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The Seminar on the Establishment and Development of the Automotive Industry in Developing Countries

Karlovy Vary, CSSR, 14 October - 1 November 1968

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MAINTENANCE OF HEAVY DUTY COMMERCIAL AUTOMOTIVE EQUIPMENT 1/

by
W.F. Eaton

Vice-President - Fleet Maintenance
The Mason and Dixon Lines
United States of America

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MAINTENANCE OF HEAVY-DUTY COMMERCIAL AUTOMOTIVE EQUIPMENT[1/]

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SUMMARY

1. This paper presents basic facts pertaining to the establishment and operation of an automotive service, maintenance and repair facility. The considerations are restricted to heavy-duty commercial automotive equipment, but, according to the author, the same principles can be applied to the maintenance of passenger automobiles.

2. The paper describes the organizational structure of the facility, the responsibility of personnel, the selection of the technical personnel from application and testing to appraisal and employment, and the methods and schedules of training of mechanics.

* This is a summary of a paper issued under the same title as ID/WG.13/4.

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3. Layout details on the construction of the maintenance facilities and basic information on workshops and equipment, particularly maintenance procedures and schedules, are given.

4. The factors affecting a planned programme for maintenance, simple methods for inventory control and ideas for the layout of the parts room are listed.

5. The paper recommends records for keeping information on repairs, warranties and cost control.

Summary

1. Countries' and nations' progress can be measured by their transportation systems. Growth depends upon movement of people and material from one location to another. In this paper an attempt has been made to explore one small portion of what may be a highly complex and complicated system of transportation and communication. However, the maintenance and repair of automotive equipment becomes highly important the day the equipment will not move because of mechanical failure. In fact, all previous planning, designing, operation etc. is useless the day the equipment is parked for repairs.

2. With this in mind, an attempt has been made to explore and discuss some basic facts pertaining to the establishing and operation of an efficient automotive equipment service and repair maintenance facility. This paper is restricted to heavy duty commercial automotive equipment, but the same principles can be adapted to the maintenance of passenger cars. Truck maintenance requirements are far more stringent and complicated than passenger car maintenance requirements.

3. An important organization set-up is outlined in such a manner that the small service and repair shop can begin with only mechanics and a head mechanic (who may be the owner), but can grow into a high volume shop by placing qualified personnel into positions as the need arises. The selection of the productive labourer is approached from basic application, thorough testing, appraisal and finally, employment.

4. Layout and construction of the maintenance facility is given necessary discussion because of its extreme importance to efficiency and production. Treatment is given to many features that can be incorporated into building plans that will expedite work flow.

5. Much emphasis is placed on methods and schedules of training mechanics who are so vital to the efficient operation of any maintenance and service shop. The training programme discussed gives advancement and reward for accomplishments, and at the same time keeps the ever important incentive before the apprentice. The programme, if followed, will turn out a seasoned and experienced mechanic and not a "ninety-day wonder".

6. Basic information is given regarding shop tools and equipment. These items usually come automatically in an established shop as the need arises to do a better job faster. Management should not deny purchase of any tool that fills a need, provided the volume warrants the expense. Repair and service shops must have the latest and most advanced tools to do an efficient job.

7. Attention is called to maintenance procedures and schedules, with consideration given to the fact that each maintenance set-up will require a differently planned programme. The factors effecting such a programme are listed, and the conclusion is drawn that often only experience sets the maintenance programme. The important thing is to have a well planned and well supervised maintenance programme backed with experience, records and meaningful testing.

8. No attempt is made to list highly sophisticated methods of inventory control and parts room layout. A simple tried and proven method is given that can be enlarged upon, improved and changed easily to meet any extreme demands. The important principle is to have the needed part when it is needed, and not have a prohibitive investment in parts that are seldom used. Parts issued from inventory must be replaced on a current basis and obsolete parts must be disposed of currently by returning to vendors under an established agreement.

9. Records for mechanical decisions, warranties, future equipment specifications and cost control are essential. This paper suggests how to compose such records. If the shop is selling service and repair work to the public, some records are not necessary, such as the mechanical history of the vehicle. The owner has the responsibility of maintaining his own record on his vehicles. However, cost records and records to show good and bad equipment are necessary in any shop.

10. The intent of the paper is to stimulate thinking and cause action to take place with anyone contemplating entering the automotive maintenance field. For those already engaged in such activity, it offers a chance of comparison between methods and procedures used, and those as set forth in the paper. It is meant to place automotive maintenance in proper prospective and help it gain the status in the field of industry that it should occupy. It gives credit to the tried and proven practices of the past and present, but is suggestive that people so engaged must remain flexible and be quick to change and accept the new and better.

Introduction

11. In developing the subject of this paper, the question comes to mind whether we are considering totally undeveloped countries in the automotive industry, or trying to upgrade automotive maintenance in countries that have the basic industry. An attempt will be made to take a middle of the road course with the hope that both the developing country and the country that wishes to upgrade its automotive maintenance will be able to reap some benefit from the treatment of the material. Any other approach could be either too primary or too advanced to serve the greatest number needing assistance in automotive maintenance.

12. The natural tendency of most individuals is to shy away from responsibility or problems related to mechanical equipment. This attitude exists due to a lack of understanding of the basic principles of why a piece of automotive equipment runs in the first place, and what is needed in the way of maintenance to keep it in trouble-free operation without costly time and repairs. Often, common sense does not prevail and the operator will continue to operate a piece of equipment with no thought given to the very important preventative maintenance that equipment requires. Too often the operator justifies his position by the theory, why should I spend money on my car or truck when it is running well and costing me nothing for maintenance. The amount of money not spent for basic maintenance is sure to bring on costly major repairs that will require a great deal more money that must be spent without choice. Too many people operate automotive equipment and know nothing about it except how to open and close the door, start the engine, accelerate, brake, steer etc. Their knowledge on the subject does not go beyond the reach and the vision of the driver's seat.

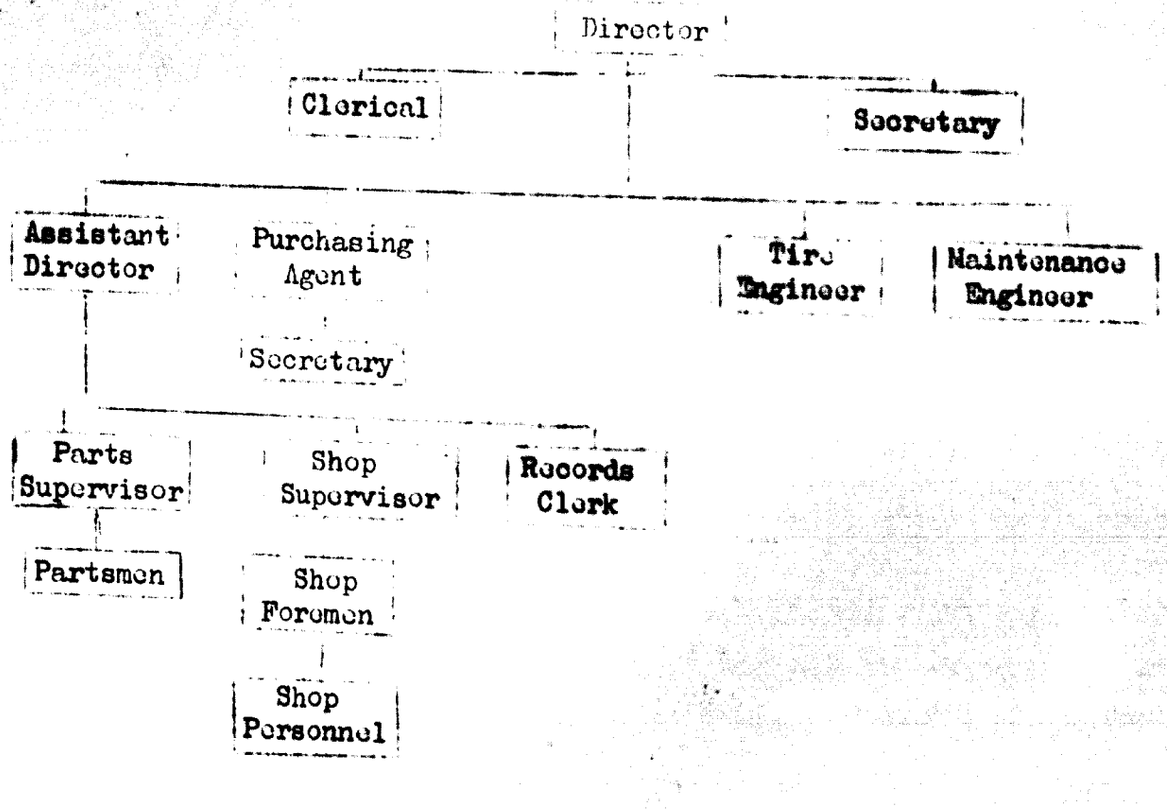
13. Any maintenance programme must continually try to defeat such an attitude. This can be done with organization, supervision, training, skills, procedures, cost figures and records. It is not an easy task because the balance weighs heavily on the side of those who give no thought to maintenance. These same individuals raise their voices the loudest when the equipment failure does occur, and strongly express a complete lack of understanding of why and how the failure could have possibly occurred. They could not find time to remove the equipment from service for preventative maintenance, but now, with a major mechanical repair necessary, they will find a way to do without it until the equipment can be returned to service.

14. Maintenance shops are often referred to as a necessary evil, drain on the profit, big spenders, non-contributors to revenue etc. The truth is that while all these things may be true, the wise owner of an automotive fleet knows that a tremendous amount of money can be saved with a well organized and efficiently operated maintenance set-up. The efficient maintenance of the equipment can be the difference between profit and loss. Equipment maintained in the proper manner can mean the difference in getting the job that brings in the revenue done, or not getting it done. Automotive equipment parked for major repairs or parked on the highway due to mechanical failure contributes very little to the efficiency of any operation.

15. In order to have an efficient automotive maintenance shop, it is necessary to have an efficient organization of individuals, entirely capable and dedicated, working as a team. There is no substitute for well-selected, trained personnel willing to accept responsibility and authority in a well-organized repair shop. Following is a manning table for the organization of a maintenance shop:

Table 1

Organizational structure



I. ORGANIZATIONAL SET-UP OF COMMERCIAL FLEET MAINTENANCE DEPARTMENT

16. Following is a description of the activities and responsibilities of each section necessary to the organization of an efficient maintenance department.

Director or superintendent of maintenance

(a) Reports to owner or company officer.

(b) Primary responsibilities:

(i) Establishes policies and procedures for sufficient and economical maintenance of all automotive equipment;

(ii) Recommends standards for the purchasing of automotive equipment, shop equipment and replacement parts;

(iii) Manages and directs subordinate personnel in the development of goals, performance standards, training methods, scheduling and all phases of activities within the maintenance department.

(c) Other responsibilities:

(i) Attends schools and councils; reads in order to keep informed on latest developments relative to automotive equipment and its maintenance;

(ii) Administers personnel safety programme;

(iii) Maintains constant watch over expenses of the department by daily reports and spot checks;

(iv) Approves requisitions for purchase of shop equipment and material;

(v) Maintains necessary liaison with owners or top management, manufacturers' representatives and salesmen and other shops within the organization.

Assistant director or superintendent of maintenance

(a) Reports to director or superintendent.

(b) Primary responsibilities:

(i) Assists the director in his duties;

(ii) Supervises and directs the operations of the maintenance facilities.

(c) Other responsibilities:

(i) Makes schedules in order to carry out policies and procedures;

(ii) Reviews and forecasts material and parts inventory needs. Co-ordinates shop foremen and promotes harmony between supervisors and labourers;

(iii) Constantly reviews costs and recommends cost savings;

(iv) Supervises and directs training of shop personnel.

Shop supervisors

(a) Reports to assistant director.

(b) Primary responsibilities:

(i) Schedules, supervises and directs the work to be done on his assigned shift;

(ii) Makes decisions on mechanical problems and conducts spot inspections of equipment before and after repair;

(iii) Advises and consults with director and assistant on mechanical and organizational procedures.

(c) Other responsibilities:

(i) Distributes repair orders to mechanics;

(ii) Approves requisitions for replacement parts and material;

(iii) Supervises and directs on-the-job training;

(iv) Directs and expedites the flow of equipment undergoing repair in the shop.

Supervisor - parts department

(a) Reports to assistant director.

(b) Primary responsibilities:

(i) Directs and controls the receiving, storing and issuing of automotive parts and related materials;

(ii) Maintains records of outgoing and incoming shipments in the parts department;

(c) Other responsibilities:

(i) Receives requisitions for priority parts orders and expedites shipment;

(ii) Maintains records of rebuilt components shipped and assures return of defective units;

(iii) Develops parts storage methods and systems to insure optimum utilization of space and personnel;

(iv) Recommends number and type of replacement parts to be regularly stocked and secures special parts;

(v) Supervises and directs subordinate personnel in the parts department.

Purchasing agent

(a) Reports to director or assistant director.

(b) Primary responsibilities.

(i) Directs and assists in the procurement of automotive parts and all material related to repair and service shop;

(ii) Negotiates annual motor fuel, lubricants and anti-freeze contracts.

(c) Other responsibilities:

(i) Expedites parts and materials of proper quality at proper price for needed delivery;

(ii) Maintains good relationship with suppliers; receives salesmen and in general stays abreast of current prices, and new and improved products.

With basic supervisory personnel, secretaries and clerical help are needed to handle correspondence, records, filing, reports and so on. The size of the service shop will determine the number of personnel. As an example, if the service shop is responsible for a fleet of 500 power units plus trailers, it may be wise to have a tire engineer and/or a maintenance engineer. Their duties are:

Tire engineer

(a) Reports to director.

(b) Primary responsibilities:

(i) Conducts critical and exhaustive investigation to effect procedures and methods for tire maintenance and the maintenance of an acceptable tire cost;

(ii) Controls disbursement of tires for recap and requisitions new tires from purchasing agent.

(c) Other responsibilities

(i) Supervises the control of all tire records;

(ii) Adjusts and scraps tires with manufacturers and recappers;

(iii) Approves all invoices relative to tire expense and handles all correspondence relative to tires.

Maintenance engineer

(a) Reports to director.

(b) Primary responsibilities:

(i) Performs assignments within the shop to augment his training with practical knowledge and the skills and attitudes necessary for an efficient and productive employee;

(ii) Develops procedures and practices to expedite mechanical jobs.

(c) Other responsibilities:

(i) Recommends design of equipment, both automotive and shop, for maximum life and efficiency;

(ii) Works out details and supervises any modification to automotive and shop equipment;

(iii) Performs any duties as assigned by the director.

17. Equally important as management and supervision are the productive personnel in the repair shop. A repair shop without skill and mechanical knowledge will render no great service to the public or the owner. Mechanical repairs would require excessive time and expense with inexperienced personnel. Failure as a result of faulty repairs would be excessive. In short, the shop must have a mechanic that knows what he is doing.

18. There are different levels or grades of mechanical work in any shop, each one justifying a different rate of pay based on knowledge and skill required. Unless the repair shop is extremely large in volume of mechanical work, there are very few phases of the operation that can be organized on an assembly line basis. For the most part, the day to day jobs require a mechanic to take a unit of equipment and make necessary repairs. These repairs will most likely be different on each unit and will not fall into enough of a pattern to warrant an assembly line approach.

19. Following are basic repair shop requirements for productive personnel:

Class A mechanic

This is the most skilled man and if he is truly class A, he can do any job in the shop. However, he may be class A along specific lines such as tune-up, rebuild, overhaul, body and fender etc. The class A mechanic is the backbone and strength of any repair shop. With his knowledge and skill, he can diagnose trouble, make repairs and restore the equipment to service, while a less skilled mechanic only attempts to find the trouble. Class A jobs include, but are not limited to the following:

(1) Rebuild and overhaul (both major and minor);

(2) Engine tune-up including dynamometer testing (if shop is equipped with one);

(3) Frame straightening and alignment;

(4) Body and fender repairs;

(5) Painting;

(6) Welding.

Class B mechanic

While this class mechanic may do all the jobs of class A, he is of lesser skill and requires closer supervision. He is in the learning stage, becoming a class A mechanic. His greatest value is in general service and repair work and replacing defective components with rebuilt or new components. He is a valuable mechanic and his true worth should not be overlooked. Depending on the variety of jobs done in a shop, he may constitute better than 50 per cent of the labour force.

Service mechanic

This mechanic is used primarily to change oil, change filters, lubricate chassis, service batteries, tire maintenance and repairs, and other routine items not requiring great skill.

Utility man

Does general clean-up work around the shop. Empties trash cans. Washes parts.

Partsman

This man must have the knowledge to receive, store and issue parts to mechanic. Should be able to make necessary record of all his transactions as they effect the procurement and dispersement of parts. Required to have limited equipment and repair knowledge.

Washer

This person is engaged in the cleaning of automotive equipment both by washing and steam cleaning.

II. PERSONNEL PROCUREMENT

20. A maintenance organization will only be as strong as the personnel employed to operate it. Therefore, proper selection of personnel and a clear progressive training programme, correctly administered, is not only desirable but mandatory in the administration of the organization.

21. Nothing is more important than having the right people to do the job. There is no harder task than that of selecting these people. The unknown and the changing characteristics of people is something that cannot always be recognised, suspected or dealt with. There is no foolproof way to employ people, and be sure of having the right people for the job. There is no way to accurately predict how the person employed will turn out. However, there are precautions that can be taken, investigations conducted, testing done and appraisals made to help eliminate the marginal to poor applicant in such critical areas as physical health, mental health, ability, general character and integrity. The time and effort spent to select the people to fill the jobs in a repair shop will return high dividends. There is no subetitute for a complete and thorough investigation of every applicant.

22. The method of procuring maintenance personnel would, of necessity, vary with the degree of development of the automotive industry in the area. One would not expect to find any degree of experience in a country that has no industry. In such a case, the obviously undesirable applicants would be eliminated. The new mechanic employee should be exposed to the automotive equipment; his interest watched and appraised very carefully. Basically, if a person is mechanically inclined, educated enough to understand instructions, and is willing to apply himself, he can be trained to be a maintenance repairman.

23. The first step in the procurement of personnel is the basic application for employment. Annex I gives an example of such an application form. It may be simplified, altered or enlarged to meet the given set of conditions in an area. Primarily, with the application one tries to learn everything possible about the applicant. The application must be followed with interviews, reference checks etc. in order to make it as complete as possible. Therefore, the history of this applicant up to the present is investigated, and with all these facts it can be determined whether he fits into the future of the organisation.

24. While it is not absolutely essential for a mechanic to be able to read and write, because there are too many good ones that cannot do either, the literate mechanic will find his way much easier with today's more sophisticated engines, transmissions, electrical systems etc., and with the rapidly changing equipment and components. He must be able to use service and repair manuals, read

micrometers, set tolerances and so on. The illiterate prospect can be taught, but it is time consuming and he does not learn new concepts very fast. It is desirable for a mechanic to have at least a high school education.

25. There are various kinds of tests that can be given job applicants to develop basic information. These tests are not all conclusive and should only be used as a guideline and to establish a norm with experience. Some recommended tests are:

(a) Test No. 1 (warm-up test) - supplier - Aptitude Test Service, Swarthmore, Pennsylvania.

(b) Perceptual Speed - supplier - Industrial Relations Center, University of Chicago, 1225 East 60th Street, Chicago, Illinois.

(c) Traffic and Driving Knowledge - supplier - Institute of Public Safety, Pennsylvania State College, State College, Pennsylvania.

(d) Mechanic's Job Knowledge Test.

26. It is this last test that is particularly important. Annex 2, consisting of 92 multiple choice mechanical questions, will very quickly tell whether the applicant has ever been exposed to the mechanical side of automotive equipment. The total score made on the test is not as important as the type of questions that are answered right or wrong. From this test it is easy to judge the applicant's knowledge and experience on petrol or diesel engines, electricity, air systems, shop tools and so on. The test questions could be grouped under the various mechanical classifications and only the questions pertaining to the type of work to be performed be given to the applicant. In any case, a discussion of the questions missed with the applicant can be very fruitful. It is always possible on a multiple choice test for the applicant to guess and make a respectable score. This test should be treated in a confidential manner. If allowed to become public, it will very quickly become useless.

27. Physical examination is of great importance in the employment of mechanics. Annex 3 gives an example of a health questionnaire and annex 4 of a physical examination. These can be modified to suit local conditions. With the lifting, straining etc. required of a mechanic, it is most important to have an X-ray of the spine and lower back to be sure there is no congenital defect or previous injury.

III. SHOP CONSTRUCTION

28. This paper will not attempt to discuss exact details in the design and building of a repair and service shop. There are too many factors effecting such a project and each shop must, by necessity, be different in order to meet these variable factors in an efficient manner. In other words, a shop must be built to the particular specifications of the owner's needs and circumstances. It is important to visit existing shops, if possible. Many ideas can be gained by observing closely and talking to others with experience in order to learn many things not to do.

29. The location and design of a maintenance facility is almost as important to achieving profit as the personnel. Mechanics should not be paid for unnecessary movement of equipment, trips to the parts room, or wasted motion in other ways. The mechanic is a production man with a valuable skill and needs to be kept on the repair job using his skill as much as possible. With this in mind, careful consideration must be given to the traffic pattern. This applies to the entrance, the exit, and the movement inside the shop. It would be impractical to move equipment in order to bring a particular job into the shop; to move equipment (perhaps undergoing repairs and unmovable) in order to take a repaired piece of equipment out of the shop. Such movements are costly and, with proper design, can be eliminated. Also, there is no savings in having the personnel walk a long distance in order to get a unit for the shop. Parking area should be convenient and readily accessible.

30. There are many "do's" and "don'ts" in the building of a repair and service shop. Listed below are a few with a brief discussion of each:

(a) Locate and design for growth. In today's expanding economy and changing dimensions of equipment, it is easy to outgrow a shop in a few years. For this reason, each component of the building should be located and designed so it can be easily expanded with minimum interruption of the existing traffic pattern and operation. Today's prefabricated steel buildings lend themselves very readily to quick, economical expansion. There can be no expansion if a building is crowded into the corner of the property or against a natural barrier.

(b) Incorporate good light, both artificial and natural. Skylights in the roof will save on electricity.

(c) If location is in a region where heat is required, design for the maximum. Give consideration to the many times the doors will be opened. Insulate fully. If possible, locate so the prevailing winter winds will not directly hit a large door.

(d) Floors should be of reinforced concrete with thickness to carry the load. They should be smoothly finished and be specially treated for hardness. Otherwise, with years of service they will become chipped and rough, creating a problem to clean and to roll such shop tools as floor jacks, transmission jacks and creepers.

(e) Entrance and exit doors should be of top quality as they will be opened and closed many times. Automotive equipment changes, so doors should be made wide and high. Overhead doors, electric motor driven, are highly desirable for ease of operation and speed. These can also be controlled with automatic, actuating devices and timers so that the operator of the equipment does not have to leave the driver's seat. In addition to the time savings and convenience, such controlled doors also save heat by closing themselves instead of waiting until someone finds time to close them. Such doors should have heavy guards spaced slightly narrower than the door opening, to protect them from damage they might receive from moving equipment. A good guard can be made with 6 inch steel pipe imbedded in concrete and filled with concrete.

(f) Roof vents will add to inside comfort in hot weather.

(g) Any noisy areas should be located away from parts room, offices and other sections where excessive noise would create tension and retard production. If dynamometer is used, partition it off in extreme area of shop and soundproof as much as practical.

(h) Exhaust removal systems are a necessity. These may be overhead systems or underfloor. Be sure it is designed with the capacity to do the job.

(i) Design for cleanliness. Shops accumulate dirt by their very nature. Locate continuous drains in the floor, cover them with removable grating and slope the floor towards them. This will take care of any water situation and will also allow the floors to be scrubbed and hosed off. Build the interior walls of a material that will allow them to be scrubbed down with a brush and detergent. Design the drains large enough to be cleaned with a shovel. Cleanliness is an important phase of any maintenance shop.

(j) Ceiling height of shop is important if trailer equipment is to be maintained. Height should be sufficient to allow mechanic to stand on top of trailer for inspection and repair without interference from structural objects. Height also lends to comfort in hot weather.

31. There are many designs that can be included in shop plans which will allow a better mechanical job to be completed faster. Listed below are a few:

(a) Hydraulic floor lifts for both empty and loaded vehicles will expedite numerous maintenance jobs. These jobs include engine frame overhaul, clutch replacement, tire change, brake repairs etc. In addition to allowing a mechanic to work at a convenient height, they also give opportunity for better inspection.

(b) Pits in the floor for inspection, greasing and changing oil are a great advantage and expedite the job. Pits should have good lighting and also a method to drain used oil into an underground storage tank outside of the building.

(c) Overhead travelling joists can be utilized for many jobs and can serve several bays in the shop. A hoist can be installed on a travelling monorail system and serve a greater area.

(d) Design a dock or ramp for loading and unloading parts convenient to the parts room.

(e) A central system for oil, grease, air and water, properly located, will assure all these very important items of being at a mechanic's fingertips when he needs them. Storage can be in underground tanks which allows volume purchases. Chassis grease can be in 55 gallon drums which can be located in a central pump room. The material can be piped to all shop areas and dispensed through automatic hose reels located overhead, and metering nozzles. If this method is chosen, the hose and nozzles are always off the floor. The air supply should be obtained from more than one compressor. This will allow the volume to be increased by the simple addition of another compressor and also assure a supply of air when a compressor has a mechanical failure. If air requirements call for a 20 hp compressor, it is better to install two 10 hp compressors. Economy is achieved because there is a point in compressor ratings where the price greatly increases and the two compressors will cost less than one. The central air system also lends itself to purging of the moisture from the compressed air. This moisture is very detrimental to air tools.

(f) If dispensing of items in (e) above is not put in overhead reels, it can be done with wall outlets. There should be enough outlets and mechanics should not move very far for such items. Electric welding outlets and general service electric outlets should be numerous and properly located.

(g) If the rebuilding of trailer equipment is to be done in the shop, the alignment and straightening problem can be expedited by a system of tie-down rings imbedded in the concrete floor. The rings can be tied to imbedded structural steel and spaced so as to serve main frames and subframes. Further advantages are available by installing wells spaced outside a frame member into which 9 inch to 10 inch steel "I" beams can be dropped for pushing or pulling with hydraulic tools. The wells on one side of the system should be tied to the wells on the other side by structural members imbedded in the concrete. With this set-up, there is sufficient strength to withstand any straightening job.

32. It is difficult to determine the size a maintenance facility should be. The size of the automotive equipment to be repaired and serviced, plus the anticipated volume, are the basic factors with which to work. It should be considered that automotive equipment changes and generally increases in size. For shop size planning, it is a good rule to consider all automotive equipment higher, wider and longer than it actually is. This practice will eliminate possible errors and also make the shop functional in the future. Space for the vehicle itself is not enough; the fact must be ever present in planning, that a mechanic must work on, around and under the equipment. The mechanic should have a work bench with mounted vice near his work area, as well as a trash can. He must have room to pull wheels from the vehicle with a wheel dolly, and he must be able to roll portable equipment such as transmission jack and floor jack around the equipment. The work bay or area itself must be large enough for quick entrance and exit of the equipment. It is not economical to have to do a lot of pulling and backing in order to park a vehicle in a repair area. As an example, calculate the time involved over a 25-year period if each piece of equipment has to be pulled up or backed up one additional time in order to gain entrance and exit from a repair area. Such waste of time and motion can be eliminated with careful planning. There is also a safety factor in the number of times equipment has to be moved. This is especially true in maintenance facilities handling high volume.

33. Another important factor to consider if the shop is to service and repair a large fleet of reasonably standardized equipment is the stocking of small, relatively inexpensive, fast-moving parts within the work area. This compliments the theory that you want the mechanic using his skill on the vehicle and not wasting time walking to the parts department for a five-cent item. For example, bolts, nuts, washers, filter cartridges, light bulbs, electric terminals etc. can be stocked in the mechanic's work area; he can make his own selection with little movement or lost time. It is true that this set-up will cause some loss of material so stocked, but the loss will not exceed the gain by keeping the mechanic on his assigned job. The parts department can keep the area stocked with material from the main parts room. Such a planned programme of storing these small items demands parts bin space in the work area and must be considered in determining the size of the area.

34. The size of a repair and service area for a typical commercial power unit of today should be considered. For example, a three-axle tractor is 96" wide and 20' long. The approach to planning this area can take many different courses. The most functional today would be a rectangular building with a door in one end or both ends. The building should be 90' wide with a 12' wide door. The minimum amount of working space on each side of the tractor should be 4' which gives a 16' wide service bay. The building has a common driveway down the middle which can feed equipment into service bays on each side. This driveway should remain open to traffic at all times and lend itself to quick, easy entrance and exit of equipment. The parking within the service bay can be angular or perpendicular. Both have their advantages and disadvantages. The angular parking is easier to gain entrance, but will net one less service bay thus requiring a longer building for the same number of 16' wide bays. The perpendicular parking is not as convenient and may require a wider building in order to eliminate one pull-up or back-up or both. However, it does give less wasted space on the ends of the building. Vehicles should not be parked closer than 6' from the wall. This gives sufficient space along the wall for work benches, trash cans, small parts bins, and mechanic movement. If money is no item, the interior common driveway can be eliminated and a door installed for each service bay. This makes a very convenient entrance, but overhead electric motor driven doors are expensive and have their maintenance problems and heat losses. If a service pit or pits is included in this facility, it should have its own entrance door. Vehicles must approach or exit a pit in a straight ahead position.

35. There are variations to this type of power equipment service and repair area, such as, parts room and offices can be located at the end of the building or in the centre. Centre location gives less walking; however, if the facility becomes a complex with different wings, the end location becomes the centre and proves to be the most convenient for all wings. Such a complex takes on the shape of a cross with parts room and offices in the convenient centre location. The cross concept lends itself well to expansion. Annex 5 illustrates a cross design for a first-floor plan.

36. To service today's very popular tractor and semitrailer hooked-in combination it must be considered that the rigs are usually designed as long as the law allows. Some operators are still operating at 50' over-all length, while some are pulling double trailers at 65' over-all length. The most functional service and repair area for combinations should have pull through bays with an entrance door and an exit door. It is not practical to plan on backing these rigs. The bays should be a minimum of 80' long to allow free passage and working room on each end. The width of the combination is 8'. The mechanic needs a minimum of 4' on each side. It is convenient to store fast moving parts, tires, portable tools, welders, work benches, portable work platforms for repair jobs, on top. This makes the bay width about 22'. The height should be approximately 20' so a mechanic can work on top of the trailer without interference from fixed objects.

37. There must also be a repair area provided for the major repair of trailers. This area can usually include space for accident repair of power equipment and a paint booth or an enclosed area for painting. A pull through repair bay is convenient. However, the traffic flow is usually not heavy in such an area so a back-in bay is acceptable. One concept that has proven satisfactory is to back in from each side with enough bay length to permit working space behind each unit, plus storage of small parts, trash cans etc. If 40' - 45' trailers are to be worked on, an ideal length is 140' for the back to back concept. This gives room for longer trailers. Bay width should be given careful consideration as it is time saving and convenient to store items such as flooring, plywood, lengths of iron and steel etc. between bays. If storage of these items is to be in this area there still has to be working space to allow for scaffolding and repairmen movement. Recommended bay width is 22' - 24'.

38. Thorough planning must precede any type of shop construction. Too many builders rush through the preliminaries which they later regret. A shop must be functional. Immediate needs should be analysed very carefully remembering long range needs. The important things must be considered regardless of cost. Saving is in the long range, not in construction cost cutting. Just ten minutes off each job over a period of years will amount to a considerable saving.

IV. TRAINING PERSONNEL

39. The training of personnel is as important as any other phase of the operation. An improperly trained employee is a potential problem. His inadequate training may make him feel discontent and he might resign. If he does not resign, he may be discharged for not doing an effective job. Tied in very closely with a training programme is the ever important subject of morale. It may be possible to employ an outstanding person, however, if immediate concern is not given to making him feel wanted and a needed part of the organization, his interest will subside. Every effort must be made to know this person; his first name, his interests and his family. His ability must be determined and recognized, as the director is trying to make the best use of this employee's ability. He must be publicly praised and privately disciplined. He must be told about his progress or lack of progress, and must continually have the right incentives in front of him.

40. Training can take many different directions and be given many different treatments. Each maintenance organizational set-up will demand varied starting points, varied methods, and will try to arrive at varied goals. People are different by nature so programmes to train them must be different. It has been stated before that anyone with mechanical aptitude and ability and a desire to learn can be trained. If the employee has these assets, the fault is the director's, if he does not become an excellent mechanic.

41. In the United States of America and other countries, various courses in mechanical subjects are offered. Some of these are found in industrial technical schools and some in privately owned and operated schools. They are all good for basic training, and probably go as far as it is possible to go with a text book and a blackboard. They offer excellent training on components such as fuel systems, electrical systems, engines, transmissions. However, it has been proven that this training must be supplemented very strongly with experience on the vehicle itself. It has never been fully explained why an individual who excelled in mechanical courses and obtained excellent experience and knowledge on the maintenance and repair of automotive components in the laboratory and classroom, cannot take a chassis with all components assembled and make it run. Putting it simply, a text book and a blackboard explaining repairs on a unit of automotive equipment is not enough. It takes experience on the vehicle itself. It takes trial and error, and it takes a lot of work to find the answer to a problem to make the repair, and then to remember what was just

learned and be able to recognize it the next time it occurs. Why would a mechanic who had many hours on text books and test stands learning a twelve-volt electrical system have trouble detecting the cause of light trouble on a tractor hooked-in combination to a semi-trailer? It happens; and proves the point that actual experience on the vehicle itself is necessary. One learns by doing with proper instruction and correction.

42. A few times in the automotive repair and service business there is a rare individual who is gifted with everything needed to make repairs. There are not many of them; but when he is found he is a mechanic who is a joy to have and to watch. He will be amazing with his accomplishments. He will have that "sixth sense" to walk up to a unit of equipment, listen to it, smell it, feel its vibrations and diagnose the trouble almost immediately. (I once thought these rare, valuable individuals were only born, but now I feel that some of them through hard work and training make themselves the desirable expert they are.) These experts are easy to recognize and worth three of the average mechanics.

43. Approximately four years are necessary and needed to train a person with the basic qualifications mentioned to be a class A mechanic. This does not mean four years to be a specialist on engine rebuild, transmission rebuild or any specific component. It means four years of training to be able to service and repair the total unit. It also does not mean four years of simply working on automotive equipment with no planned programme of training. If there is no planned training, the very nature of a maintenance repair shop will often find the same mechanic doing the same job day after day. This happens because it is the easy way. He has learned the one particular job and it is easier to continue to give him all of them than to take time and effort to train him. This approach is not fair to the individual or the company. The individual could get eliminated by technological changes in the industry and all chance of advancement can be destroyed. The company can loose the services of one who might have been a valuable class A mechanic. By not having a fully trained man available, vacancies cannot be satisfactorily filled and substandard repairs result. The truly valuable mechanic is the one who can do anything.

44. The industry refers to a mechanic who is learning as an apprentice. Because he spends four years being trained, he should be as young as possible but still mature. (To train an elderly employee may mean he would retire after a few years of service). This is not discriminating against the elderly. It

is simple economics. It takes time and money to train people and the investment is sizable once they are trained. Full compensation cannot be reaped from an employee while he is being trained, so he must work for the shop for as many years as possible after he becomes a valuable, skilled member of the organisation in order to reclaim the investment with dividends. In annex 6 are recommended apprenticeship courses.

45. A good apprentice training programme should require 8,000 to 9,000 hours. With the nineteen sample work processes given in annex 6, such a programme can be outlined to fit the need of the maintenance organization. These suggestions can be altered, rearranged or tailored in any manner to fit the repair and maintenance requirements. Some items would not be applicable to the equipment to be maintained while other items might need to be inserted. The important thing is to have a planned programme and stick with it, review it regularly and change it if needed. Such classifications as painting or body and panel beater are 8,000 hours work processes within themselves, and very little of the other requirements are related or needed.

46. It is not wise to put more apprentices in a shop than can be absorbed upon completion of apprenticeship. Also, proper supervision and training cannot be given if there are too many apprentices. The apprentice should receive a progressive increase in his earnings as he completes phases of his course. The first increase could be after the first 500 hours and be graduated based on total hours completed until he is accepted as a mechanic at the going mechanic rate.

47. With the apprenticeship course, each apprentice should be required to enroll in and attend regularly approved classes of related instruction at least 150 hours per year, not to exceed 600 hours in four years. These classes should be attended at night or other times than regular work hours. An organization might feel that this is too demanding, but it should be remembered that it is not only trying to provide skill for the future in its shop, but also the individual is being trained for his life's work. He is gaining an occupation that will afford him and his family a better than average standard of living. The apprentice owes something to the organization other than just meeting the hourly requirements on the job.

48. The best classes are those conducted on the premises with supervisors acting as instructors. However, instructors can be engaged from companies manufacturing vehicles or components. These instructors are usually specialists in their particular field and can give instruction of great value. A closer relationship between mechanic and supervisor is formed if supervision is used extensively in an apprentice programme. In fact, supervisors gain job knowledge and many useful suggestions to assist them in their daily duties.

49. Some suggested related classroom sessions are:

Wiring and ignition diagrams with emphasis on schematics;

Fundamental hydraulics and OHM Law;

Elementary blueprint reading;

Fundamentals of mathematics;

Precision measurements;

Power transmissions;

Theory and science of such items as transmissions, clutches, steering carburetion etc.;

Business management;

Safety courses;

Labour problems.

50. A written test should be given upon completion of each instruction session and a record made of the score attained. Also, it is highly important that a record be maintained of each apprentice's hours completed in specific work processes and the total hours in the apprenticeship course. There can be a tendency, due to the work load, to leave an apprentice on a particular phase of his training after he has completed the required hours. This should not be done, as it creates doubt of his progress. You may want him to repeat a work process because he has not mastered it, or prolong it a number of hours, but this should be discussed and agreed to with the apprentice so that he knows exactly where he stands and where he failed to qualify.

51. There are many highly useful training aids that can be used for apprenticeships training or upgrading established mechanics. Manufacturers of equipment and components offer training classes both on and off the premises. Many have mobile units fully equipped that will visit and conduct classes. These are highly successful because they often have drawings, pictures, slides, sectioned parts and components that can be disassembled and assembled under instruction.

All manufacturers offer service manuals, rebuild manuals, service bulletins etc., which are always useful in a training session. Today's films and slides are excellent and can be shown anytime on portable equipment. These have been successful during lunch periods or rest periods. Correspondence or home study courses are available and usually can be developed in any desired area of training. In these, printed material and drawings are furnished and written tests required. These have been successful with the mechanic paying the full cost, or being refunded a portion or all of the cost if the course is completed. One such service as this is Interstate Training Service, Portland, Oregon.

52. When a problem develops and is eventually solved, one of the most useful and simple training aids is to draw up a work bench, lay out all the parts and call everyone together. This will normally take only a few minutes but the problem and the solution can be thoroughly explained and illustrated with the parts. Let the mechanic who found the trouble do the talking. This brings him into the training and gives him a sense of pride. If this is not done, the next mechanic who runs into the same problem a week later may spend twice the time trying to solve it. Communication is difficult and important, and it is highly desirable that every mechanic be given the benefit of any and all solutions to maintenance and service problems or time saving methods and procedures.

53. It cannot be over-emphasized that on-the-job training, means learning by doing. The trainee should not merely watch the skilled mechanic and hand him tools. The apprentice will of course, need assistance and instruction on many maintenance procedures and problems. This kind of assistance must be given either by supervision or a skilled mechanic but let the apprentice do the job. His rate and degree of learning will be accelerated if he does the job. Most of the learning process of becoming a skilled mechanic consists of running into the problem and finding the solution. No amount of talk or observing can offset the knowledge obtained by doing the job with his own hands and tools. He will make mistakes, some of them costly. The training programme should assure that he will learn from his mistakes and will not make the same mistake two times. You will find that any training is easier to do and more fruitful, if the trainee has been exposed to the equipment or the component. For example, if the mechanic has been trained on generators only and the fleet is switched to alternators, a basic training course should be given before he comes in contact with an alternator. Extensive and detailed training should follow after he has developed enough desire and curiosity. The mechanic who has been exposed to the alternator and met some problems will have many questions to ask.

V. SHOP TOOLS AND EQUIPMENT

54. Nut and bolt maintenance is on the decrease, but the old familiar tools and equipment will be needed for some time. As long as the nut must be turned and the bolt held, tools will be needed. The only change is that tools must be supplemented regularly in order to repair and service today's exotic equipment. Electronic and highly specialized tools and test equipment are essential to diagnose precisely, accurately and fast. It is not good enough to know that an engine has a knock or lacks power, or that a differential or transmission is noisy.

55. There are great numbers of special tools and test equipment. The purchase of such items must be governed by volume to justify the investment. The cost of the job in one's own shop versus the cost in an outside shop is a factor to be considered. Availability of an outside shop to do a special job or excessive delay in having the outside shop do the job are factors; but the availability of the knowledge and skill in one's own shop must also be considered. Basically, tools are a prime requisite. A shop without necessary tools is an inefficient shop. Any tool that will do a job better and faster should be purchased if the volume in the shop warrants the investment.

56. It is standard in the industry for a mechanic to supply standard hand tools up to ½" drive size and often 3/4" size. These include ratchets, sockets, box and open end wrenches, hammers, screwdrivers, extensions, flex drives, pliers of all types, punches, chisels, set screw wrenches, feeler gauges, measuring tape, hacksaw etc. This takes care of a lot of hand tools and often a mechanic has an investment of US$ 1,200 to US$ 1,500. As a rule, mechanics take pride in good tools and will take care of them. They are usually eager to add a new tool to their collection. They know that the proper tool may save an hour of struggling and get the job done in five minutes.

57. Special tools and equipment are usually furnished by the company and supplied from a tool room or the parts room. Often a mechanic must be convinced of a new tool's worth. Even after supervisors and mechanics decide that the tool is needed, it will still have to be sold. A new tool in the shop often gathers dust after the first few days. The mechanic will say it takes too long to hook it up, or the job could be done faster the old way. These statements are correct the first few times the new tool is used, but with training and practice it will do a better job, faster. Mechanics do not accept changes easily.

58. Annex 7 gives a list of tools and shop equipment that may be necessary in a repair and service shop. This is not necessarily a complete list nor are these items all necessary and should be purchased before a new shop opens its doors. The type of work performed and volume will dictate the tools and equipment to purchase. It is better economically to find the need for the tool and then make the purchase than to make the purchase and never find a need. Minimum needs for these items will create quite an investment.

59. Without a doubt however, the day will come when automotive equipment is built harnessed with a standard connexion to be plugged into a computer which will render a tabulated sheet showing all malfunctions, parts needed and adjustments required. Even after this progress, the mechanic and his tools will still be needed.

VI. MAINTENANCE PROCEDURES AND SCHEDULES

60. Maintenance procedures and schedules will vary with the type of equipment, climate, miles operated per month, type of terrain, speeds, loads and road conditions. It is always necessary that maintenance procedures and schedules be tailored to the demands and conditions of the operation. Often the demands are not known except by experience and records; procedures and schedules must be set by them and supported with testing. Primarily, anyone charged with the responsibility of maintaining a fleet of automotive equipment must remain flexible in his thinking and planning. When a change is needed to correct a weakness, it must be recognized and the changes made. What is done in the way of procedure, methods and planning one month should be looked at the next month, because they may be wrong and need changing. The automotive industry is a changing industry in itself. It does not furnish many dull moments.

61. It is entirely possible to over maintain as well as under maintain. A middle-of-the-road course is best. With proper procedures and schedules, the first and most important task is to secure a dollar value for a dollar spent. Not too many years ago, it was considered good maintenance to pull components at a set mileage, based on experience, in order to avoid a failure. While this is necessary and good for air-plane maintenance and safety, it is not necessarily required on ground equipment. In a fleet of 200 commercial vehicles purchased at the same time 25 per cent fail at 150,000 miles, so the decision is made to pull the balance and rebuild before they fail. It is true the balance might

fail in the next 25,000 miles but chances are good that many of the alternators will exceed 350,000 miles. Parts and components are too costly to waste any miles by pulling them for rebuild on a set schedule. This is not to say that an engine should be kept in service after the oil pressure drops or a differential allowed to continue in service after the slack becomes excessive. To ignore such obvious signs and wait for the failure might increase the cost of the overhaul. The low oil pressure could ruin the crankshaft before the engine fails, and the excessive slack in the differential might cost a seizure if allowed to operate until failure. The important thing is to have the test equipment and the mechanical skill to diagnose each component and know when maximum mileage has been obtained. Again, there is no substitute for good test equipment and trained, skilled personnel to assure a dollar value for a dollar spent.

62. Basically, maintenance is tied closely to what is purchased in the way of equipment and components, and the skill and responsibility of the operator; keeping the locks of the vehicle stopped, the air it breathes clean; keeping it properly lubricated with clean fuel and leaving it alone as long as things operate in a normal fashion. When the procedure and schedule calls for too many adjustments there is always room for error and mileage can shorten. For example, a set mileage to adjust valves and injectors on today's diesel engine can cause trouble. Original adjustment could have been better than it was after a mechanic backed off and re-adjusted. If things are operating in a normal fashion, the vehicle should be left alone. Such practice saves many hours of labour and the vehicle is better off.

63. The heart of a maintenance programme in commercial vehicles is the preventative maintenance (PM) phase. As mentioned before, there is no magic formula for establishing the mileage figure that a vehicle should be pulled from operation and put in the shop for preventative maintenance. For example, a diesel tractor that accumulates 100,000 - 120,000 miles per year has a PM schedule set at 10,000 miles with a 5,000 mile chassis lubrication. With today's greases, it is often acceptable to eliminate the 5,000 mile lubrication and only plan a 10,000 mile maintenance schedule. Today's automatic chassis lubrication systems are acceptable, and in addition to furnishing timely and good lubrication, also allow the tractor to remain in service and out of the shop. Any design, component, procedure or scheduling that allows the vehicle to stay out of the shop is well

worth the time and money to secure. There is a cost to bring a vehicle into a shop and take it out again, even though no mechanical work is performed. Everything connected with a commercial vehicle maintenance programme should be considered and resolved, with the foremost thought being to keep the vehicle on the road operating satisfactorily.

64. The work and inspections performed on PM schedules will vary for the same reasons anything connected with maintenance must vary. As a rule a PM check sheet is given to the mechanic along with the shop repair order. The regular repair order will contain items reported wrong by the driver, plus any special maintenance checks that current conditions dictate. The PM check list can be arrived at in various ways and can accomplish more than one result. The PM sheet can be very useful in training mechanics by calling their attention to points on the vehicle that require inspection and care. It can be changed to train the mechanics on a new and different model so that they become aware of different things to check. It can contain check items applicable to the first year of vehicle operation and be expanded to cover the second year as more things need attention. As the vehicle grows older, PM inspections should be changed to meet the mechanical conditions. The PM checks can also include different items at different mileages. There are things to be done at 50,000 mile inspections that are not necessarily on the four preceeding inspections.

65. PM check lists should be as brief as possible and still gain the desired results. Lengthy lists require too much reading and marking time on the part of the mechanic. Once the mechanic was trained in the routing items to be covered, he should be expected to automatically cover them without having to read a check list. As a rule, mechanics do not care for reading and writing, and difficulties may be encountered in getting them to write things for the record. Most shops assign a mechanic a number which he is to use to mark off any item he repairs. He should also be required to list anything he finds needing mechanical attention and mark it off if he makes repairs. It is necessary that the mechanic performing the mechanical operation put his name on the work order and the PM sheet. This identifies faulty jobs to the individual so his mistakes can be called to his attention; and it also allows any other mechanic that might be assigned to the job to know what work has been performed.

All PM inspections should contain the following:

Change oil and oil filters;

Lubricate vehicle completely;

Check all gear box oil levels;

Check clutch adjustment;

Clean all filters and replace if necessary;

Check coolant level;

Check and gauge tires;

Check all lights;

Check water level in batteries;

Check and correct all oil, water, fuel and air leaks;

Inspect operation of all instruments;

Adjust brakes;

Check belts - condition and tension;

Check engine for knocks or unusual noise.

66. These are basic items and necessary for long trouble-free miles on the vehicle. Often it is practical to use a short PM for 10,000 mile inspections another for 20,000 mile inspections or more, and then use a more extensive PM inspection for one scheduled inspection. Annex 3 is an example of a shop repair order and PM inspection list. This form can take on any shape or size; made to suit any need. It can be a one-part form with information on front and back or be more by using carbon paper. More than one copy is often necessary to satisfy records and book-keeping. For labour control and cost control, it is necessary that a mechanic show hours spent on a job. The information on time can also be used to establish a normal time for a particular job in the shop and will readily show training progress or the inefficient mechanic. There will always be mechanics who can do their jobs in far less time than others for reasons that they work harder, steadily, have more mechanical ability and are better trained. Also, there will be mechanics who are good at a particular job and may even cut the normal time in half for the job they like to do and do best. It is the supervisor's responsibility to learn his mechanic's exceptional traits and use them to the fullest advantage.

67. A PM inspection list that is changed at intervals will keep mechanics out of a set pattern and make them more alert. Otherwise, it may become so routine that they do what is known as a pencil check. This is merely checking off on items without a thorough inspection and is useless in a maintenance programme.

68. We have spoken of a 10,000 mile service and inspection on a diesel tractor. Petrol powered vehicles will not perform with such an extended service and inspection schedule. They require more attention and while costing less to purchase and less for engine overhaul, their out-of-service time will be much greater. The same is true of vehicles doing local pick-up and delivery work in a stop and go operation, whether they be gasoline or diesel. The idling time and the starting and stopping frequency are very detrimental to engines, transmissions, clutches, universals etc. The maintenance on such vehicles needs to be set on both a mileage basis and a time basis; for example - 2,000 miles or sixty days. As a rule, these vehicles are low mileage vehicles but the service required of them is extremely rough. Here are some good accepted maintenance practices:

(a) With the cost of tires, it is false economy to install steering tires without balancing them and checking camber, caster and toe-in of the front axle. New vehicles should receive the same attention. Assembly line production does not turn out vehicles with the steering and front axle set right or are any two sets alike.

(b) Dual tires should be matched to ½" diameter with the larger tire on the outside.

(c) A transmission replacement should not be made without checking the clutch condition. Most of the time is spent on removing the transmission and there is a risk removing it again in a short time for clutch trouble.

(d) Rejected bearings and pilot bearings are cheap on clutch replacement. Old bearings should be replaced.

(e) Any doubtful bearing should not be used. It is not worth it.

(f) To tear down an engine and re-use the rings and rod and main bearings no matter how good they look is not worth the time and expense.

(g) Anytime the head must be removed from an engine, the valve seating should be checked.

(h) If the wheel is off for any reason, thorough inspection and maintenance should be performed on the brakes and components.

(i) In the rebuilding of components or the repair of parts such as sheet metal, the material and labour cost compared to a new item should be evaluated. Sometimes it does not pay. Parts purchased individually and assembled will cost more than an assembly ready to use from the manufacturer.

(j) It may be wise to use patch-up maintenance on an exposed component, but if time and trouble are going to be expended on a mechanical repair, it should be done right and restored to its original condition as fully as possible. Repeat failures are costly.

(k) Water and oil should be checked plus a visual inspection for leaks should be made anytime a maintenance shop has contact with a vehicle. It also helps to have the driver trained the same way.

(l) Commercial fleets that maintain their own stock of fuel should have specifications to assure fuel economy and engine performance. Engine manufacturers' specifications are broad and can be easily met by fuel suppliers but they will not necessarily do justice to engines or economy. In order to assure getting what is specified and paid for it is necessary to arrange for spot testing. Oil and greases should be treated in the same manner. Annex 9 gives sample specifications on No. 2 diesel fuel, petrol, oil and grease. This can be changed to meet operating condition. Economy, horsepower, starting properties, minimum sludge etc. should be noticed. An all-purpose chassis grease is advantageous as it can be used for all applications, including bearings, water pumps etc.

(m) Most maintenance people agree it is good practice to change the filter element each time the crankcase oil is changed. Oil change mileage can be arrived at by laboratory testing. The expense of the oil itself is not too important as oil purchased in bulk is economical. However, the labour to do the changing, the time out of service, and the price of the filter element are factors to consider in oil change periods. The oil change mileage should always be set within a safe range. You cannot afford to take a chance and often vehicles do not receive an oil change exactly on time due to operational needs and the fact that they may be away from their regular service location when scheduled mileage is reached.

(n) In cold climates, diesel equipment requires starting aids. Engine warmers have proven very satisfactory, both in the cooling system and the crankcase. Insulated battery cases with heating elements have merit as the efficiency of a cold battery is very low. If either is used in the air intake system, it must be used properly. Improper use will fill the combustion chamber and lock up the engine, or if it does fire, head gaskets will blow, valves get damaged, heads cracked, head studs loosened etc. Neither should be used on petrol engines because of the danger of explosion.

VII. PARTS ROOM AND INVENTORY

69. The parts room and the inventory of parts are extremely important because they represent a sizable investment. The inventory itself is money lying idle that may or may not be used, so it is important to have the parts that are needed and not have the parts that are never needed. An expensive unit of automotive equipment idle because of lack of a small one dollar part does not add up to very good economics. The equipment is just as idle for the dollar item as it is for a $2,000 engine. This is not to say that anyone can predict just what parts will fail and be needed, or is it to say that parts should not be in the parts bin in anticipation of usage. It is better to have the part the day it is needed and get the vehicle rolling again, than to have argued over the investment of the part in the first place and decided not to purchase it, thus parking the vehicle to wait for the arrival of the part.

70. If the above paragraph is confusing, it was meant to be. It all means that any maintenance set-up requires a good, capable, alert parts supervisor; the same is true of purchasing agent and well trained partsmen. Like everything else connected with maintenance, varying conditions dictate the size and the investment of a parts inventory. Some of the varying conditions are:

(a) The availability of the part from the vendor; his location, transportation time, and his stocking practices must be considered. If engine parts are available in the same city as the repair shop, an investment in the parts room is unnecessary. The vendor should carry the investment; orders can be placed when the need arises.

(b) The different models of equipment and components the maintenance shop is responsible for directly effect the inventory. This is one good reason it pays to standardize.

(c) The age of the equipment to be maintained directly effects the value and the number of items to be put in inventory. As a rule, while automotive equipment is operating at low mileage after being purchased, it will not require the expensive items to rebuild engines, transmissions, differentials etc.

(d) The component rebuild programme trained for and practiced will effect inventory. If a component is replaced every time it fails, the items in an inventory will decrease in number but certainly increase the value of the inventory. Also, such a practice will greatly increase over-all maintenance cost. Less skill is required in a "parts replacement" shop, as most components do not require great skill to remove and replace. It is very important that the parts room contain rebuilt components such as engines, transmissions, differentials,

clutches, alternators, starters, control valves, injectors, fuel pumps, etc. Such items, if rebuilt properly with quality parts and tested on proper test equipment, will give many economical miles on the vehicle. To have the rebuilt item in the parts room means returning the vehicle to service immediately rather than having to remove the component, rebuild it and reinstall it.

(e) The replacement or trade-in schedule of automotive equipment has its effect. If this schedule is known, inventory can be phased out accordingly. After all of a particular model has been sold, traded or retired, parts are not needed in the inventory that only apply to the model.

71. The parts room, under the control of the parts supervisor, must first be located for convenience of receiving parts, issuing parts and best serving the entire shop area. For this reason, it usually needs to be located in the centre of all activity. Within the parts room, the arrangement requires long and careful study. A mechanic should not have to walk too far to draw a part from the parts room, and neither should the partsman walk far. If the shop set-up is a complex, and the parts are issued from more than one point, the parts applicable to certain work should be stocked convenient to that work. Fast moving items should be located close to the issue point.

72. There are various arrangements for the stocking of parts. One such arrangement would group all parts of a manufacturer together while another would group all parts pertaining to components together, such as engine parts in a section and transmission parts in a section. Another method would stock parts numerically, either by vendor part number or by a cross-reference system of numbers. The important thing is to have a system that is thoroughly understood by supervisors and partsmen. It is not always easy to locate the desired part unless the system is well established and followed daily. If the parts cannot be located, the mechanic and the vehicle are waiting and costing. Parts bins should be numbered, as well as the shelves, and tied into a locating system and a numbering system. Particular section locations must contain room for growth, or one section will grow over into another less active section and eventually the entire system would be confused.

73. The number of items carried in a parts room will govern the system of control and records. A simple method is to have a perpetual inventory record. Such a record will contain a card for each item showing part number and all cross-reference numbers. To this card must be posted all receipts of the item from the vendor and all issues so that a current balance is always shown. The card also should contain bin location, current price, last vendor, number on order and not received, and a figure representing maximum number to stock, plus a figure to show minimum number to stock. The maximum and minimum will be determined by usage, availability and whether one tries to maintain a sixty-day supply of parts or some other period. When the inventory card shows a minimum number, a requisition should be sent to the purchasing agent to order enough to bring your stock back to maximum. Maximums and minimums must be flexible to meet current conditions. For example, parts usage will increase on various items as vehicles get older; and maximums and minimums will have to be increased accordingly to serve the need.

74. The inventory record should be constantly researched for parts that are not being used and obsolete parts. Some arrangements should always be worked out with vendors to allow you to return such items. Often a handling charge of about 10 per cent will have to be paid but this is better than having the dead stock in the parts room year after year. A parts room should always represent a current situation and if it does not, it will not serve the needs of the service department and the investment will be excessive.

75. Some systems make a daily accounting so that all parts used in a day will be posted on the record. Others do not post on the record until the shop repair order is turned in, indicating the job is finished. The objection to the latter is that often the shop may be loaded with jobs requiring several days repair, so the parts used do not get ordered to replenish stocks on a current basis.

76. The method given above to control inventory is the oldest and most basic. Many shops today are large enough that all information is fed into some type of accounting machine and the machine in turn gives usage, tells what to order and what is not being used. If this service is available, it is highly recommended.

77. It is the purchasing agent's responsibility to secure the part requisitioned from the parts room for the best price and within an acceptable time limit. While doing this, he cannot accept less than the best quality. There is always a vender with a cheaper price which is good if the quality is good. Maintenance shops cannot accept poor quality in any item. Too much time and effort is spent to make repairs to use poor quality parts and have the job to do over in a short period. Money spent for quality is always money well spent.

VIII. RECORDS

78. A repair and service shop that is responsible for all the maintenance on a fleet of vehicles should have a system of records that will readily tell the past history of maintenance on the vehicle. While the system can be detailed, primarily it should contain information only in detail enough to allow a shop supervisor to make a decision easily.

79. Annex 10 is an example of a two-part record. All repair orders from the shop, invoices or just knowledge of an item can be posted to such a record if applicable. The record lists PM inspections, filter changes, engine repairs, component replacements and accidents. No cost should be involved, just the date and miles. This information will often allow the supervisor to direct the mechanic to the trouble immediately. It will also identify repeat maintenance where maybe the vehicle has had the same component replaced more than once and it continues to fail because the root of the trouble was not located on the first replacement. Also, if a vehicle is released to operate with a doubtful repair, it can be tagged on this record to recheck the condition on its next trip into the shop.

80. The record can also be used to obtain miles of service on important components. This information helps on warranty claims, specifications of new equipment and anticipated shop work.

81. No maintenance organization can function properly without records. Parts inventory records and maintenance vehicle records have been discussed. There also must be cost records or the efficiency, progress or lack of progress in the shop cannot be judged. A shop labour rate per hour must be established and used to compute the labour cost on each job. This is needed whether the shop sells labour to the public or maintains a company owned fleet. The labour rate

can be figured in various ways depending on how it is to be used. If only used for comparative purposes as in a company owned fleet, it can be computed on the actual rate paid the mechanic plus insurance, vacation and other fringe benefits. This method puts all other expense in an overhead figure. Probably the best labour rate is to figure total cost which includes all of the first method, plus supervision, heat, water, lights, rent, parts room cost, depreciation of shop equipment, taxes, insurance, miscellaneous supplies not put in inventory and so on. These items should all be computed separately so they can be watched for inefficiencies. The shop labour rate will decrease anytime the volume warrants additional labour as a greater number of productive hours will be used to absorb the fixed expense. The important thing is to have a system of cost control that will tell which items are needed in order to appraise shop efficiency.

82. If a fleet of commercial vehicles is maintained, it is useful information to have a unit cost system. This will allow evaluation of different makes and models of equipment. It gives the cost factor on important components and allows costly items to be immediately recognized. If such a record is maintained for years, it allows cost normals to be established and is an excellent tool for controlling cost. It is extremely valuable in writing specifications on new vehicles or components. It establishes the ratio between parts and labour which can be an important factor in determining when to trade or sell the old equipment.

83. Annex II shows such a breakdown on thirteen items. This can be expanded to include any detailed information desired. As given, it is minimum information and in order to find details, a research of the repair orders and parts expense would have to be made. However, it does give direction of where to look for excessive cost.

84. Code 100, electrical and ignition, could be expanded to read as follows:

110 - starter	150 - sparkplugs
120 - alternator	160 - distributor
130 - lights	170 - wiring
140 - battery	180 - coil

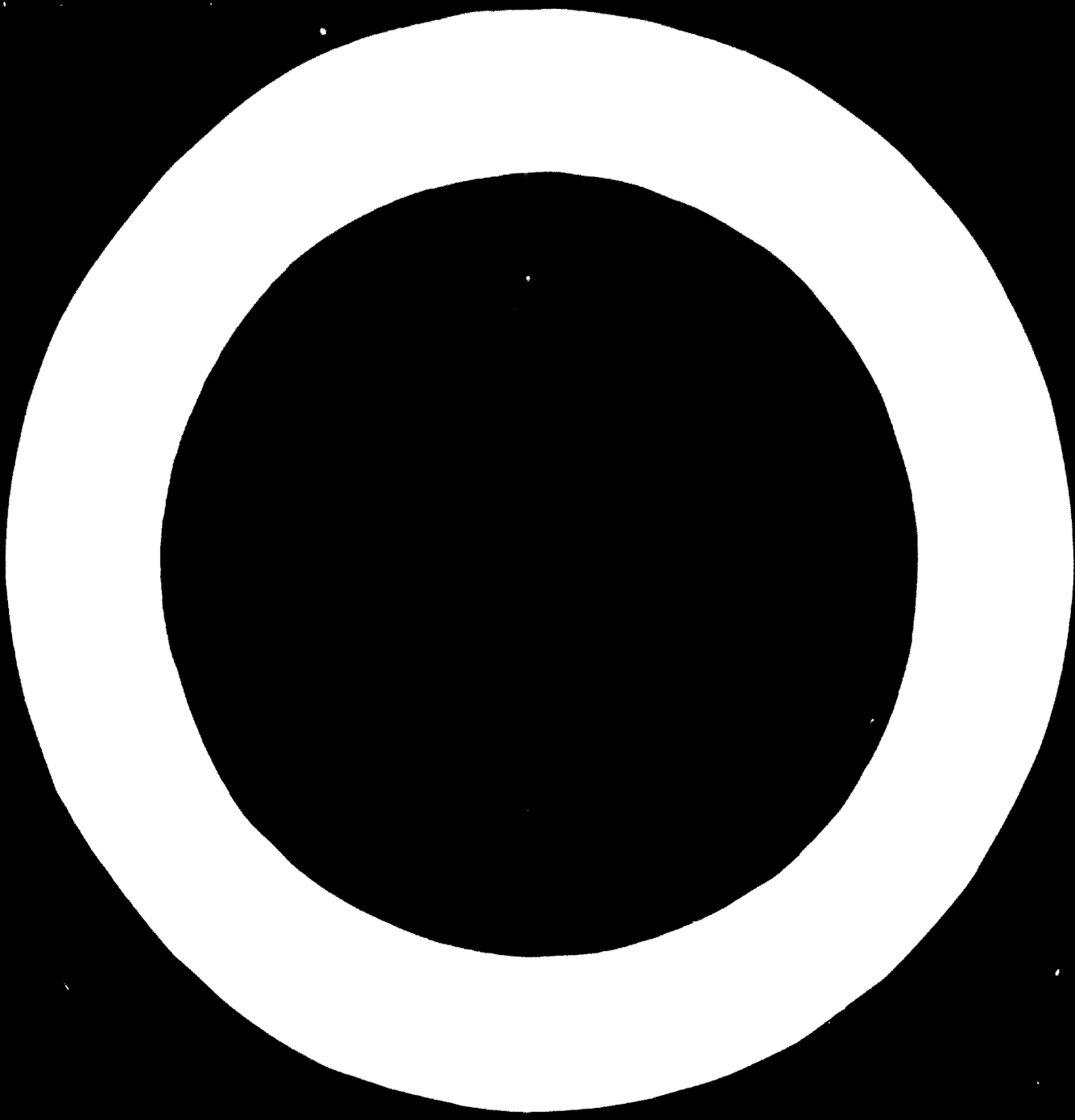
Even these classifications can be further reduced such as 121 - alternator armature; 122 - alternator brushes. If the breakdown of expense items is too detailed there will be alot of record keeping that may not ever mean anything or ever be used. Records that tell nothing and are not used are useless and

poor economy. Just enough records are required to control cost and to guide mechanical decisions and specifications. Table II shows codes which may be used to indicate failure of components.

IX. CONCLUSION

85. Maintenance of automotive equipment is a highly interesting and ever-changing field. Transportation is essential in progressive development of any country. The future is bright, and presently the field is on the threshold of many highly interesting developments such as petrol turbine engines. Maintenance people must remain flexible, be progressive and always search for something better whether it be equipment or methods.

86. If the person in charge of the design and specifications of commercial equipment does not eliminate approximately 90 per cent of his maintenance problems with design and specifications, he has failed in one important phase of his duties.



APPLICATION FOR EMPLOYMENT

DATE OF APPLICATION

JOB CODES

APPLICANT PLEASE PRINT ... ALL QUESTIONS MUST BE ANSWERED
COMPLETELY. FALSIFICATION ... DISQUALIFICATION OR TERMINATION OF
EMPLOYMENT ... TREATED AS CONFIDENTIAL.

LAST NAME	FIRST			SOCIAL SECURITY NO.
		STATE	ZIP	PHONE NO.

BUSINESS ADDRESS

RESERVE STATUS

	ADDRESS	MAJOR COURSES

WHAT ARE YOUR hobbies?	WHAT DO YOU DO for recreation?

LIST IN ORDER THE JOBS MOST QUALIFIED FOR AND INTERESTED IN	1	4	WAGE OR SALARY EXPECTED (FILL IN ONE BOX)	HOURLY	WEEKLY	MONTHLY
	2	5		$	$	$
	3	6				

EMPLOYMENT EXPERIENCE – PAST TEN YEARS
[illegible] Periods Of Unemployment)

FROM MO-YEAR	TO MO-YEAR	[illegible] ADDRESS	[illegible] AND SUPERVISOR'S NAME	SALARY	REASON FOR LEAVING

ARE YOU NOW EMPLOYED? [illegible] MAY WE [illegible] TO YOUR [illegible] EMPLOYMENT, HOW LONG [illegible]

WHAT OFFICE MACHINES CAN YOU OPERATE? [illegible] TYPING SPEED [illegible] SHORTHAND SPEED [illegible]

REFERENCES
[illegible] List Former Employers or Relatives)

NAME	[illegible]	STREET	CITY	STATE - ZIP	PHONE NO.

[illegible] that it is good only for ninety days (90-DAYS) from the [illegible] signed. If the applicant [illegible] by this Company after expiration of the initial ninety-day period, he or she must file a [illegible] application.

DATE ______________ SIGNED ______________

[illegible] BELOW THIS LINE

DATE	INTERVIEWER	REMARKS

Annex 2

MECHANIC'S JOB-KNOWLEDGE TEST

(Circle the letter you think represents correct answer)

1. WHAT SPECIAL GAUGE IS THE BEST TO USE TO PROPERLY GAUGE SPARK PLUG GAPS?
   a. Flat feeler gauge
   b. Square feeler gauge
   c. Round feeler gauge
   d. Tension gauge

2. THE INSTRUMENT USED TO CHECK IGNITION TIMING IS THE:
   a. Neon timing light
   b. Voltameter
   c. Distributor clamp
   d. Low voltage tester

3. A TORQUE WRENCH MEASURES:
   a. Number of threads per inch
   b. Size of nut
   c. Strength of bolts and nuts
   d. Pull in lb-ft.

4. IN THREADING A HOLE, USE:
   a. Die
   b. Bit
   c. Reamer
   d. Tap

5. WHEN MAKING A COMPRESSION TEST ON AN ENGINE, IT IS VERY IMPORTANT TO:
   a. Have the engine running
   b. Turn on the ignition switch
   c. Remove all spark plugs
   d. Remove one spark plug

6. RESISTANCE IS MEASURED IN TERMS OF:
   a. Volts
   b. Ohms
   c. Amperes
   d. Watts

7. WHICH UNIT PROTECTS A GENERATOR?
   a. Coil
   b. Radio supressor
   c. Voltage regulator

8. THE COLOUR OF THE "NOSE" OF A SPARK PLUG AFTER OPERATION, IF IT IS IN PROPER HEAT RANGE, SHOULD BE:
   a. White
   b. Brown
   c. Dark blue
   d. Black

9. WHEN A DISTRIBUTOR HAS ONE SET OF POINTS ON A SIX-CYLINDER ENGINE, THE CAM HAS:
   a. One lobe
   b. Three lobes
   c. Six lobes
   d. Twelve lobes

10. WHEN THE TIMING LIGHT FLASHES BEFORE THE TIMING MARKS LINE UP WITH THE POINTER THE TIMING IS:
    a. Too late
    b. All right
    c. Grounded
    d. Too fast

11. WHEN INSTALLING SPARK PLUG WIRES IN THE DISTRIBUTOR CAP, YOU MUST KNOW BOTH THE FIRING ORDER AND:
   a. Piston displacement
   b. Rotation
   c. Venturi action
   d. Throttle action

12. THE SEGMENTS OF A SWITCH ARE INSULATED BY:
   a. Friction tape
   b. Rubber
   c. Tinfoil
   d. Mica

13. A COLD-RUNNING ENGINE INDICATES:
   a. Ignition timing incorrect
   b. Radiator filled to the top
   c. Open thermostat

14. A COMMON CHECK THAT CAN BE QUICKLY MADE FOR TOO RAPID WEAR ON TIRES IS:
   a. The angle of steering knuckle arms
   b. Camber
   c. Toe-in
   d. Caster

15. A DIFFERENTIAL IS NEEDED IN ORDER TO:
   a. Increase the power of the truck
   b. Allow one wheel to turn faster than the other
   c. Increase the speed of the truck

16. WHERE WOULD YOU ATTACH THE TIE-ROD?
   a. To the front wheels
   b. To the Pitman arm
   c. To the steering knuckle arm
   d. To the drag link

17. WHAT IS THE PURPOSE OF THE MANIFOLD HEATING DEVICE?
   a. Maintain an even engine temperature
   b. Provide heat for the driver
   c. Preheat the gases in the intake manifold
   d. Warm the oil so it will flow sooner

18. VACUUM OF A WELL TUNED ENGINE SHOULD BE:
   a. 22 to 24 inches
   b. 10 to 24 inches
   c. 18 to 21 inches
   d. 24 to 32 inches

19. AN INCREASE IN COMPRESSION WHEN OIL IS PUT INTO A CYLINDER INDICATES:
   a. Head gasket is "shot"
   b. Rings faulty
   c. Piston loose

20. THE SEQUENCE OF TIGHTENING CYLINDER HEAD SHOULD BE:
   a. From either side of head to the other
   b. From either end
   c. From the middle towards each end

21. WHAT IS THE FIRING ORDER OF A SIX-CYLINDER ENGINE?
   a. 153642
   b. 152643
   c. 153624
   d. 142536

22. IF VALVE SPRINGS ARE TOO STRONG THEY CAUSE:
   a. The valve to remain closed too long
   b. The valve to break
   c. The valve to open too soon
   d. The valve to not open at all

23. WHEN THE EXHAUST VALVE ON #5 CYLINDER HAS JUST CLOSED ON A SIX-CYLINDER ENGINE, WHICH OF THE CYLINDERS IS TO FIRE NEXT?
   a. #4
   b. #6
   c. #1
   d. #5
   e. #2
   f. #3

24. TOO MUCH CLEARANCE BETWEEN THE OIL PUMP BODY AND THE GEARS WOULD SHOW UP AS A TENDENCY FOR THE:
   a. Oil relief valve to stick
   b. Oil pump to overheat
   c. Back pressure to build up
   d. Oil pressure to drop

25. A HALF CHARGED CONDITION OF THE BATTERY, ALTHOUGH THE VEHICLE IS IN NORMAL USE, INDICATES WHAT TROUBLE?
   a. Coil shorted
   b. Armature grounded
   c. Voltage regulator

26. POOR OIL MILEAGE MAY BE A RESULT OF TOO MUCH:
   a. Intake valve guide clearance
   b. Camshaft end play
   c. Exhaust valve guide clearance
   d. Valve tappet clearance

27. LOW CARBURETOR FUEL LEVEL WOULD CAUSE:
   a. Rich mixture at high speed
   b. Rich mixture at low speed
   c. Lean mixture at high speed

28. LOW FUEL-PUMP PRESSURE WILL RESULT FROM:
   a. Spring too strong
   b. Leaking diaphragm
   c. Mounting bolts loose
   d. Valves not seating properly

29. POOR VEHICLE PERFORMANCE (CARBURETTOR) CAUSED BY RICH MIXTURE IS DUE TO:
   a. High fuel level or float setting
   b. Low fuel level or float setting
   c. Restricted main fuel passage
   d. Accelerating pump stuck

30. A PISTON'S SIZE IS MEASURED AT THE:
   a. Skirt
   b. Below ring grooves
   c. Top

31. WHICH CONDITION WOULD CAUSE UNEQUAL CASTER?
   a. Twisted axle
   b. Bent steering knuckles
   c. Unequal air pressure in front tires

32. WORN MAIN BEARINGS MAY BE INDICATED BY:
   a. Engine stopping
   b. High oil pressure
   c. Low oil pressure
   d. Engine running hot

33. THE BREAKER POINTS ARE CONNECTED TO:
   a. Secondary coil
   b. Primary coil
   c. Distributor rotor
   d. Spark plugs

34. IF THE ENGINE IS IDLING AT 300 RPM, HOW FAST IS THE DISTRIBUTOR TURNING?
   a. 150 RPM
   b. 100 RPM
   c. 600 RPM

35. HOW WOULD YOU RELEASE THE BRAKES ON A TRAILER AFTER AN EMERGENCY APPLICATION?
   a. Bleed the reservoirs on trailer
   b. Disconnect the emergency or charged line
   c. Equalize the pressure in truck and trailer system
   d. Rotate the brake shoe adjusting nut counter-clock-wise

36. WHICH OF THE FOLLOWING COULD CAUSE THE CARBURETTOR TO FLOOD?
   a. Too small jets
   b. Low fuel pump pressure
   c. Bent main nozzle
   d. Pinhole leak in the float

37. A CRACKED INTAKE MANIFOLD CAUSES:
   a. A noticeable rise in oil pressure
   b. Piston slap
   c. Carburettor to give too rich mixture
   d. Engine skips and misses

38. WHERE WOULD YOU START BLEEDING A VACUUM HYDRAULIC BRAKE SYSTEM?
   a. Brake line to left rear wheel cylinder
   b. Vacuum-hydraulic
   c. Line furthest from the master cylinder
   d. Master cylinder

39. "KICKBACK" IN ENGINE STARTING IS CAUSED BY:
   a. Defective vacuum advance
   b. Carbonised engine
   c. Bad points
   d. Spark advanced too far

40. WHAT IS ADJUSTED BY THE ECCENTRIC NUT ON THE WORM AND SECTOR TYPE STEERING GEAR?
   a. Back lash
   b. Cross shaft end play
   c. Worm end play

41. A VACUUM HYDRAULIC UNIT IS INSTALLED FOR THE PURPOSE OF:
   a. Equalizing output on brakes
   b. Retarding brake action
   c. Increasing line pressure

42. POSSIBLE CAUSE FOR CLUTCH SLIPPAGE IS:
   a. Flywheel housing misalignment
   b. Incorrect pedal free travel
   c. Burned-out clutch release bearing

43. HOPPING OR SHIMMY IS CAUSED BY:
   a. Loose front wheel bearings
   b. Over-inflated tires
   c. Zero camber setting
   d. Boot in tire

44. IF BATTERY AND CONNECTIONS ARE GOOD, THE MOST PROBABLE STARTER FAILURE IS:
   a. Bent starter shaft
   b. Grounded field
   c. Loose bushings
   d. Bad starter switch

45. A "HARD" BRAKE PEDAL ON HYDRAULIC BRAKES INDICATES:
   a. Shoe retracting springs broken
   b. Shoes not centralized
   c. Too much clearance between shoe and drum

46. THE HAND LEVER IN THE AIR BRAKE SYSTEM IS:
   a. Controls the amount of pressure applied to trailer brakes
   b. Controls the amount of air entering compressor
   c. Controls the reservoir pressure

47. WEAK BREAKER POINT SPRING TENSION IS INDICATED BY:
   a. Ping on acceleration
   b. Miss at high speed
   c. Crossfire

48. A TRANSMISSION INTERLOCKING DEVICE IS USED TO:
   a. Make shifting easier
   b. Prevent shifting to more than one gear at a time
   c. Eliminate transmission noise while driving

49. DO PLUNGER OR HOLLOW CYLINDERS NEED TO BE CLEANED?
   a. Yes
   b. No

50. IF YES, WITH:
   a. Soap and water
   b. Solvent, such as kerosene
   c. Dry rag

51. THE SMALLEST ALLOWABLE VOLTAGE OF A FULLY CHARGED BATTERY UNDER LOAD IS:
   a. 6 volts
   b. 3.5 volts
   c. 5 volts

52. THE MARKS ON CRANKSHAFT AND CAMSHAFT GEARS SHOULD BE LINED UP TO:
   a. Insure a proper fit of meshed teeth
   b. Time valves correctly
   c. Prevent excessive wear on gears

53. SLUDGE IN THE ENGINE OIL PAN CAN BE CAUSED BY
   a. Valves sticking
   b. Leak in the oil pan
   c. Dirty oil
   d. Misfiring

54. WHICH CLEANING MEDIUM WOULD YOU RECOMMEND FOR CLEANING HYDRAULIC PARTS?
   a. Alcohol
   b. Lead-free gasoline
   c. Kerosene
   d. Benzene

55. WHERE SHOULD THE GREASE VALVE ON UNIVERSAL JOINTS BE LOCATED?
   a. Between trunnion shaft and bearing cup
   b. In the end of bearing cup
   c. In the center of the cross

56. A GOOD FUEL PUMP SHOULD SEND PRESSURES:
   a. 14 to 16 lb
   b. 2 to 4 lb
   c. 10 to 12 lb
   d. 6 to 8 lb

57. TO CL... ...OUR-TYPE CONTACTS, USE
   a. Petrol
   b. Fine-cut file
   c. Non-metallic sand paper

58. WHAT, PROBABLY CAUSED ..., COULD CAUSE ... VALVE TO STICK OPEN?
   a. Light valve spring
   b. Bent rocker arm
   c. Insufficient clearance

59. AN IMPORTANT FUNCTION OF THE CONDENSER IS TO:
   a. Decrease coil intake
   b. Prevent arcing at points
   c. Decrease the voltage at points
   d. Increase the voltage at points

60. WHICH OF THE FOLLOWING THINGS COULD HAVE BEEN DONE TO CAUSE THE CARBURETOR ADJUSTING SCREWS TO BE SET OUTSIDE THE LIMITS?
   a. Poor idle adjustment
   b. Low top speed engine power
   c. Lean mixture at all speeds
   d. Choked condition and poor mileage

61. THE PRIMARY PURPOSE OF A TURBOCHARGER ON A DIESEL ENGINE IS TO:
   a. Increase fuel mileage
   b. Gain RPM's
   c. Increase horsepower

62. ON A TWO-CYCLE ENGINE THE CRANKSHAFT TURNS HOW MANY TIMES TO FIRE ONE CYCLINDER?
   a. Two times
   b. One time
   c. Four times

63. ON A FOUR-CYCLE ENGINE THE CRANKSHAFT TURNS HOW MANY TIMES TO FIRE ONE CYCLINDER?
   a. Two times
   b. One time
   c. Four times

64. WHICH OF THE FOLLOWING ITEMS IS FOUND ON A DIESEL ENGINE?
   a. Distributor
   b. Spark plug
   c. Fuel pump
   d. Condensor

65. IF A DIESEL ENGINE "RUNS AWAY" YOU SHOULD:
   a. Turn off the ignition switch
   b. Break the intake fuel line
   c. Put transmission in neutral

66. WHICH ITEM BELOW COULD CAUSE AN ENGINE TO RUN "TOO HOT"?
   a. Wrong adapter
   b. Worn front tires
   c. Engine out of tune
   d. Drive line bent

67. RADIATOR SHUTTERS ARE USED TO CONTROL:
   a. Fuel pressure
   b. Intake air pressure
   c. Water temperature
   d. Air conditioner

68. A DI[illegible] ENGINE [illegible] WITH:
   a. Compression
   b. Spark plug
   c. Glow plug

69. OIL I[illegible] AIR SYSTEM OF [illegible] INDICATES:
   a. Overfilled crankcase
   b. Faulty oil pump
   c. Low cylinder compression
   d. Worn compressor rings

70. RESTRICTIC[illegible] IN AIR BRAKE [illegible] OF DIESEL ENGINE COULD CAUSE:
   a. High engine temperature
   b. Low oil pressure
   c. Excessive smoke
   d. Faulty air brakes

71. WHAT IS MEANT BY "FREE PLAY" IN A CLUTCH:
   a. The travel of the clutch pedal
   b. The gear in the clutch disc
   c. The distance from the throw-out bearing to the clutch fingers
   d. The tension of the clutch springs

72. THE COMPRESSION IS USED TO:
   a. Open the valves
   b. Control the compression of the engine
   c. Regulate the clutch travel
   d. Steer the vehicle

73. COMPRESSIO[illegible] IN A DIESEL ENGINE IS:
   a. Higher than petrol engine
   b. Same as petrol engine
   c. Lower than petrol engine

74. CONNECTING ROD BEARINGS USED WITH A .010 UNDERSIZED CRANKSHAFT:
   a. .010 undersize
   b. Standard
   c. .010 oversize
   d. .020 oversize

75. AIR FROM USED IN AIR SYSTEM IS CONTROLLED BY:
   a. Air compressor
   b. Air tank
   c. Safety valve
   d. Air governor

76. FUSES ARE USED IN ELECTRICAL SYSTEMS OF TRUCKS TO:
   a. Make lights brighter
   b. Extend life of bulbs
   c. Break the circuit when needed
   d. Increase speed of windshield wipers

77. UNEVEN INFLATION OF TIRES CAUSES:
   a. Center of tire to wear fast
   b. Outside shoulder of tire to dip out
   c. Both outside edges of tire tread to wear excessively

78. WHAT IS CONSIDERED AT LEVEL IN AUTOMOTIVE BATTERY:
   a. Half full
   b. Completely full
   c. Three-eighths of an inch above plates
   d. Three-fourths full

79. THE RATE AT WHICH A BATTERY IS CHARGED IS DETERMINED BY:
   a. Amp meter
   b. Generator output
   c. Day or night driving
   d. Gauge of wire from battery to junction box

80. A 12-VOLT GENERATOR IS CONTROLLED BY:
   a. 12-volt positive ground regulator
   b. 6-volt positive ground regulator
   c. Dash amp meter
   d. Speed of the engine

81. THRUST WASHERS ARE USED TO:
   a. Control stroke of piston
   b. Time engine
   c. Regulate end play of crankshaft
   d. Align driveline

82. IN ORDER TO RUN, DIESEL ENGINES MUST HAVE:
   a. Battery current
   b. Coil
   c. Injectors
   d. Shutter control

83. THE ACTUATION OF A DIESEL TRACTOR SERVES TO:
   a. Inflate tires
   b. Unhook fifth wheel
   c. Store air
   d. Filter the air system

84. HOW MANY PIECES OF METAL ARE IN EACH STEEL WHEEL?
   a. One piece in each wheel
   b. Two pieces in each wheel
   c. Four pieces in each wheel
   d. Six pieces in each wheel

85. A THROTTLE CONTROL ON A DIESEL ENGINE IS DRIVEN BY.
   a. Belts
   b. Gears
   c. Exhaust gases
   d. Self Driven

86. AVERAGE COOLING SYSTEM PRESS USED WOULD MOST LIKELY BE:
   a. Five pounds
   b. Ten pounds
   c. Twenty pounds
   d. Fifty pounds

87. ON A TANDEM LOAD TRAILER AXLE WEIGHT IS EQUALIZED BY:
   a. Springs
   b. Spring hangers
   c. Equalizer
   d. Torque arms

88. TRAILER AXLE ALIGNMENT IS ADJUSTED BY:
   a. Torque arms
   b. Hangers
   c. Tie bolt
   d. King pin

89. WHICH DIFFERENTIAL RATIO WILL PRODUCE THE HIGHEST SPEED?
   a. 5:25 -1
   b. 7:17 -1
   c. 4:11 -1
   d. 5:00 -1

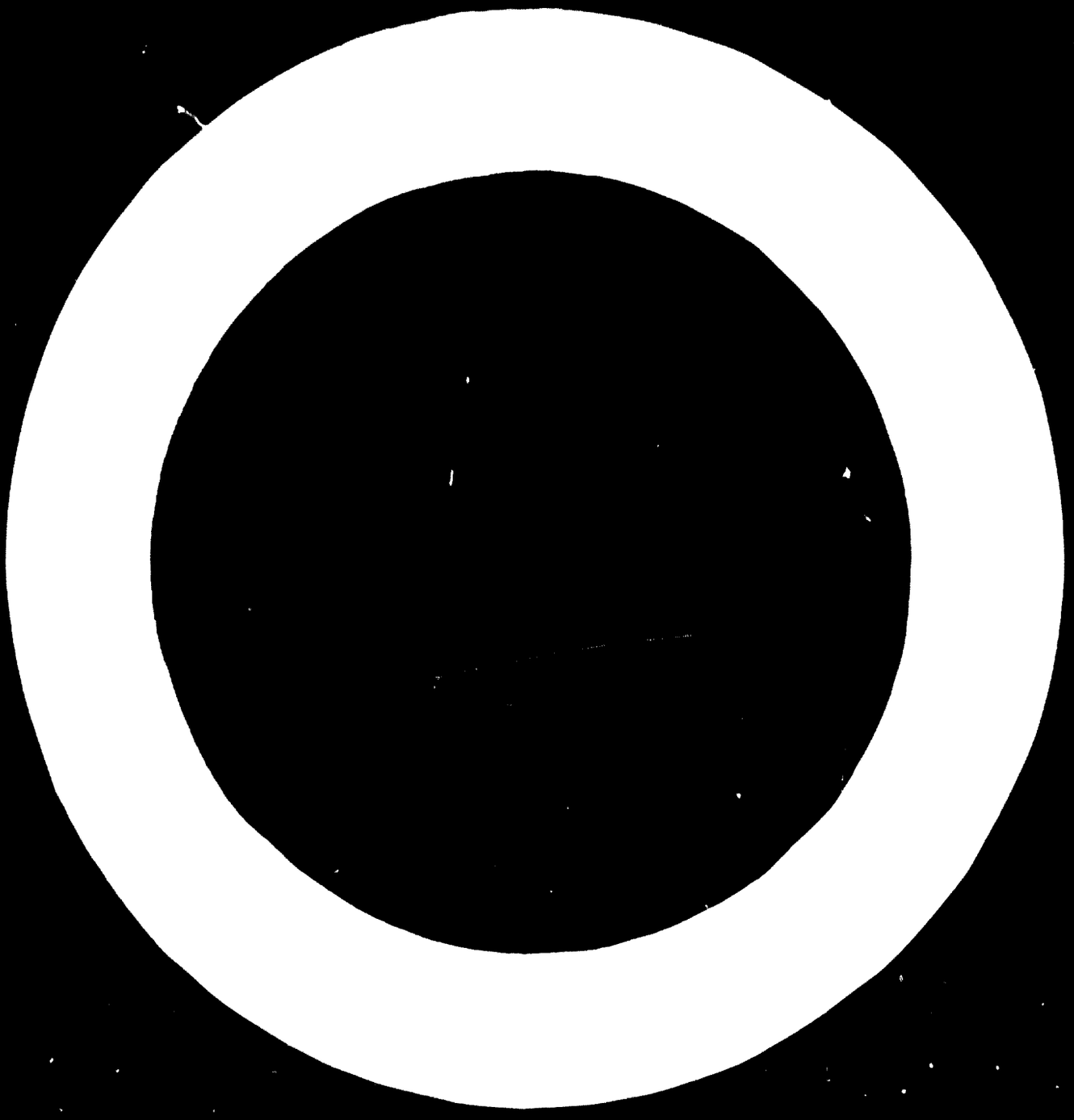
90. AIR CHAMBERS ARE USED TO:
   a. Activate the slack adjusters
   b. Inflate tires
   c. Operate air windshield wiper
   d. Regulate air pressure

91. A STRAIGHT IS USED TO:

a. Rebore cylinders
b. Line bore block
c. Check horsepower
d. Time engine

92. TO MAKE UP FOR WEAR OF THE BRAKE OF TRAILER, YOU COULD TURN WHEN ADJUSTING DRUM?

a. Vertically
b. Counter-clockwise
c. Clockwise
d. Horizontally



Annex 3

EMPLOYEE HEALTH QUESTIONNAIRE

NAME _____ AGE ____ HEIGHT _____ WEIGHT _____

ADDRESS _____ PHONE NO _____

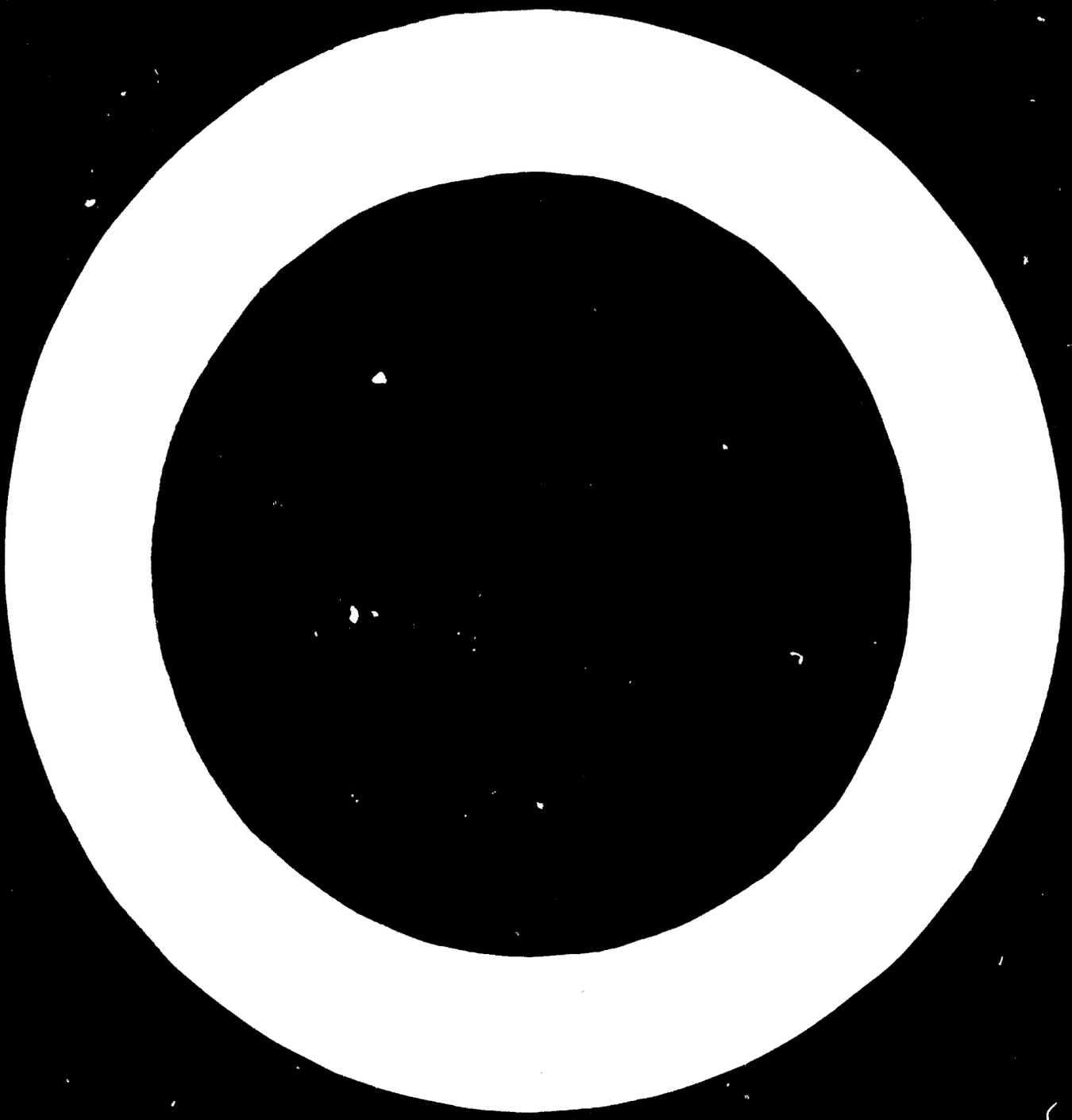
YOUR DOCTOR'S NAME & ADDRESS _____

DIRECTIONS: Read each question thoroughly. If you can answer YES to the questions asked, draw a circle around the YES. If you have to answer NO to the question asked, draw a circle around the NO. Please do not skip any items.

1. Do you need glasses to read? ..... YES NO
2. Do you need glasses to see things at a distance? ..... YES NO
3. Are you hard of hearing? ..... YES NO
4. Do you often catch severe colds? ..... YES NO
5. Have you ever had T. B. (Tuberculosis)? ..... YES NO
6. Did you ever live with anyone who had T. B.? ..... YES NO
7. Do you ever suffer from asthma? ..... YES NO
8. Are you troubled by constant coughing? ..... YES NO
9. Have you ever coughed up blood? ..... YES NO
10. Has a doctor ever said your blood pressure was too high? ..... YES NO
11. Do you have pains in the heart or chest? ..... YES NO
12. Are you often bothered by thumping of the heart? ..... YES NO
13. Are your ankles often badly swollen? ..... YES NO
14. Do you get out of breath long before anyone else? ..... YES NO
15. Has a doctor ever said you had heart trouble? ..... YES NO
16. Do you suffer from indigestion? ..... YES NO
17. Do you suffer from constant stomach trouble? ..... YES NO
18. Do you constantly suffer from bad constipation? ..... YES NO
19. Have you ever had piles (rectal hemorrhoids)? ..... YES NO
20. Have you ever had serious liver or gall bladder trouble? ..... YES NO
21. Are your joints often painfully swollen? ..... YES NO
22. Do weak or painful feet make your life miserable? ..... YES NO
23. Do pains in the back make it hard for you to keep up with your work? ..... YES NO
24. Are you troubled with a serious bodily disability or deformity? ..... YES NO
25. Does your skin often break out in a rash? ..... YES NO
26. Do you suffer badly from frequent severe headaches?... YES NO
27. Have you fainted more than twice in your life? ..... YES NO
28. Was any part of your body ever paralyzed? ..... YES NO
29. Did you ever have a fit or convulsion (epilepsy)? ..... YES NO
30. Has a doctor ever said you had a hernia (rupture)? ..... YES NO
31. Do you often have severe burning pain when you urinate? ..... YES NO
32. Has a doctor ever said you had kidney or bladder ache? ..... YES NO
33. Does working tire you out completely? ..... YES NO
34. Are you frequently ill? ..... YES NO
35. Do you wear yourself out worrying about your health?.. YES NO
36. Did you ever have malaria? ..... YES NO
37. Were you ever treated for anemia (thin blood)? ..... YES NO
38. Do you have diabetes (sugar disease)? ..... YES NO
39. Did a doctor ever say you had a goiter (in your neck)?.. YES NO
40. Did a doctor ever treat you for tumor or cancer? ..... YES NO
41. Do you suffer from any chronic disease? ..... YES NO
42. Did a doctor ever say you had varicose veins (swollen veins) in your legs? ..... YES NO
43. Did you ever have a serious operation? ..... YES NO
44. Did you ever have a serious injury? ..... YES NO
45. Do you often have small accidents or injuries? ..... YES NO
46. Have you ever injured your back? ..... YES NO
47. Do you usually feel unhappy and depressed? ..... YES NO
48. Did you ever have a nervous breakdown? ..... YES NO
49. Were you ever a patient in a mental hospital (for your nerves)? ..... YES NO
50. Does it make you angry to have anyone tell you what to do? ..... YES NO
51. Do people often annoy and irritate you? ..... YES NO
52. How many days did you lose from work last year due to sickness? _____
53. Were you ever compensated for occupational injury or disease? ..... YES NO
54. Are you now drawing disability benefits from any source? ..... YES NO
55. Does your wife (husband) have any known physical impairment? ..... YES NO

    Is it a condition that requires regular medical attention? ..... YES NO
56. Are any of your dependent children in poor health? ..... YES NO
57. Are you or any of your dependents now covered for any form of health insurance? ..... YES NO
58. Were you ever addicted to drugs or alcohol? ..... YES NO
59. Were you ever denied life insurance? ..... YES NO
60. Have you been refused employment because of health? ..... YES NO
61. If female, have you had health problems peculiar to your sex? ..... YES NO
62. Do you consider your health? Good ( ) Fair ( ) Poor ( )

DATE _____ YOUR SIGNATURE _____



Annex 4

PHYSICAL EXAMINATION

NAME _____ MARITAL STATUS _____ SEX ___ COLOR _____

ADDRESS _____ PHONE NO. _____

AGE ____ APPARENT AGE ____ HEIGHT _____

WEIGHT _____ RECENT GAIN-LOSS _____

TEMPERATURE ____ PULSE _____ RESP. _____

SKIN: CLEAR _____ DISEASED _____

VACCINATION HISTORY: _____

_____

VISION: RIGHT EYE 20/ ____ LEFT EYE 20/ ____

WITH GLASSES: RIGHT 20/ ____ LEFT 20/ ____

HEARING: RIGHT EAR _____ LEFT EAR _____

APPEARANCE: GOOD ( ) FAIR ( ) POOR ( )

DEVELOPMENT: GOOD ( ) FAIR ( ) POOR ( )

IS BLOOD SEROLOGY INDICATED? YES ( ) NO ( )

HEART: LOCATION: _____

NORMAL ( ) ABNORMAL SIGNS ( )

BLOOD PRESSURE _____ / _____

LUNGS: CLEAR ( ) ABNORMAL SIGNS ( )

CHEST X-RAY INDICATED? YES ( ) NO ( )

NECK: GLANDS NORMAL ( ) ABNORMAL ( )

THYROID NORMAL ( ) ABNORMAL ( )

THROAT NORMAL ( ) ABNORMAL ( )

MOUTH: TONGUE NORMAL ( ) ABNORMAL ( )

GUMS NORMAL ( ) ABNORMAL ( )

TEETH GOOD ( ) CARIOUS ( )

BRIDGEWORK ( ) DENTURES ( )

NOSE: NORMAL ( ) ABNORMAL ( )

ABDOMEN: NORMAL ( ) ABNORMAL ( )

ANY SCARS, TENDERNESS, LIVER EDGE?

_____

HERNIA: YES ( ) NO ( )

INGUINAL RINGS: NORMAL ( ) ABNORMAL ( )

UPPER EXTREMITIES: NORMAL ( ) ABNORMAL ( )

LOWER EXTREMITIES: NORMAL ( ) ABNORMAL ( )

GENITALIA: NORMAL ( ) ABNORMAL ( )

PROSTATE: NORMAL ( ) ABNORMAL ( )

SPINE: NORMAL ( ) ABNORMAL ( )

RECTUM: NORMAL ( ) ABNORMAL ( )

URINE: SPECIFIC GRAVITY _____ ALBUMIN _____

SUGAR _____ REACTION ____ CASTS ____

Does examinee have any abnormalities, organic or functional disorders that might interfere with his or her employment? If so, please give details thereof and your recommendations below.

_____

_____

_____

_____

I certify that all answers given in connection with the examination are true to the best of my knowledge, and understand that any willful false statements may result in my dismissal from the Company, if hired.

SIGNED _____
EXAMINEE

Date of Examination _____

I classify the examinee 1 2 3 4

SIGNED _____
MEDICAL DOCTOR

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2 OF 2

DO

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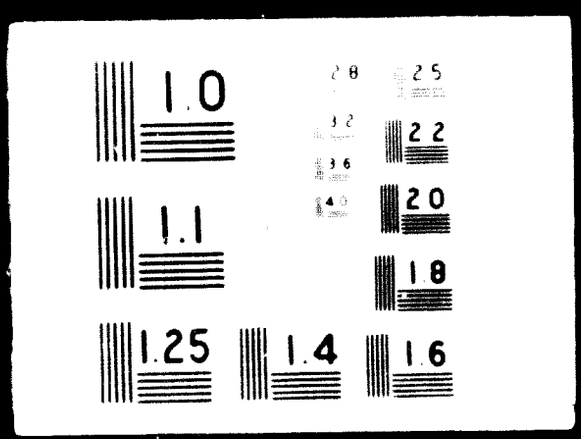

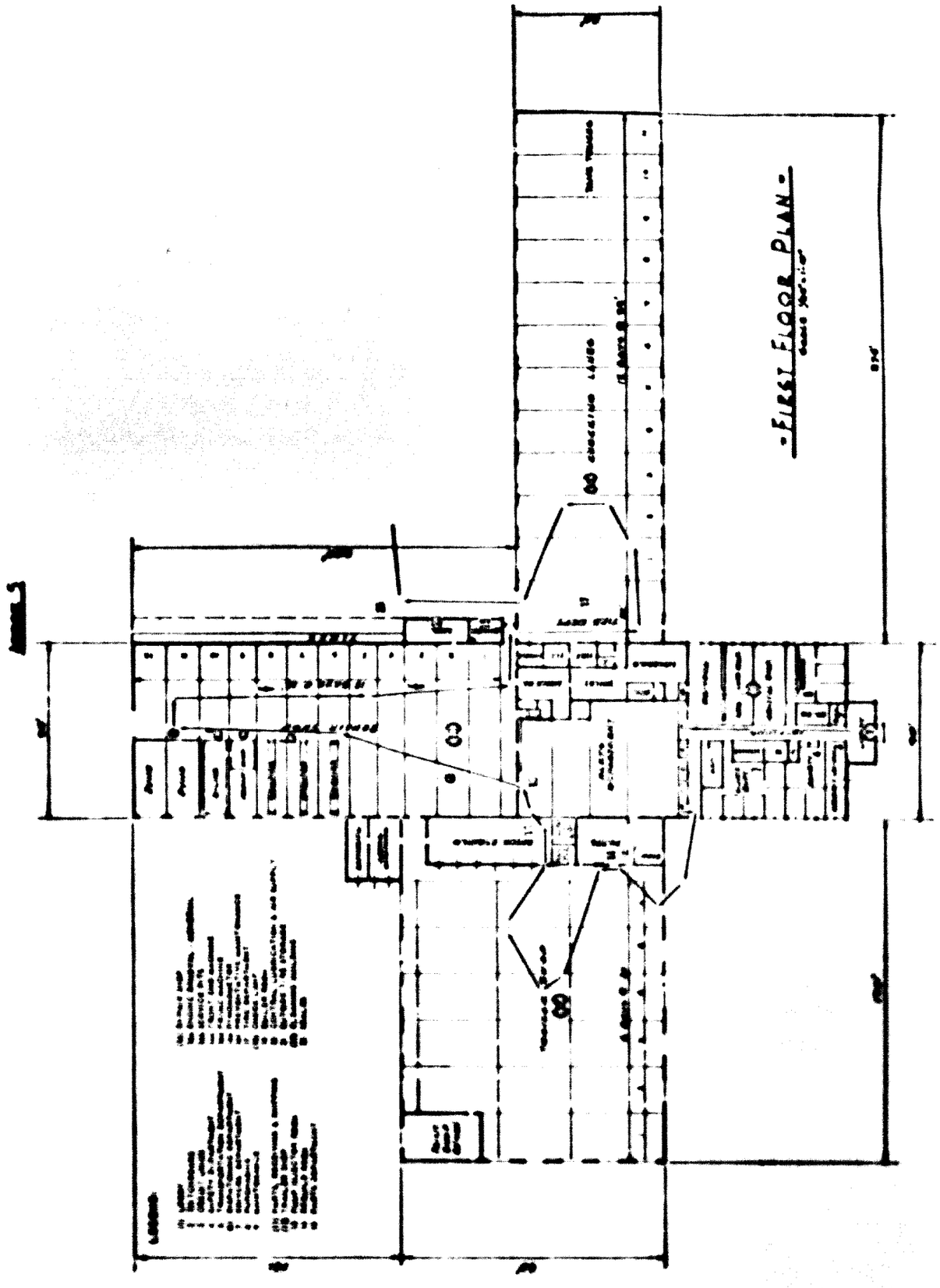
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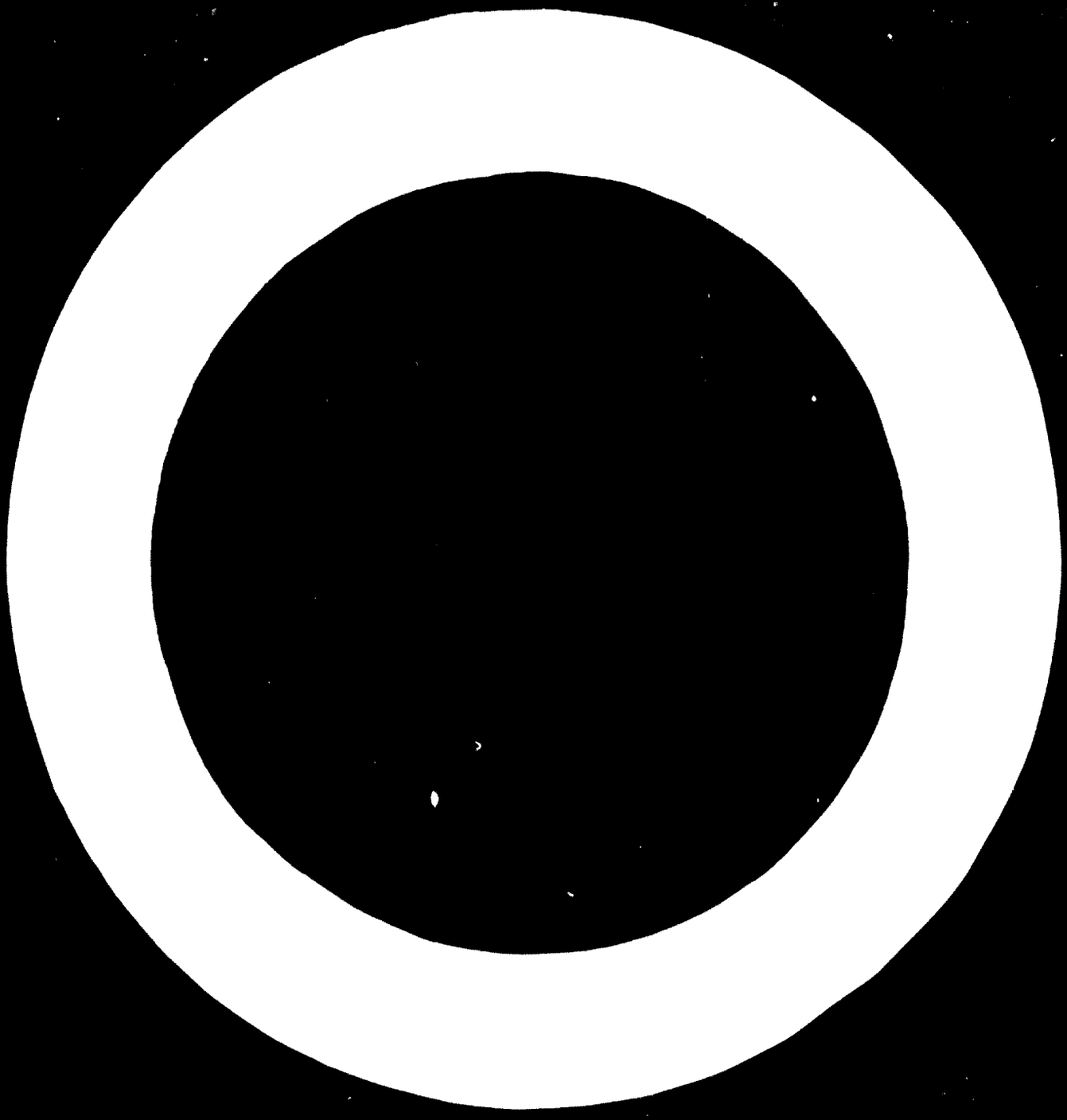


Annex 6

Apprenticeship courses

WORK PROCESSES	APPROXIMATE HOURS
I. Cleaning and inspecting parts	500
(a) Learning all parts and accessories (b) Requisitions and acquiring of parts knowledge	
II. Cylinder heads	750
(a) Cleaning and inspecting (b) Replacing valve guides (c) Removing and replacing valve seats (d) Reaming valve guides (e) Grinding valve seats with grinder (f) Lapping valves (g) Checking valves with dial indicator (h) Installing injector tubes or brass (i) Replacing welch plugs and water test head (j) Rebushing rocker arms and reaming bushings (k) Checking and replacing rocker arm rollers (l) Torquing cylinder head bolts (m) Installation of cylinder head and gaskets (n) Torquing injectors and adjustments	
III. Cylinder blocks and liners	1200
(a) Removing and installing cylinder sleeves, both wet and dry (b) Cleaning and checking water passages (c) Checking counter bores for sleeves (d) Recutting and straightening counter bores (e) Removing and replacing cylinder studs (f) Cleaning piston ring grooves, fitting pistons and rings for clearance (g) Installing and fitting piston pin bushings and piston pins (h) Checking piston rod weight, alignment and rod bores (i) Honing and boring cylinders (j) Cleaning and inspecting oil passages and lines	

APPROXIMATE HOURS

(k) Checking, removing and installing timing gears
(l) Checking main bearing saddles, crankshaft wear and cracks and radius area
(m) Reasons for magnafluxing
(n) Checking clearances and installing main and rod bearings
(o) Proper torquing of main and rod bearings
(p) Line reaming and installing camshaft bearings
(q) Pressure test oil systems
(r) Dial indicating run out on flywheel, housing and dampner
(s) Repair of accessory drive gears
(t) Check and set timing
(u) Checking and repair of oil pump
(v) Installation of crankcase pan and gasket

IV. Clutch — 600

(a) Removing and replacing clutches
(b) Checking and adjusting clutches and linkages
(c) Rebuilding pressure plates
(d) Relining clutch discs

V. Transmission — 1000

(a) Removing and installing transmissions
(b) Adjusting linkage, shift cylinders etc.
(c) Rebuilding transmissions
(d) Inspection of gears and bearings
(e) Clearances and tolerances
(f) Power takeoff

VI. Drive axle — 500

(a) Removing and replacing
(b) Complete rebuild
(c) Inspecting, adjusting and replacement of all gears, bearings and seals
(d) Removing and replacing axles
(e) Rebuild or replace universal joints, yokes, splines etc.

VII. Cooling system — 500

(a) Checking and cleaning internal and external, including reverse flush
(b) Removal, repair and replacement of water pump

APPROXIMATE HOURS

(c) Fan inspection and replacement
(d) Checking and replacement of thermostats
(e) Minor repairs to radiator tubes
(f) Gasket replacement on radiator tanks
(g) Cooling system pressures
(h) Use of anti-freeze
(i) Inspection and replacement of hoses
(j) Inspection and adjustment of belts

VIII. Front end and steering — 850

(a) Remove, repair and install steering box adjustment
(b) Replace front springs
(c) Set camber, caster, toe-in and turning radius
(d) Replace wheel seals
(e) Check shock absorbers
(f) Replace and repair tie rod ends
(g) Replace front axle, king pins and bushings
(h) Balance front wheels

IX. Brakes — 700

(a) Minor and major adjustment
(b) Bleeding hydraulic systems
(c) Replace and turn drums
(d) Relining brake shoes
(e) Rebuild wheel cylinders and master cylinders
(f) Check and repair brake power system
(g) Repair and adjust parking brake
(h) Repair and reset automatic adjusters
(i) Rework or replace backing plates
(j) Rebush cams and repair slack adjusters
(k) Rebuild brake chambers
(l) Trace and have knowledge of all lines, valves and adjustments

X. Electrical systems — 950

(a) Use of equipment to check electrical systems
(b) Repair and adjustment of alternators, starters, generators and voltage regulators
(c) Making and installing replacement wiring systems
(d) Repair and trouble shooting series parallel switches
(e) Battery testing and charging

APPROXIMATE HOURS

(f) Coils, condensors, distributors - repair and replace
(g) Tracing of circuits for shorts on all lights
(h) Installing and testing electrical accessories, including wipers, gauges, horns etc.

XI. Fuel systems — 2500

(a) Parts identification
(b) Injectors - remove, repair, flow-rate and install
(c) Assembling and disassembling diesel fuel pumps
(d) Calibration of fuel pumps
(e) Repair and test fuel pumps and carburetors
(f) Installing fuel lines
(g) Check, repair or rebuild governors and correct all governor functions
(h) Service air cleaners and fuel filtration system

XII. Lubrication — 250

(a) Use of various oils and greases
(b) Cleaning and replacement of all filtering elements
(c) Greasing - front axle, drive shaft, brake components, steering accessories, clutch bearings, universals etc.
(d) Changing lubricate - crankcase, transmission, differential, air cleaners etc.
(e) Lubrication and adjustment of wheel bearings, seal replacement
(f) Lubrication of water pump, distributor, alternator
(g) Inspect and correct all lubricant leaks

XIII. Engine tune-up and trouble-shoot — 1500

(a) Use timing devices, analysers, compression gauges
(b) Clean and test spark plugs, ignition wiring, distributor adjustment
(c) Check firing order and timing
(d) Adjusting valves and injectors
(e) Use of vacuum gauge and tachometer
(f) Dynamometer testing
(g) Use of fuel flowrater
(h) Complete analysis of engine operation and detail listing of repairs needed

APPROXIMATE HOURS

XIV. Welding — 800

(a) Acetylene - cutting, brazing and welding
(b) Electric - cutting and welding
(c) Special - stainless steel and aluminium
(d) Knowledge of metals and welding supplies

XV. Air system — 160

(a) Removal and overhaul air compressors
(b) Rebuilding all air application valves, relay valves etc.
(c) Trouble shooting on air system

XVI. Bench work — 500

(a) Hydraulic test equipment
(b) Rebuilding hydraulic cylinder, valves, power steering etc.
(c) Operation of various machines
  (1) Valve refacer
  (2) Armature lathe
  (3) Brake drum lathe
  (4) Portable drills
  (5) Boring bars
  (6) Arbor press
  (7) Brake tester
  (8) Grinders
  (9) All test equipment

XVII. Automatic transmissions — 450

(a) Repair, rework or replace all types of automotive transmissions
(b) Analyse and test procedures for trouble shooting automotive transmissions
(c) Function and knowledge of torque converters
(d) Repair and rebuild industrial type torque converters
(e) Test and evaluate torque converter functions
(f) Adjusting and rebuilding steering clutches
(g) Relining clutch bands
(h) Adjusting and installing bearings and seals

APPROXIMATE HOURS

XVIII. Painting 6000

(a) Prepare body and fenders for painting
(b) Sanding and rub down preparation
(c) Use of spray gun, spray booths, regulators and their maintenance
(d) Mix paints and knowledge of paints, primers and thinners
(e) Touch up brush
(f) Colour matching
(g) Air sanding
(h) Masking and taping

XIX. Truck and trailer body mechanic **8000 Total**

(a) Stripping wrecked trucks
(b) Straightening frames and miscellaneous parts - 2500 hours
(c) Rebuilding cabs, doors etc.
(d) Layout and fabrication
(e) Riveting
(f) Welding
(g) Chassis assemblies
(h) Use of body fillers
(i) Changing springs and axle assemblies
(j) Installing fifth wheels

Annex 7

Tools and shop equipment for a repair and service shop

Wheel dolly to pull dual wheels
Floor jacks
Hand jacks
Transmission jack which can usually be adapted to differential jack
Bearing and gear pullers
Seal seating tools
Wheel nut wrench
Axle tread chaser
Power hand drills
Power impact wrenches and sockets
Power hand chisel
Compression gauge
Pressure and vacuum gauges
Water and/or mercury manometers
Heli-Coil set
Tire changing equipment
Brake drum lathe
Brake shoe grinder
Brake shoe relining machine
Battery test equipment
Battery charger
Distributor test machine
Valve spring tester
Valve refacing machine
Valve seating vacuum tester
Valve seating tool
Valve lapping tool
Volt-AMP tester
Spark-plug cleaner and tester
Armature tester
Armature lathe
Electric welder
Acetylene-oxygen welding equipment with hoses, valves, and gauges
Welding equipment for stainless steel and aluminium
Air compressor
Torque wrenches, inch pound and foot pound
Tap die set
Micrometers - inside and outside
Depth gauges
Telescoping gauges
Wire gauges
Feeler and thickness gauges
Calipers - inside and outside
Dial indicators
Cylinder gauges
Bench grinders
Portable grinders

Vices
Sander
Surface grinder
Honing equipment
Reamers, various sizes
Tubing cutter
Tubing flaring tool
Bolt cutters
Sockets, above 1"
Thermometer
Ring glan gauges
Ring glan cleaner tool
Hole saw sets
Vacuum pump
OHM gauge
Tubing bender
Metal shear
Magnifying glass
Ridge reamer
Liner puller, wet and dry
Liner and block boring tool
Line boring bar
Chain wrench
Piston ring compressor
Heavy duty C clamps
Heavy duty cabinet clamps
Metal cutting bandsaw
Drill press
Heavy duty press 50 to 60 tons
Engine rebuild stand
Transmission and differential rebuild stand
Engine shutter control test equipment
Degrease tank
Steam cleaning equipment
Adjustable safety stands
Lubrication equipment
Painting equipment including gun, hose, regulator etc.
Tobin arc bar

This is special equipment that requires volume in order to warrant investment, unless the equipment is not available in the area.

Magnaflux machine
Crankshaft grinder
Balancing equipment for clutches, drivelines, crankshafts etc.
Diesel fuel pump test equipment
Injector tester and flow-rate equipment
Wheel balancer and aligner
Heavy duty frame and axle straightening machine
Front end machine for setting caster and camber
Dynamometer
Ignition oscilloscopes
Ultra-high frequency sound detectors for leaks and friction

ANNEX B

REPAIR ORDER

REPAIR ORDER NO. _____ UNIT NO. _____ MILES _____ TIME IN _____

STATION _____ FOREMAN _____ DATE _____ POST SERVICE CARD _____ TIME OUT _____

PARTS AND MATERIAL					WORK DESCRIPTION AND INSTRUCTION	LABOR			
DESCRIPTION	CODE	AMOUNT		ACTION		DESCRIPTION	CODE	TIME	AMOUNT
PM SERVICE	001					PM SERVICE	001		
ROAD CALL	010					ROAD CALL	010		
INSTRUMENTS & ACCESSORIES	050					INSTRUMENTS & ACCESSORIES	050		
ELECTRICAL & IGNITION	100					ELECTRICAL & IGNITION	100		
ENGINE & COOLING	200					ENGINE & COOLING	200		
FUEL SYSTEM	300					FUEL SYSTEM	300		
FRONT AXLE & STEERING	400					FRONT AXLE & STEERING	400		
REAR AXLE DIFFERENTIAL DRIVE SHAFT	500					REAR AXLE DIFFERENTIAL DRIVE SHAFT	500		
CAB & BODY	600					CAB & BODY	600		
BRAKES & AIR SYSTEM	700					BRAKES & AIR SYSTEM	700		
CLUTCH	800					CLUTCH	800		
TRANSMISSION	900					TRANSMISSION	900		
ACCIDENT	950					ACCIDENT	950		
TOTAL						TOTAL			

DA FORM 5988-E

Annex B (continued)

PARTS USED

QUANTITY	DESCRIPTION	UNIT COST	TOTAL COST

TIRE CHANGE REPORT

CODE NUMBER	FROM UNIT	ON UNIT	LOCATION

ROAD CALL AND BREAKDOWN

DATE ________ TIME ________ DRIVER ________

LOCATION ________

TRACTOR NO. ________ TRAILER NO. ________ PHONE NO. ________

TROUBLE REPORTED ________

____

DESCRIPTION OF WORK DONE: ________

____

____

____

____

MECHANIC ________ TIME OUT ________ TIME IN ________

MILES ROUND TRIP ________ TIME UNIT BACK ON ROAD ________

MECHANIC'S SIGNATURE ________

DRIVER'S SIGNATURE ________

CALL RECEIVED BY ________

____

REMARKS ________

____

____

____

ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF

Annex 9

Sample specifications on diesel fuel, petrol, oil and grease

Diesel Fuel

Diesel fuel shall be an all purpose fuel intended for use in all automotive type diesel engines under all normal conditions of service. It shall be a straight run petroleum distillate, free from water, grit, acid and fibrous or other foreign matter likely to clog or injure pumps, nozzles or valves. It shall conform to the following chemical and physical detail requirements:

Cetane Number	Min. 45
Distillation Test	
90% point	Max. 520°F
End point	Max. 650°F
Flash point	Min. 125°F
Pour point	Max. 15°F
Viscosity S. U. @ 100°F	30-45 Secs.
Carbon residue on 10% bottoms	Max. 0.15%
Sulphur	Max. 0.50%
Water and sediment	Max. 0.05%
Corrosion	Pass
Ash	Max. 0.01%
API Gravity	Max. 36

Petrol

Regular petrol shall consist of blends of refined hydrocarbons derived from petroleum, natural gasoline or blends thereof with synthetic hydrocarbons, or aromatic hydrocarbons, or both. Regular petrol shall be free from water, sediment and suspended matter.

Detail requirements

Distillation Range

75°C - 10% Min. Percentages to be evaporated
140°C - 50% Min. Percentages to be evaporated
200°C - 90% Min. Percentages to be evaporated

Distillation residue shall not exceed 10%

Gum shall not exceed 4MG per 100 ML

Vapour pressure - Maximum should be set in pound per square inch based on temperature and location.

Corrosion - Meet requirements for classification 1 for ASTM Test for copper strip corrosion.

Octane Number - Minimum 92 Research method.
Sensitivity at no time greater than 10.

Sulphur - Not exceed 0.2%

Testing shall confora to methods of testing prescribed by ASTM Specifications D-439-50T.

Lubricating oil - internal

One type of heavy duty suitable for crankcase lubrication of reciprocating internal combustion engines of both spark ignition and compression ignition types all conditions of service.

Materials - Petroleum products compounded with functional additive materials (detergents, dispersants, oxidation and corrosion inhibitors). No re-refined components shall be used.

Physical requirements oil

Grade 30

Viscosity @ 210°F kinematic, centistokes		9.65 - 12.98
Saybolt universal seconds		58 - 70
Viscosity @ 0°F kinematic centistokes	Max.	43,570
Saybolt universal seconds	Max.	200,000
Viscosity index	Min.	-
Pour point degree F	Max.	0
Stable pour point degree F	Max.	-
Flash point degree F	Min.	390

Viscosity at 0°F shall be obtained by linear extrapolation of the viscosity values determined at 210°F and 100°F using the Kinematic Viscosity Temperature Chart C (or the Saybolt Universal Viscosity Temperature Chart A), described in Method 9121 of Federal Test Method Standard No. 791.

After being cooled below its pour point, the oil shall regain its homogeneity on standing at a temperature which is not higher than 10°F above the pour point.

Most manufacturers of today's heavy duty commercial equipment specify Extreme Pressure 90W differential grease. This meets Military Specifications MIL-L-2105B.

Multi-speed transmissions require 90W straight mineral oil in majority of operations.

Annex 10

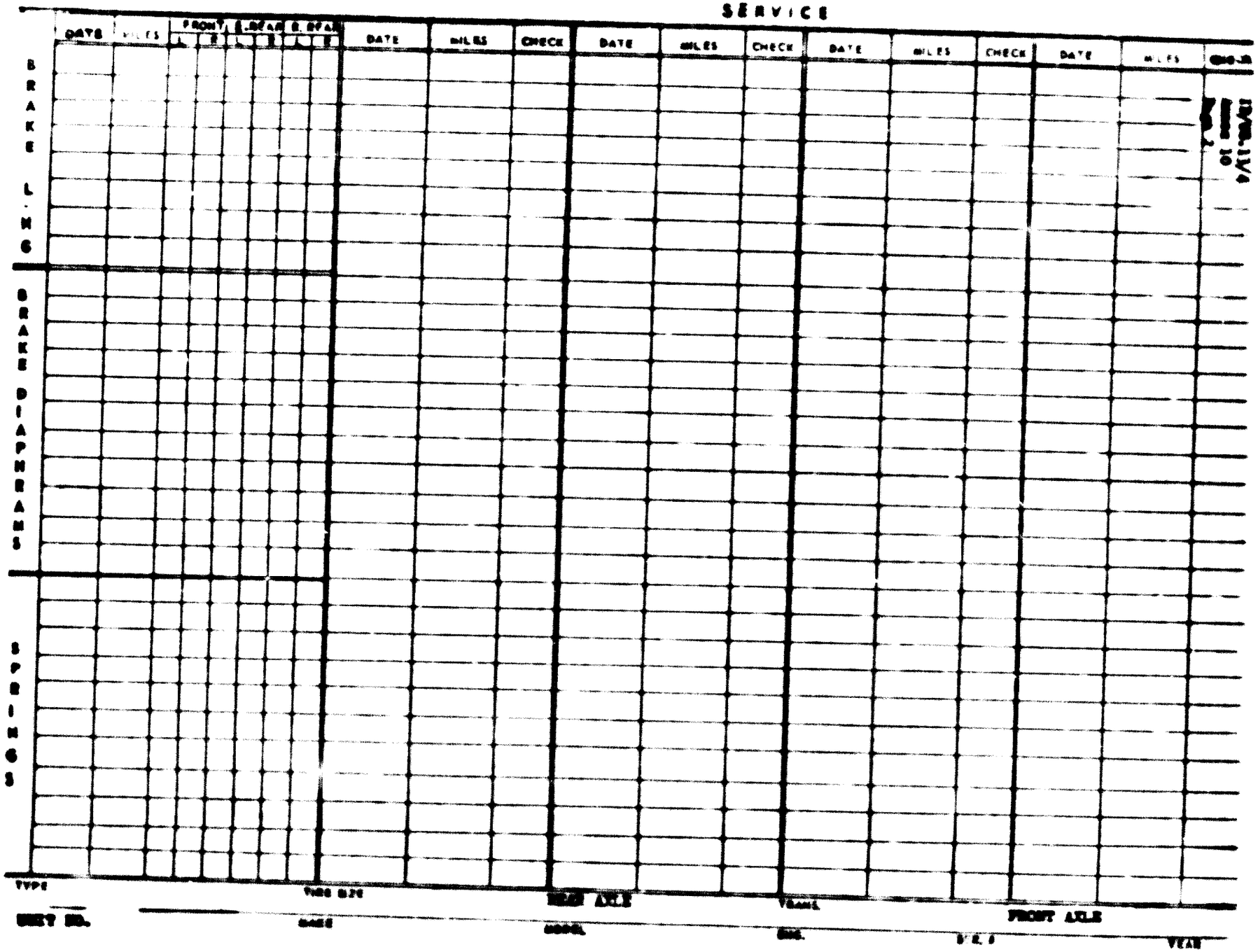
EQUIPMENT NO. _____

MAINTENANCE RECORD

	TRANS	DIFF.	TRANS OIL	DIFF. GREASE	ALT.	CLUTCH SPEEDO	PRIMARY FILTER	FUEL FILTER	GEN	MISC.	MISCELLANEOUS
D											
M											
D											
M											
D											
M											
D											
M											
D										PUMP STARTED	
M											
D											
M											
D											
M											
D											
M											
D										PUMP PRIMED	
M											
D											
M											
D											
M											
D											
M											

DATE	MILES	ENGINE	ACCIDENT REPORTS

Annex 10 (continued)



Annex 11

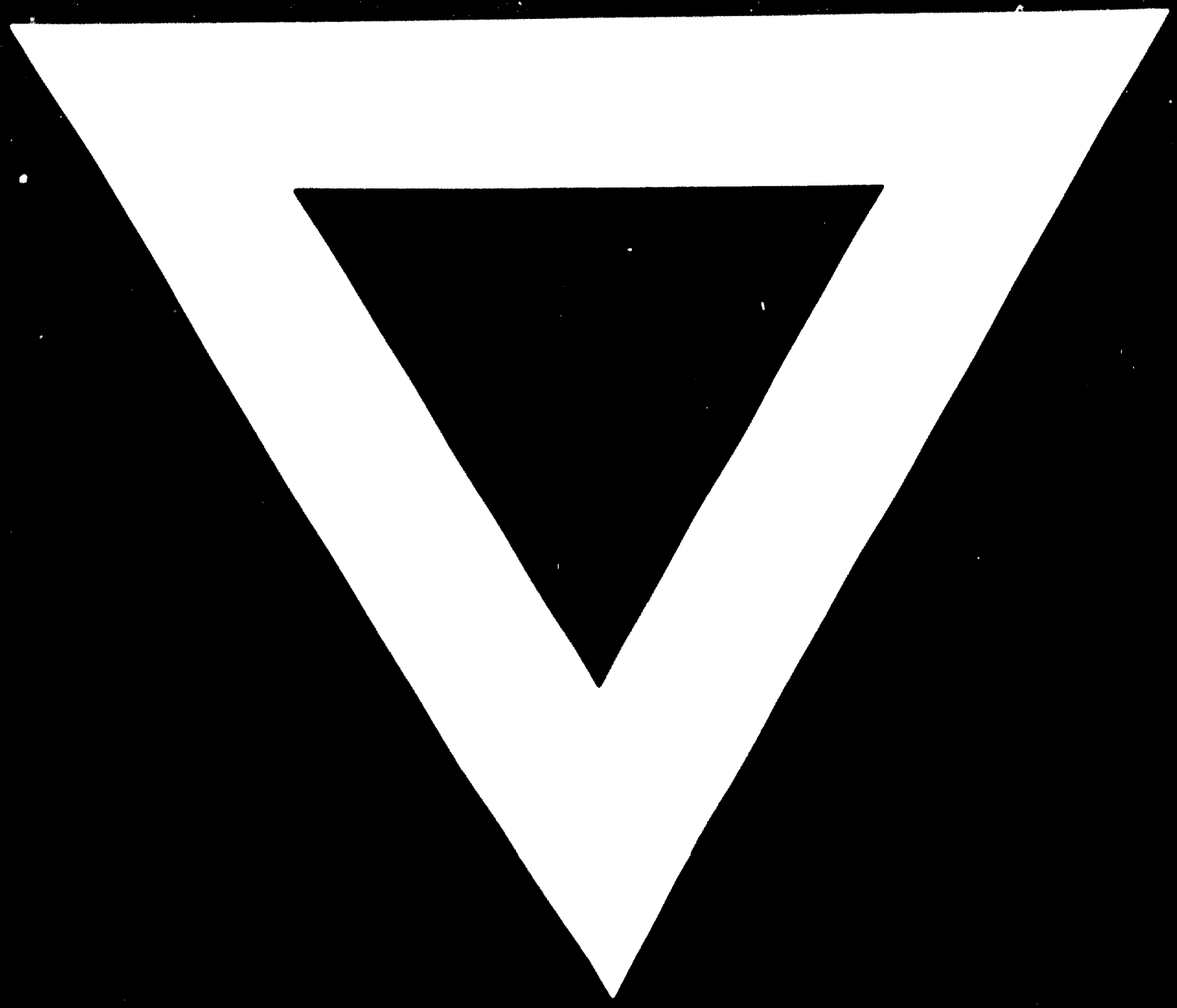
Maintenance Repair Codes

GROUP	CODE	SUB-GROUPS
PM SERVICE	001	Oil change, grease Filter changes (oil, fuel etc. as part of PM)
ROAD CALL	010	
INSTRUMENTS AND ACCESSORIES	050	Tachometer and attaching parts Speedometer and attaching parts All gauges Horn and wire Battery and cables Throttle, choke and engine shutdown Accelerator controls Engine alarm Low air buzzer Safety equipment PTO pump Air Conditioner and related parts
ELECTRICAL AND IGNITION	100	Lamps, bulbs Indicators Starter, alternator Starter, alt. controls Distributor and controls Plugs, coil, wiring Volt regulator, relays
ENGINE AND COOLING	200	Engine / components Accessory drive, belts Cylinder head, cover Manifolds Engine mounting Oil lines, filters Radiator and mounting Fan and drive Water pump Water fittings, hose Ferry filter Shutters, shutterstat, valves Thermostat

NOTE - Code all Dyno Work 200 - Unless work performed specifies another code.

GROUP	CODE	SUB-GROUPS
FUEL SYSTEM	300	Fuel tanks, lines and fittings Fuel filter Fuel pump Blower, governor Carb Air cleaner Injector
FRONT AXLE AND STEERING	400	Axle, steering knuckle and king pin Steering arm, tie rod Steering gear, column Steering wheel Drag link Power steering Wheel bearings, seals Springs, leaves Landing gear and attaching parts
REAR AXLE AND DRIVE LINE	500	Axle housing Axle shaft Carrier Gear and pinion Axle control Drive line tubing Universal joints Yokes, flanges Spring, leaves Wheel bearings, seals Sliding tandem
CAB AND BODY	600	All sheet metal Fenders Heater and controls Mirrors Fifth wheel Battery box and cover Bumpers Hood Frame, crossmembers Exhaust pipe, muffler Tow hooks Cab glass Floor covering, seals Engine cover Seats

GROUP	CODE	SUB-GROUPS
BRAKES AND AIR SYSTEM	700	Shoe and lining Compressor and governor Brake shoe mounting Wheel cylinder Brake camshaft Slack adjuster Brake chamber Master cylinder Brake valves, lines Air tank Parking brake and controls Brake pedal and linkage Drums, wheels
CLUTCH	800	Plate, disc Flywheel Centre plate Controls, linkage Bearings
TRANSMISSION	850	All components Mounting Shift lever, controls Power take-off, controls
ACCIDENT	900	



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