FUELLING POINTS ETC, NOT SITED

A.E.D. 1-8-56

PART IV - OVERHAUL AND MAIN WORKS

73. It is our practice to determine the life of an engine for overhaul by crankshaft life. However, dependent on the provision of skilled staff, it may be necessary for overhaul to include what is a mileage-maintenance examination of cylinder-heads and pistons as part of the main programme.

74. The mileage of diesel railcars between major overhauls is generally determined by the condition of the engines, and as a rule these have had at least one Light Dock prior to the main overhaul. Only with increasing experience of operation and high standards of maintenance will it be possible to increase mileages between major overhauls.

75. It follows, therefore, that mileages between repairs must be assessed in the light of operating conditions prevailing and standard of maintenance achieved, and no firm figure can be arrived at other than through practical experience with a particular service. An approximate assessment of the mileage before the Intermediate Repair is undertaken could be 60,000 - 80,000 miles in normal service. For the purpose of these notes, however, major repairs will be divided into:-

(a) Top Overhaul and Light Dock. (60,000 - 80,000 miles approximately).

(b) Major Overhaul (at mileage determined from service experience).

76. Both Light Docks and Major Repairs should be carried out in the Main Works, in order that use may be made of the skilled artisans and extensive equipment provided and a more thorough as well as more speedy operation conducted with proper supervision.

INSPECTION

77. As far as the traction equipment is concerned, incoming diesels for overhaul must first pass through a rigid system of inspection following a thorough cleansing of all under-floor units. As a result of such examinations, Inspection Sheets will be completed and checked by the appropriate authority who will be responsible for formulating workshop instructions relative to each component. The individual in authority is also responsible for deciding whether a unit requires to be removed from the diesel car.

78. A pro-forma for an Inspection Report, applicable to Light Docks or Major Repairs, follows, and it will be observed that provision is made for separate reports for No.1 and No.2 side units of a power car. Entries will be made as each unit is examined. It may be desirable to use separate forms for each class of unit (engines, gearboxes, final drives, etc.) to fit in with workshop practice at particular overhaul centres.

INSPECTION REPORT

Diesel Traction Equipment Only

Diesel Car No. Date of Inspection 19

Unit	No.1 Side Report	Initials	No.2 Side Report	Initials
(a) Engine				
Serial Number				
Compression				
Rocker Gear				
Injectors				
Injector Studs				
Injector Pipes				
Oil Pressure				
Water Pump				
Suspension (Front)				
Suspension (Rear)				
Starter Motor				
Starter Ring Gear				
Fluid-Coupling				
Drive Belts				
Lift Pump				
Fuel Tanks				
Throttle Motor				
Air Cleaner				
(b) Radiator				
Core				
Pipes				
Hoses				
Thermostat				
Fan				
Fan shaft/s				
(c) Free Wheel Shaft				
Free Wheel				
Universals				
Splines				
(d) Gearbox				
Suspension				
Pistons				
Band 1				
Band 2				
Band 3				
Top Speed Clutch				

FIG.13

TYPICAL MAINTENANCE CENTRE

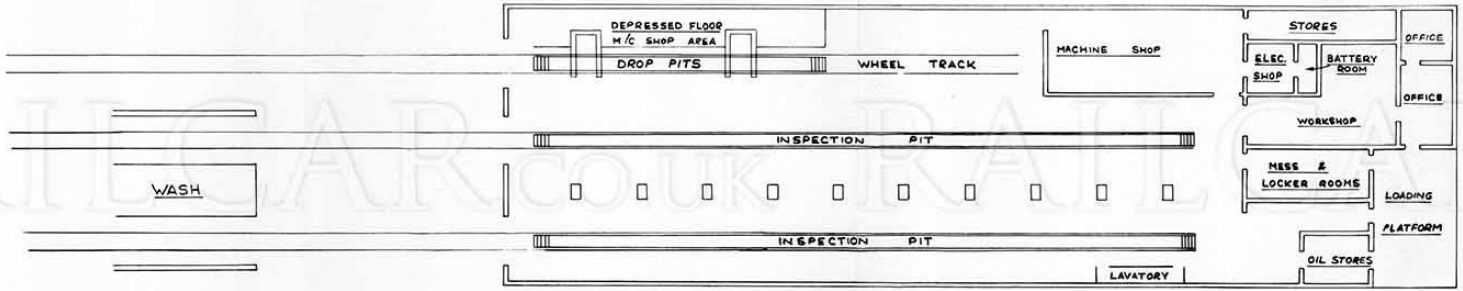


FIG. 13

TYPICAL

MAINTENANCE CENTRE

(WITH DROP PIT FACILITIES)

FUELLING POINTS, ETC. NOT SITED

AED 1.8.56

Unit	No.1 Side Report	Initials	No.2 Side Report	Initials
(e) Cardan Shafts Universals & Splines				
(f) Final Drive				
Gears				
Glands				
Reverse Mech.				
(g) Controls				
Throttle Motor				
Throttle Controller				
Gear Controller				
E.P. Valves				
Instruments				
(h) Auxiliaries				
Generator				
Exhauster				
Compressor				
Unloader V.				
Diverter V.				
Reducing Valve				
Belts				
Pulleys				
Tensioners				
Anti-freeze unit				
Tachometer				
(i) Warning Devices				
Fire Control				
Low Water				
Oil Pressure				
(j) Wiring				
Jumpers				
Jumper receptacles				
Switchgear				
Relays				
(k) Batteries				

Signature:

(Date)

79. Inspection Sheets must comprehensively cover all sections of the railcar in order that the Inspectors concerned may not overlook any point - each blank line having to be completed. Following the initial inspection which is applicable to Intermediate or Heavy Repairs, units sanctioned by the Superintendent will be removed and sent to the stores, and it is at this juncture that procedures are segregated.

TOP OVERHAUL & LIGHT DOCK

80. The extent to which a Light Dock is carried out will be governed by the unit-exchange work undertaken during the mileage prior to shopping - providing a unit-exchange scheme has been organised. On the assumption that no unit changes have taken place, the scheduled work for a Light Dock of traction equipment will be:-

OPERATION G (at mileage determined from experience - normally 60,000-80,000 miles.)

G1	Engine		Lift cylinder-heads. De-carbonise and
		x	grind in valves as per Service Manual. (Replace valves as necessary). Change cylinder-head gaskets. Record bore wear for each cylinder (maximum and at 1" from top).
		x	Change engine case (if necessary) or pistons and rings only; "L" type engines - change liners.
		x	Check water pump impellor and packing.
		x	Remove and clean engine base. Examine engine mountings and replace components if applicable.
G2	Lub.-Oil Systems	x	Check lub.-oil pump gears and drive. Check oil supply to rockers.
G3	Cooling Systems	x	Remove and clean radiators, internally and externally. Replace unserviceable hoses.
G4	Fuel System		Remove and clean tanks (internally and externally); examine and repair as required.
G5	Injection Equipt.	x	Change injection-pump complete with lift-pump. Change injectors.
G6	Aux. Drives		Change belts, pulleys and tensioner as called for in Inspection Report.
G7	Fluid Couplings		Carry out work called for in Report (e.g. glands).
G8	Gearboxes	x	Reline bands as necessary. Clean operating pistons and replace defective sealing-rings.

FIG.14

TYPICAL MAIN WORKS FOR DIESEL MULTIPLE-UNIT TRAINS

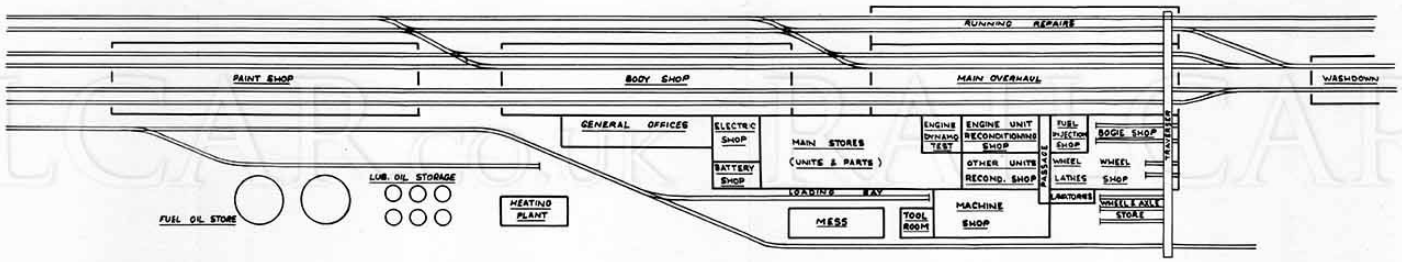


FIG. 14

TYPICAL MAIN WORKS

FOR DIESEL MULTIPLE UNIT TRAINS

A.E.D. 4.9.56.

OPERATION G

G9	Final drives		Replace worn components (e.g. axle oil seals), according to Report.
G10	Trans shafts		Replace any loose bolts, missing split-pins, etc., as tabulated in Inspection Report.
G11	Air System	x	Change compressor units if reported. Change defective E.P. valves. Check air connection unions. Replace worn drive belts. Change unloader and diverter valves if reported.
G12	Vacuum system	x	Change exhauster units if applicable. Replace worn drive-belts.
G13	Electrical	x	Change generators and starter motors as required by Inspection Report.

x Components for which reconditioned units should be available from stock.

MAJOR OVERHAUL

81. Heavy repairs whilst more extensive follow the same general procedure laid down for Light Docking, and at this stage it is usual for any modifications found necessary in the light of operating experience to be carried out. After initial inspection (see para. 77) the traction equipment should be removed and overhauled in accordance with the manufacturer's recommended procedure (see Service Manual), although a considerable proportion of the work should be dealt with by means of exchange units drawn from the Unit Stores. Upon arrival of a diesel car at main works the following action by the staff should be undertaken:-

(a) Remove tool kit, keys, flags, detonators etc., check and store. Remove all inspection panels, seats and floor traps and after checking pass to Stores. Clean car in preparation for entry into main works.

(b) Drain cooling system. Drain oil from engines, separators, gearboxes and final drives.

(c) Remove engines (see Fig. 15), gearboxes, exhausters, compressors, throttle motors, vacuum separators, silencers, cardan shafts, air pressure switches, control boxes, fuses, E.P. valves, generators, starter motors and batteries.

(d) Lift Railcar and remove bogies. Examine all connections and wires, driver's control units and clean all components, remove all metal dust and dirt, check cams for wear, change worn out springs.

(e) Overhaul fan assemblies; examine all air pipes.

(f) Cardan Shafts. Clean units, check for true running and wear, change worn components.

(g) Engines. Overhaul engine in accordance with B.U.T. Manual. (see Fig.16)

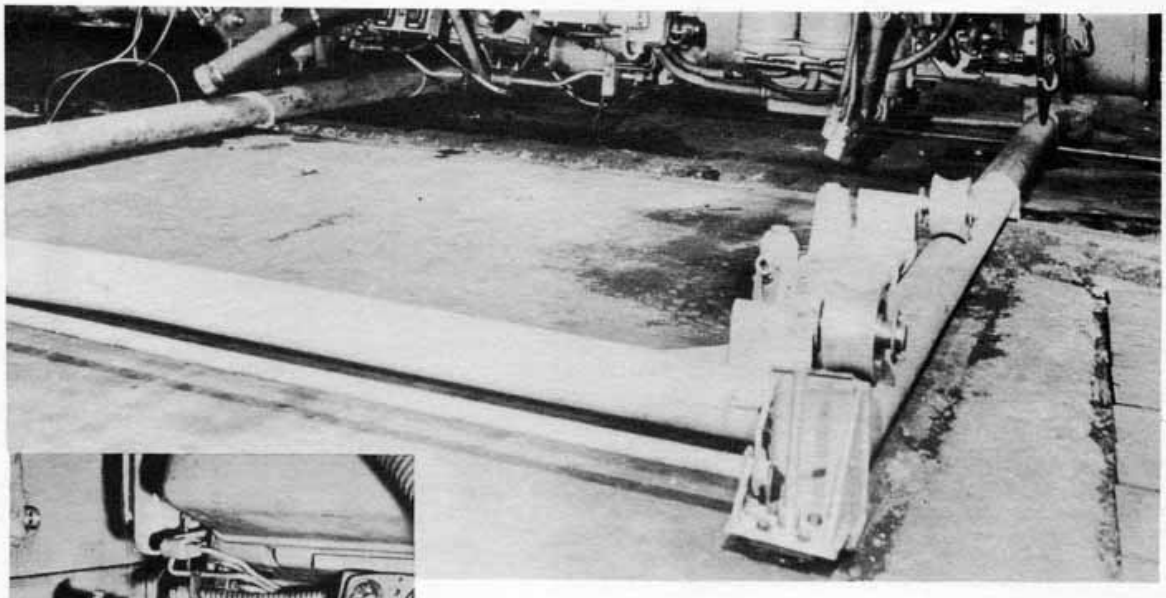
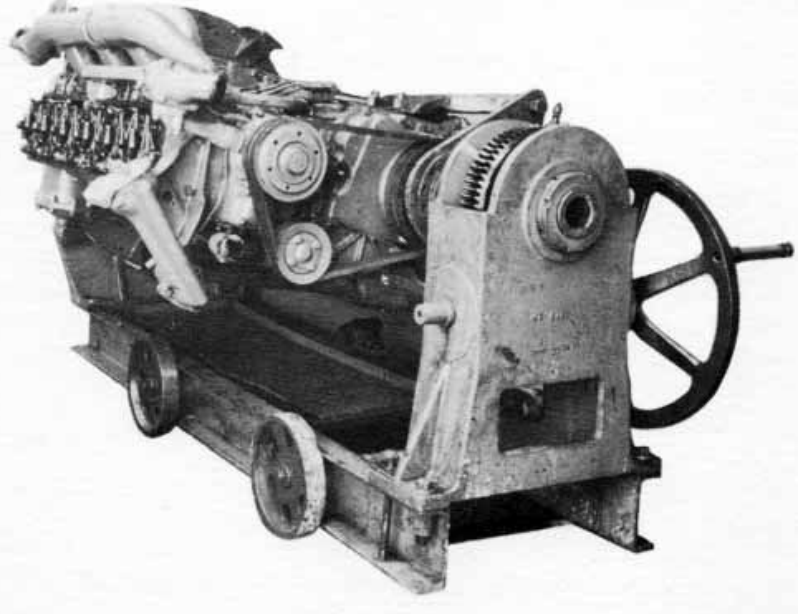


Fig. 15. Illustrating method of removing horizontal diesel engine by means of hydraulic-jack fitted trolley.

Fig. 16. Engine mounted in universal engine stand to facilitate overhaul.



(h) Gearboxes. Clean thoroughly. Overhaul in accordance with B.U.T. Manual. Change all badly worn mounting rubbers.

(i) Vacuum System Clean units, dismantle exhausters, examine blades, races and bore, change seals, strip all valves, clean and reseat. Change worn driving belts.

(j) Air System. Clean units, dismantle compressors, examine valves, piston rings, bearings and oil seals. Change worn components and reassemble. Blow out all air pipes, change worn driving belts.

(k) Throttle Motors. Strip and clean, examine bores, fit new piston seals. Reassemble and ensure that spring returns all pistons on early types. Change all leaking lubricators. Bench test before refitting to the Railcar, using the complete set of E.P. valves from the car in question.

(l) Oil Separators. Clean units, strip and thoroughly clean all filters and pipes, reassemble.

(m) Silencers and Exhaust Trunking. Examine silencers for cracks and loose baffles. Change silencers complete if the case is too thin. Change any broken studs, change or repair any damaged trunking.

(n) Control Panels. Clean all dust from back, clean terminals and replace. Fuses:- Clean all contacts and examine for discolouration, reassemble.

(o) E.P. Valves. Strip, clean, check valve seats, change defective joints. Reshellac windings (the E.P. valve manufacturer's have special test rigs and settings).

(p) Generators and Starter Motors. Service in accordance with the manufacturer's Manual.

(q) Final Drives. Dismantle driving shaft, examine races and change if worn or noisy. Examine gear teeth, shafts, clean breathers, change forward and reverse piston cup washers, check forward and reverse action. Check striking fork for wear and replace if necessary.

(r) Replace all units and bogies on Railcar.

(s) Fill all units with oil, water etc., rectify all leaks.
Charge air system and rectify air leaks.
Check function of pneumatic and electrical controls.

(t) Start engines and ensure that each engine component is working correctly i.e. water pump, lubricating oil pump, fuel injection pump, controls etc. Check and correct vacuum leaks. Run engine for approximately four hours then tighten cylinder head holding down nuts and re-adjust valve clearances.
Carry out static test of gearbox operation.

(u) Couple Railcar in multiple with another unit and re-check all controls.

(v) Undertake trial run and ensure that each engine and transmission is performing correctly by isolating each side alternatively. Rectify all defects discovered on intial trial.

(w) Carry out final road trials. Rectify further defects if any, and pass Railcar to paint shop.

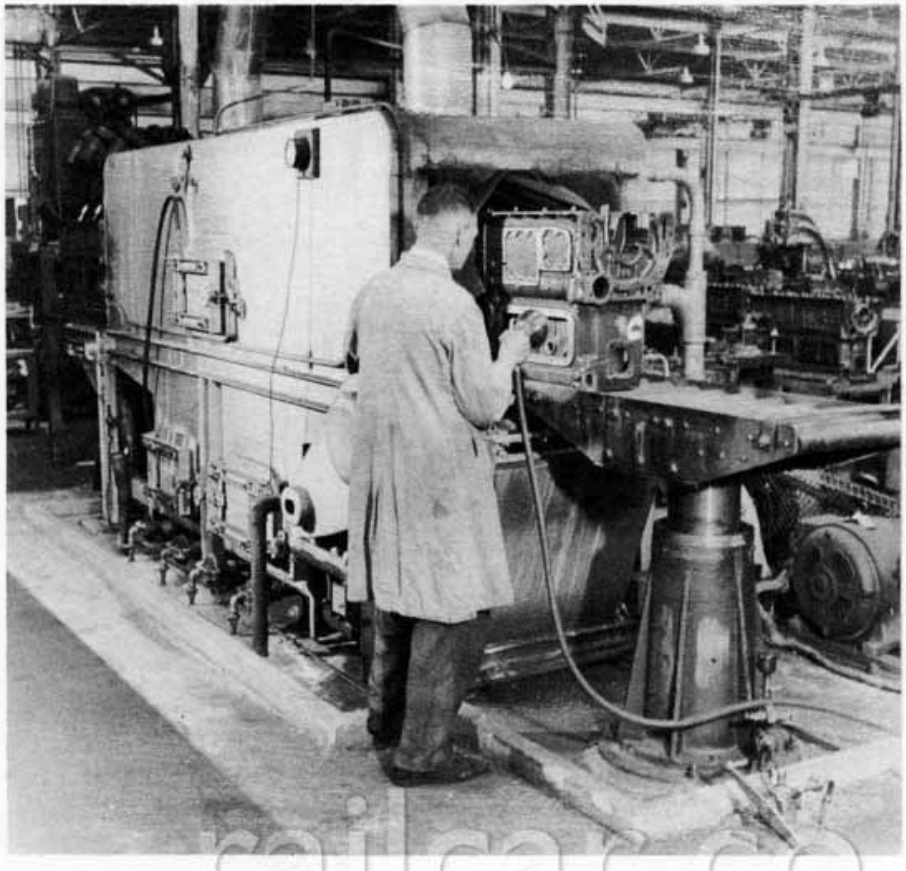


Fig. 17. Engine Block passing through cleaning plant (see para. 83)

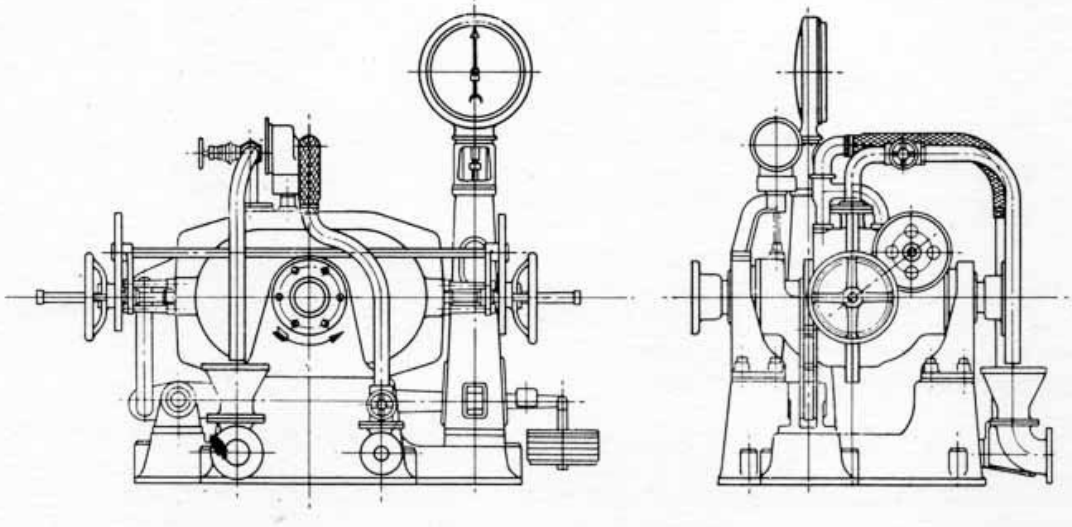


Fig. 18. Side and end arrangements of engine dynomometer. (Froude Patent)

82. It will be appreciated that the work tabulated above will, where the system is functioning, be divided among the various unit shops, but emphasis is placed on the fact that the whole operation can be expedited if exchange units are available to the shop staff.

83. In order to demonstrate the method by which a defective unit removed from a car should be passed through a main works organisation, the following example is quoted.

A defective engine unit having been returned to the reception side of the Stores will be passed to the engine unit shop where it will enter the cleaning section, there it is dismantled and the components cleaned by steam or chemical cleanser. The various components are placed in wire baskets and sent to the respective sub-sections dealing with them, a chargeman undertaking minor unit and the sub-assembly inspection (e.g. cylinder heads, water pump, fuel injection pump, starter motor etc.). The engine case and crankshaft will then be measured for wear, and if outside the limits laid down the crankshaft will be sent for regrinding, in addition the crankshaft will receive a magnetic flaw detection test.

For engine re-assembly a simple construction line should be used whereby the bare engine-case starts at one end of the line and progresses to the other end on a wheeled trolley, reconditioned components lying on the supply benches en route, being added, as it proceeds (see Fig. 16).

Each minor unit, (e.g. water circulating pumps, fuel lift pumps), should be tested on special rigs after repair, but in many instances it will be found that the wear experienced is so slight as to entail little more than cleaning and re-adjustment.

All cylinder heads should be stripped out in the appropriate section, and these items will by hydraulically tested for cracks and fissures. Valve springs should be tested for deflection under load and if outside the maker's limits scrapped.

84. After assembly the engine should be transferred to the Engine Test Shop where a dynamometer test should be carried out (note:- procedure given is a typical one, but different units may call for varied tests).

(a) 60 minutes motoring.

(b) 60 minutes fuel and light load.

(c) Check for cylinder head tightness, tappets, oil leaks, adjustment etc.

(d) Power test at 800 r.p.m. for 10 minutes.

(e) Power test at 1,000 r.p.m. for 10 minutes.

(f) Power test at 1,350 r.p.m. for 10 minutes.

(g) Power test at 1,700 r.p.m. for 10 minutes.

(h) Power test at 1,800 r.p.m. for 10 minutes.

(i) Check cylinder heads and tappets etc.

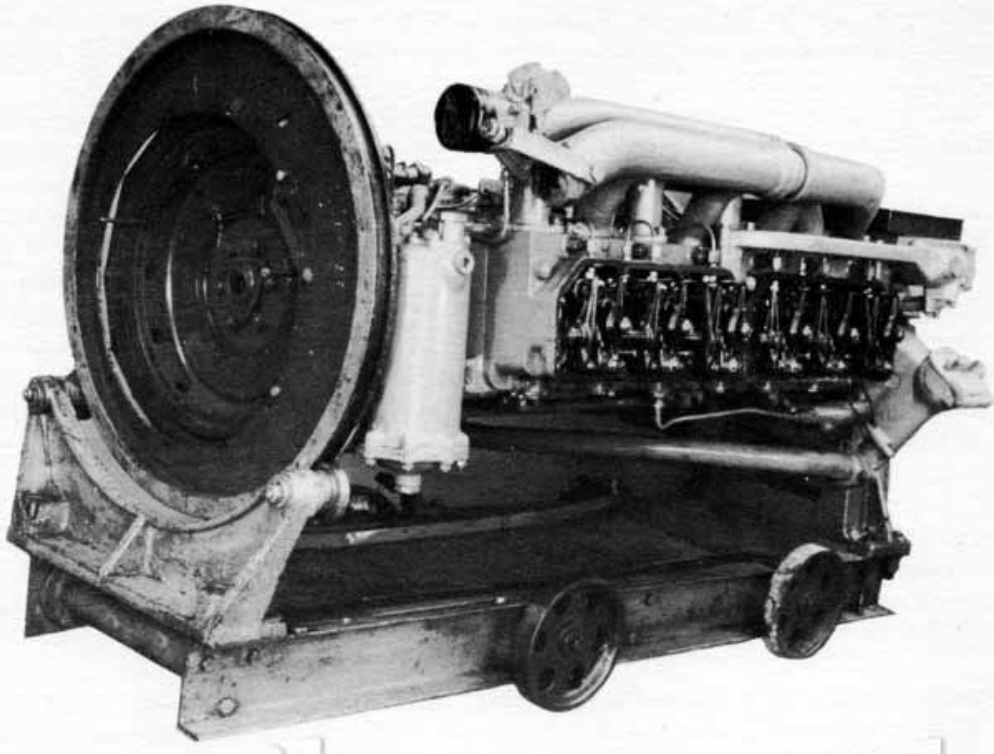


Fig. 19. Diesel engine mounted in Universal engine stand (opposite view to that shown in Fig. 16)

Fig. 20. Gearbox assembly stand with baseplate and brake-band gear in position.

Fig. 21. Special equipment used for assembly of gearbox running gear.

WORKSHOP EQUIPMENT

85. The following items of workshop equipment are desirable at main works, but these items will vary according to the size and nature of the works and in view of the fact that certain equipment already in existence may be utilised.

1. Universal Engine Stand.
2. Degreasing tank.
3. Degreasing baskets together with pulley block and runway.
4. Boxes and racks for broken-down components.
5. Engine crankshaft grinding machine.
6. * Engine connecting rod boring machine.
7. General purpose hydraulic press.
8. Engine cylinder honing machine and equipment.
9. Injector grinding and lapping machine.
10. Engine valve refacing machine.
11. Engine valve-seat grinding machine.
12. Engine valve-seat boring and screwing machine.
13. Valve-spring testing machine.
14. Hand-tools for fuel pumps and injectors.
15. Fuel injection-pump test bench.
16. Dynamometer test bench and equipment.
17. Vertical milling machine.
18. Radial drill.

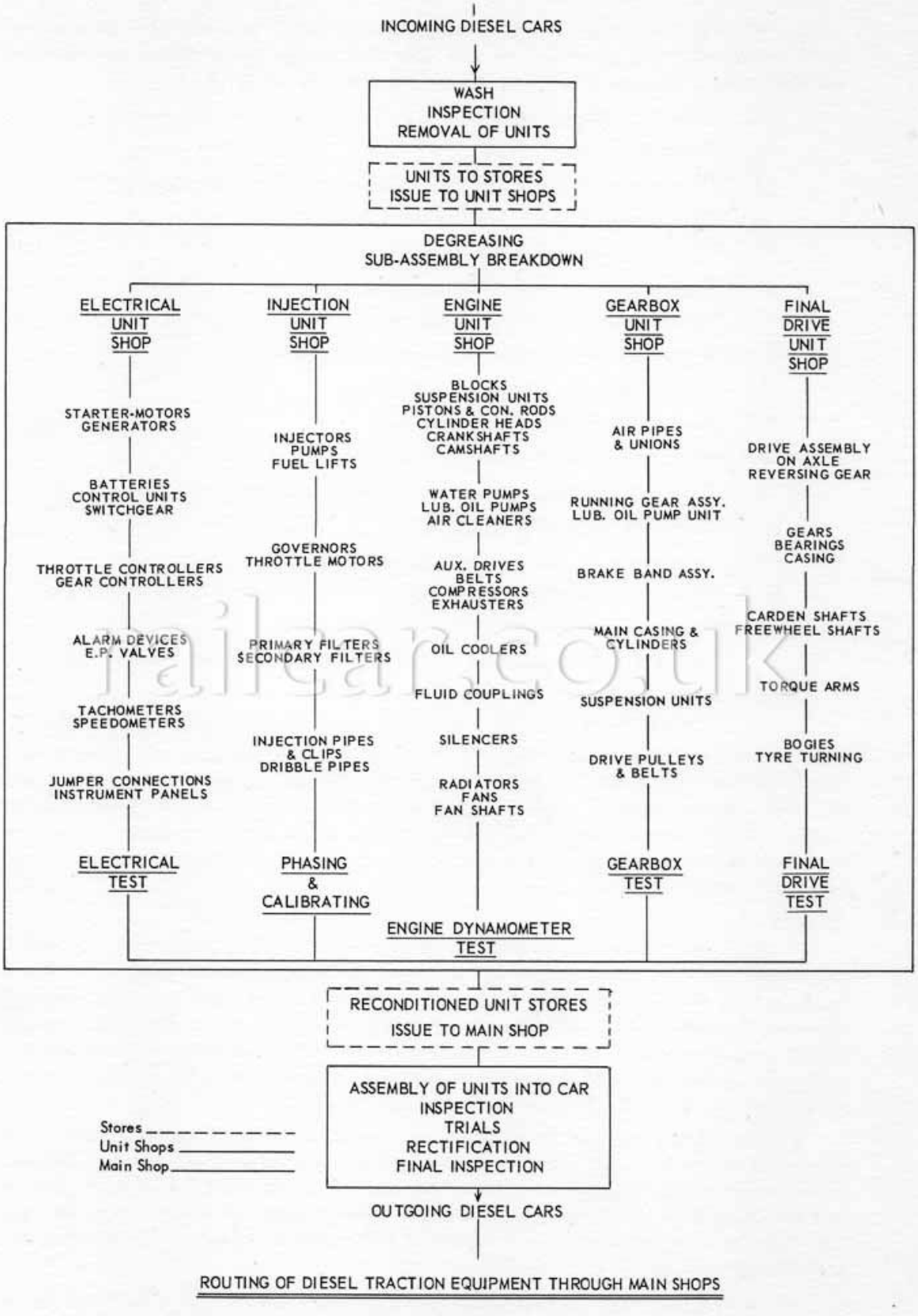
* This item only required if certain types of engines are dealt with.

86. Following light docking or major overhaul diesel cars returned to service should receive Operation 'X' at the responsible Service or Maintenance Depot (see para. 62). This operation takes place at 1,000 miles and a target to this effect should be displayed on the railcar when it has completed the main works schedule. In addition it is important that relative documents sent to the Motive Power Superintendent concerned be endorsed accordingly.

STAFF

87. Generally speaking railways have had little opportunity to train staff in the maintenance of high speed diesel engines and allied transmission equipment. Where training facilities are available it is essential that they be developed to a high degree and all classes of artisan staff given adequate training. A week or a few days spent at a training school is quite insufficient and experience has shown that often an outstanding mechanic lacks the ability to impart knowledge to others. The initiation of individual certificates of competency is highly desirable.

88. The emphasis of all training should be on fault diagnosis for in this way more than any other, can time be saved, and failures in service avoided. Before diesel units are introduced in an area a power car should be provided for instructional purposes and the interior be given over to sectioned-units, charts and wiring diagrams. Such railcars must be kept constantly up to date and will serve to introduce mechanical, electrical and driving staff to the new form of traction.



ROUTING OF DIESEL TRACTION EQUIPMENT THROUGH MAIN SHOPS

FIG.22

MASTER MAINTENANCE SCHEDULE

MASTER MAINTENANCE SCHEDULE.

FIG. 22

JOB Nº	UNIT.	(A) DAILY.	(B) DAILY.	(X) INITIAL 1000 MILES.	(C) EVERY 3000 MILES.	(D) EVERY 6000 MILES.	(E) EVERY 12000 MILES.	(F) EVERY 36000 MILES.
1	ENGINES.	START AND ENSURE OPERATING CORRECTLY	CARRY OUT ATTENTION TO MINOR DEFECTS REPORTED BY ENGINEMEN.	TIGHTEN DOWN CYLINDER HEADS. ADJUST VALVE CLEARANCES.	CLEAN OIL-BATH AIR CLEANERS LUBRICATE CONTROLS, CLEVIS PINS, ETC.	THOROUGHLY WASH DOWN CHECK CYLINDER HEAD NUTS (& JACK NUTS WHERE FITTED) WITH TORQUE WRENCH ADJUST VALVE CLEARANCES, CHECK VALVE OPERATING GEAR, THIMBLES, COTTERS & LUBRICATION OF ROCKERS VALVE COVERS & SUMP NUTS FOR TIGHTNESS. START & CHECK FOR EXCESSIVE EXHAUST SMOKE.	CHECK EXHAUST MANIFOLD HOLDING DOWN NUTS. CHECK EXHAUST PIPES AND SILENCERS FOR LEAKS.	CHECK ENGINE SUSPENSION THOROUGHLY.
2	LUB. OIL SYSTEMS.	CHECK LEVELS IN SUMPS AND TOP UP IF NECESSARY.			THOROUGHLY EXAMINE ALL CONNECTIONS FOR LEAKAGE AND RECTIFY.	CHANGE OIL. CHANGE FILTER ELEMENTS (AND CLEAN CENTRIFUGAL TYPE.) RUN ENGINE AT FAST IDLE FOR 5 MINS, THEN, WITH ENGINE STOPPED RE-CHECK OIL LEVEL & TOP UP TO FULL MARK.	CHECK AND ADJUST OIL PRESSURE WITH ENGINE HOT.	REMOVE SUMP AND OIL GRIDS, CLEAN AND REPLACE.
3	COOLING SYSTEMS.	REPLENISH AS NECESSARY (USING ANTI-FREEZE IN CORRECT PROPORTION TO WATER, IN WINTER)			THOROUGHLY INSPECT AND CHECK FOR LEAKS ALL HOSES AND CONNECTIONS. CHECK ANTI-FREEZE DURING WINTER.	EXAMINE RADIATORS, CLEAN ELEMENTS EXTERNALLY: ENSURE DUCTING AND SCREENS ARE FREE OF OBSTRUCTION.	CHECK THAT ALL DRAIN COCKS ARE CLEAR.	STEAM OUT RADIATORS.
4	FUEL SYSTEM.	REPLENISH TANKS AS NECESSARY AND ENSURE FILLER CAPS ARE ADEQUATELY SECURED.			CLEAN ALL FILTERS AND CHANGE ELEMENTS IF NECESSARY (PAPER ELEMENTS ONLY- 12,000 MILES) THOROUGHLY EXAMINE FOR LEAKS AT CONNECTIONS AND PIPE LINES.	CHECK FUEL LIFT-PUMP, SUCTION, DELIVERY AND RETURN LINES FOR LEAKS AND TIGHTNESS OF UNIONS.	CHECK FUEL-TANK SUPPORTS. EXAMINE FUEL-TANKS FOR LEAKS AND FILLER CAPS FOR OVERSPLASH. CHANGE PAPER ELEMENT FUEL FILTERS.	CARRY OUT OPERATIONS C4, D4 & E4
5	INJECTION EQUIPMENT.				RUN ENGINES AND TEST INJECTORS, BY CUTTING OUT EACH ONE INDIVIDUALLY.	CHECK INJECTOR DRIBBLE PIPES AND GALLERY FOR TIGHTNESS AND LEAKS. EXAMINE INJECTION PUMP CONTROL LEVERS, PINS AND NUTS.	TIGHTEN INJECTION-PUMP HOLDING DOWN BOLTS: ENSURE INJECTION-PUMP SEALS ARE INTACT. CHECK INJECTION-PUMP COUPLINGS AND TIMING TEST EACH INJECTOR AND CHANGE IF NECESSARY.	CHANGE INJECTORS.
6	AUX. DRIVES.	CHECK BELTS ARE SOUND AND TENSION CORRECT.			LUBRICATE. EXAMINE THOROUGHLY. ADJUST BELT TENSIONS. CHECK TIGHTNESS OF COUPLING BOLTS AND SECURITY OF LOCKING DEVICES.	CARRY OUT OPERATION C6.	THOROUGHLY EXAMINE ALL DRIVES AND CHANGE BELTS IF NECESSARY.	CARRY OUT OPERATIONS C6 & E6
7	FLUID COUPLINGS.	CHECK OIL LEVEL AND TOP-UP IF NECESSARY			CHECK FOR LEAKAGE FROM BELLOWS GLANDS AND PERIPHERY JOINTS.	CARRY OUT OPERATION C7.	CHECK STARTER RING GEAR TEETH	CARRY OUT OPERATION C7 & E7
8	GEARBOXES	CHECK LUB. OIL LEVEL AND TOP-UP IF REQUIRED.		DRAIN AND REFILL WITH FRESH OIL	DRAIN OFF WATER	EXAMINE SUSPENSION, PINS AND NUTS.	CLEAN BREATHER ASSEMBLY	CHANGE OIL. CHECK BANDS FOR WEAR
9	FINAL DRIVES.			DRAIN AND REFILL WITH FRESH OIL	CHECK OIL LEVEL	CHECK TORQUE ARM SUSPENSION, PINS, NUTS AND LOCKING DEVICES.	CHECK FOR TIGHTNESS OF GLAND LOCK NUTS AND BANJO BOLTS. CHECK AIR CYLINDER COVERS FOR TIGHTNESS. CHECK CLEARANCES OF REVERSING DOGS	CHANGE OIL. EXAMINE OPERATING CYLINDERS AND PISTONS INSPECT AXLES.
10	TRANS: SHAFTS.	ENSURE SHAFTS ARE FREE OF TOOLS, LEAD LIGHTS, RAG, ETC.			EXAMINE SHAFTS, COUPLINGS AND BOLTS THOROUGHLY.	CHECK SHAFTS FOR 'PLAY'. LUBRICATE COUPLINGS AND SPLINES. CHECK THAT ALL NIPPLES ARE IN POSITION AND TIGHT. CHECK WELDED JOINTS.	CARRY OUT OPERATION C10	CARRY OUT OPERATIONS C10 & D10
11	AIR SYSTEM.	START ENGINES. DRAIN RESERVOIRS, CLOSE DRAINS AND CHECK PRESSURE.			MAKE THOROUGH EXAMINATION OF ALL CONNECTIONS FOR LEAKAGE. CHECK ANTI-FREEZE UNIT WHEN IN USE. & TOP UP AS NECESSARY	LUBRICATE THROTTLE MOTORS, CHECK TIGHTNESS OF UNIONS: EXAMINE AND CLEAN DELIVERY, REDUCING & UNLOADER VALVES. CHANGE UNLOADER & DIVERTER FELTS IF NECESSARY	EXAMINE AND CLEAN COMPRESSOR AIR FILTERS AND DELIVERY VALVES.	CARRY OUT OPERATIONS C.11, D.11 & E.11.
12	VACUUM SYSTEM.	START ENGINES, CREATE VACUUM AND CHECK FOR LEAKAGE.			CHECK VACUUM SEPARATOR OIL LEVEL AND TOP UP AS REQUIRED.	EXAMINE THOROUGHLY ALL CONNECTIONS FOR LEAKS	DRAIN EXCESS OIL FROM SEPARATOR & CLEAN FILTERS.	CHANGE OIL. IN EXHAUSTER RESERVOIRS.
13	ELECTRICAL.	CHECK WARNING LIGHTS WITH ENGINES RUNNING. CHECK GENERATORS OUTPUT. OPERATE THROTTLE & GEAR CONTROLS. CHECK DEADMAN DEVICE.			EXAMINE FUSES: EXAMINE JUMPER CONNECTIONS FOR DAMAGE AND LOOSENESS AT PINS & SOCKETS: CHECK STARTER MOTOR CONNECTIONS AND ENSURE TIGHTNESS TEST LOW WATER ALARM DEVICE.	CHECK LEVEL OF ELECTROLYTE AND TOP-UP IF NECESSARY. CLEAN BATTERIES. VASELINE BATTERY TERMINALS.	CHECK STARTER MOTOR PINIONS. EXAMINE CONTROL RELAYS, E.P.VALVES AND ENSURE CONTROL SWITCH GEAR CONTACTS ARE MATING.	CLEAN ALL CONTACTS: CHECK ALL FUSES, SWITCHES AND LEADS FOR INSULATION AND CONTACT. CLEAN GENERATOR AND STARTER MOTOR COMMUTATORS & BRUSH GEAR. RENEW BRUSHES IF NECESSARY. LUBRICATE BEARINGS. OIL STARTER PINION. EXAMINE & CHECK OIL PRESSURE SWITCHES.