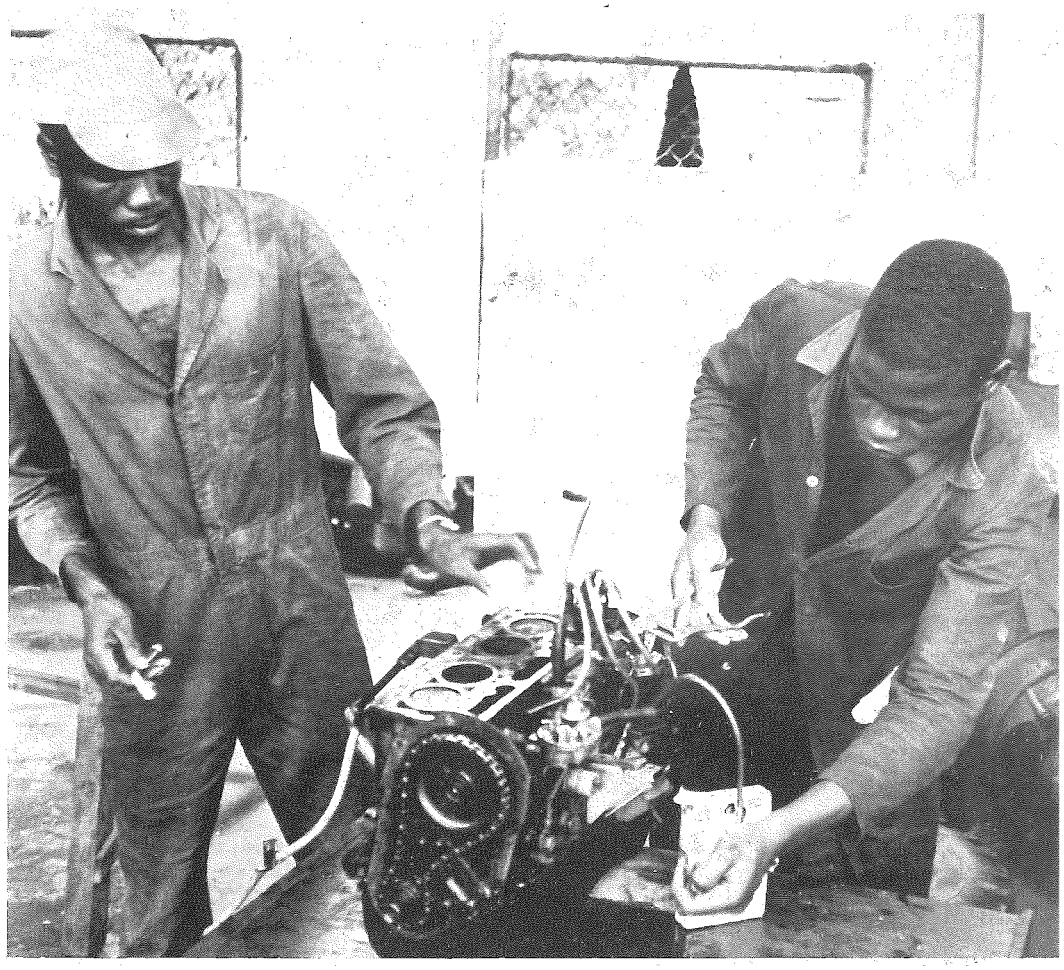
FAO AGRICULTURAL SERVICES BULLETIN 30

machinery servicing organizations



FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS ROME

FAO AGRICULTURAL SERVICES BULLETIN 30

machinery servicing organizations

by

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(heavy equipment)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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C O N T E N T S

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I.

INTRODUCTION

The vital role of selective agricultural mechanization along with other inputs in modern agriculture is well recognized. Machinery input forms a major part of the capital investment. Maximum returns from other farm inputs to a large extent depend on the serviceability and optimum utilization of machinery.

Economic planners and other experts concerned with the development of modern agriculture are aware of the importance of selection of appropriate machinery, training of farm machinery operators and regular maintenance of these machines by the operators. Sometimes professional advice in this direction is utilized, when new agricultural projects are initiated.

Unfortunately, this in itself is not sufficient to achieve the desired goals of agricultural development and maximum return from the investment. It is essential that the machinery purchased must remain serviceable and available for work not only in the early stages but throughout the economic life of the machines.

Timeliness in farm operations is crucial. Many agricultural operations have to be performed within a very short time, adjusting the schedule to the unpredictable weather conditions, over which the agriculturists have very little or no control.

Therefore, any breakdown of agricultural machinery during this active season, even for a short period can mean a big loss or even total failure. Whenever such a situation arises, which unfortunately often happens in many agricultural schemes in the developing countries, the evident eyesore that cannot be ignored is the machinery waiting for repairs.

The immediate obvious reaction is to point out the insufficient service and repair facilities or inadequate spare parts supply. In fact, these are only superficial symptoms. Even then, sometimes, repairshop facilities are increased to such an extent that it is difficult to manage them and they become an end in themselves. At other times the reaction leads to ad hoc massive order for spare parts, which may outlive the machines they were intended for. Often, the problem still remains unsolved in the following seasons, in spite of increased economic burden.

The real problem, in fact, is prior planning. Planning of the servicing organization in quantitative terms, not after the machinery has been purchased, but planning and considering the type of servicing organization along with the selection and purchase of machinery. It is a prerequisite that the two of them i.e. the purchase of machinery and the establishment of a servicing organization, are considered simultaneously, as interdependent. It must be realised that the fixed investment required

for an adequate and effective servicing organization may be as much as one quarter or more of the total investment in machinery; the availability and optimum utilization of machinery to a great extent depends upon the servicing organization from the onset. Furthermore, the fixed servicing cost per hour may constitute from 10 to 25% of the total cost per hour of machine operation. Therefore it is essential that the establishment of a machinery servicing organization be properly planned and given adequate consideration.

This book is intended to point out the factors contributing to the proper organization of servicing structures, analyse them, quantify the problems and provide guidelines along which a systematic activity can be planned. These guidelines are based on empirical data and likely to vary to a certain extent under different conditions.

It is hoped that this book will prove useful to the economic planners for project formulation and to the agricultural engineers in implementing these.

II.

COMPONENTS OF A SERVICING ORGANIZATION

There is frequently a wrong notion from the start, concerning the objectives of a servicing organization, which aim at repairing machines in record time , having all the spare parts always available, and making arrangements for the quick arrival of a mechanic after a machine has broken down.

The first and main objective of a servicing organization is to anticipate breakdowns and avoid machine downtime. The capacity to act quickly, to have adequate spare parts available and be able to face an emergency should be in-built characteristics of a good workshop organization, not objectives in themselves.

A servicing organization, for that matter any efficient organization, is generally divided into different sections, for ease of administration and better control, but no organization may be split up into too many parts that coordination becomes a bottleneck.

A machinery servicing organization may be divided into the following three sections:

a) Personnel and training section

b) Shop and field repair section

c) Spare parts section.

(a) Personnel and training section

The first and most important component of a service and repair organization is the staff, especially their managing and planning ability, in addition to their technical skills, without which very little can be accomplished.

A service manager, like any one else in a managing position has to earn confidence in his organization from the people above and outside, while creating inside the conditions that will allow his men to perform the job he has specified for them. This calls for training - under one form or another - at all levels; management, financial, administrative and technical training must be kept as an indispensable activity. The service manager must plan his own training besides regular and scheduled training sessions for technical and administrative employees.

Technical knowledge and job know-how can be created and generally has to be created under these circumstances in the developing countries; the organization has to be geared for this basic activity through a scheduled training programme.

b) Shop and field repair section

In a machinery service and repair organization this section has two components:

(i) Main repair shop

(ii) Field repair shops and mobile service.

The object of a repair and service organization, as stated before, is to anticipate breakdowns and avoid machine downtime. No confusion should exist between a proper organization and an isolated mechanic, whose job is to repair a broken down machine as quickly as possible. An isolated mechanic acts after, while an organization must act before the machine develops serious problems.

The main activity of a servicing organization therefore, is of a preventive nature, with a secondary action on correction, while an isolated mechanic cannot but mostly have a corrective action. Pushed to its extreme, this order of priorities leads to a field activity almost exclusively of a preventive nature and shop activity predominantly corrective. Under ideal conditions the field mechanic replaces machine assemblies/components before they break down; these assemblies/components being later repaired in the shop and kept in the component bank for later use. This procedure calls for an initial investment in assemblies/components but avoids heavier investment in repairshops and spare parts.

It calls for field mechanics especially good in diagnosing failures, machine operators with enough training to detect the initial minor symptoms, good management of the whole operation to anticipate the needs and have replacements available. Result: top machine availability.

c) Spare parts section

Adequate spare parts availability is indispensable for effective and economical servicing and repair of machinery. Economy in spare parts below the adequate level is nearly always a false economy, though leading to lower investment for a short time, but always to a much larger investment in machinery and/or repair work and certainly leading to a lower machine availability and lower return on overall investment.

Lack of spare parts is all too often used as an excuse for poor service, which in reality is very often caused by poor management. Sudden bursts of overreaction in parts stocking seldom pays off in a higher spares availability and it certainly is a very expensive and ineffective way of keeping the machines available.

It is common practice in many developing countries, whenever new machines are imported, to bring in a very high percentage of its value as spare parts. Besides the very high financial cost of such a procedure (often a good part of the initial stock will never be used), it will not

significantly improve the parts availability when compared to a well balanced stock, and at the same time it unbalances the supplier, be it a dealer or even a manufacturer.

Therefore, extreme care should be taken in determining and keeping a well balanced stock of spare parts.

III.

SETTING UP A SERVICING AND REPAIR ORGANIZATION

In some developing countries, where many large scale land development projects are being set up, generally there are not enough repair and spares facilities to cater for such needs. To the manufacturers and their dealers, the organization of servicing facilities is frequently a losing proposition, if only direct income is accounted for. Therefore, in most cases, it is a pre-requisite that a servicing and repair organization is established along with the new projects.

The existence of a repair organization and/or the size and functions of such an organization should always be decided by economic analysis. Some of the questions to be answered are: how much can be gained or may be lost, how much will it cost, what investment will be required and at what return rate, what is the manpower needed and available, what other activities or sources of income will be affected by machine stoppage.

Personnel:

Whatever the justifications for setting up such an organization, the first and foremost consideration is the staff and their technical ability. Some rules are indicated below to determine the number of mechanics required, according to the types of machines:

TYPE OF MACHINE	ANNUAL WORKING HOURS	REPAIR TIME	ACTUAL TIME IN HOURS FOR REPAIRS
Farm wheel tractors	800	5%	40
Farm crawler tractors	1500	7%	105
3-Point or towed equipment for above	-	40% *	16-42 *
Earthmoving machines	2000	10%	200
Special Agricultural machines (like combine harvesters, etc.)	No more than 500	10%	No more than 50

* 40% of time needed for tractor repairs, during the corresponding working period.

TIME AVAILABLE FOR WORK PER YEAR

Theoretically a mechanic has approximately 2,000 hours available for work per year. At 100% efficiency, one mechanic can service 35 wheel or 13 crawler farm tractors with corresponding equipment or 10 earthmoving machines, if all the machines are brought into the repair shop.

Normally 30% of his time is considered as lost, due to annual leave, sickness, absenteeism, etc., so that approximately 1400 hours per man per year are available for work; of course, wide variations must be accepted depending on local conditions. The exception to this rule is the field serviceman, who usually works longer hours, due to exigencies of field work, and may total more than 2,000 "paying" hours. Nevertheless, his actual productive hours of work may be lower due to varying weather conditions (too hot or too cold, rain, dust storms, etc.) and time lost in travel.

CATEGORIES OF PERSONNEL

(a) Shop foreman:

Normally a shop foreman must devote 10% of his time to each serviceman in the shop. Therefore, as a general rule there should be one full-time foreman for 7 service personnel. They should be chosen for their technical skill, organizing and managerial ability.

(b) Field mechanics:

Field mechanics should be chosen among the best men, technically and personally. Working frequently on their own, without any immediate supervision or guidance, they should be able to inspect, detect future weak points, diagnose faults and correct them.

(c) Specialists for overhaul:

Working under the guidance of their foremen, they must form teams capable of carrying out a full overhaul of a machine.

Each one must be trustworthy in the following:

Engine

Transmission

Electrical

Hydraulic

Undercarriage

Welding, blacksmithy, etc.

(d) Helpers:

This category is normally classed as apprentices, assistantmechanics and so on. Their number varies often from 10 to 20% of the number of mechanics. In some countries, depending mostly on their wages, there may be one helper to a mechanic. But for efficiency sake, this high rate should be avoided.

The commonly accepted distribution of the above categories is:

General mechanics	30-50%
Field mechanics	50-30%
Hydraulic specialists	7%
Other specialists	8%
Helpers	5%

The proportions indicated above will significantly change depending on field activity. In the case of a governmental agency, whose machines are to be exclusively serviced by their own mechanics, a frequency of 12 or more mechanic visits per year per machine will not be out of proportion. Whereas, a private dealer or servicing organization should not count on visiting more than 60% of the existing machines during any year and no more than 6 visits per machine per year.

The personnel required for the spare parts store should be added to the set up mentioned above. Depending on various factors the personnel may be:

Parts manager

Store room staff

Stock control staff.

TRAINING

As already mentioned, training should be considered as an essential component of the organization and the activities of this section should be continuous, especially when earthmoving and specialized agricultural machines are to be serviced.

A training programme will depend on the local requirements and facilities already available in the country or region. The need for organized training may be due to any one or more of the following reasons:

(i) Increase in the number of machines which requires an increase in the number of men, so that the ratio of mechanics/machines is kept at convenient level.

(ii) Expansion of mechanized area or other activities, with corresponding expansion of the servicing and repair facilities.

(iii) Increase in types of machines or replacement of old machines by new models/types.

(iv) Increase the efficiency of the servicing organization.

The training programme must have courses adapted to the different levels of know-how and specialization, such as shop foremen, specialized mechanics, store keepers, helpers etc. The programme will include:

(i) Formation courses or apprenticeships for technical school work in the shop, under the guidance of experienced staff, in such tasks as disassembling, assembling etc.

(ii) Specialized courses for the staff who have shown preference for either hydraulics, engines, injection system or electrical system etc.

(iii) Information courses on specific models.

(iv) Refresher courses for all different categories of staff.

In order to be able to put on such an activity the programme must have:

(i) A team of well prepared instructors.

(ii) Suitable facilities

(iii) Adequate training aids.

Besides the basic programme and facilities, it is convenient and desirable to have a mobile training vehicle in order to:

(i) Show to the machine users the importance of servicing.

(ii) Give them advice and instructions on daily maintenance and easy to accomplish repairs.

(iii) Give general mechanical information, especially under visual form (films, slides, cut-away models, etc.)

In order to be able to accomplish these tasks, the training vehicle must:

(i) Be equipped with a good electrical system

(ii) Be comfortable enough

(iii) Be fast and sturdy enough

(iv) Be able to house or conveniently show to a number of participants, whatever visual aids are available.

(v) Be easily mounted on an existing body.

(vi) Have a good volume and load capacity.

(vii) Have readily available a good supply of training aids.

TECHNICAL PUBLICATIONS:

Technical publications have a very important role in a servicing and repair organization, not only during training but throughout the working life of the machine. These publications should be readily available to the staff, whenever they feel the need for it, whether before, during or after the repairs. Staff who are interested and capable of consulting these publications, should be encouraged to do so and be helped, whenever and as required. This is one of the cheapest and easiest methods of continuous improvement in the organization.

Manufacturers of all reputable and reliable machinery publish Workshop Repair Manuals and other technical detailed information. In case they are not available free, these must be purchased along with the machines and made available to the staff concerned.

Manufacturers, in addition, either regularly or from time to time, bring out alterations, corrections or additions to such publications; arrangements must be made to receive these and appropriate action should be taken to make use of them.

Technical publications, in no way should be kept as decorative pieces in the workshop office but full advantage should be taken for self improvement by their use.

To the repairshop staff the technical publications will:

(i) serve as a guide in repair work.

(ii) show all the details of calibrations and torques.

(iii) serve as notice to any changes from previous models.

(iv) point out any repair techniques developed for the new machines.

(v) Explain the proper use of special tools.

WORK SHOP: TYPE AND SIZE

The size and type of a work shop will be determined by the number of machines to be serviced, their type, age and annual hours of work, as well as proportion of repairs intended to be carried out in the shop and in the field. The last factor, as already mentioned, is a most important one, as far as machine availability is concerned. Still, if adequate spare parts are not available or there is a communications gap, a reinforcement of the activity will not necessarily mean higher availability of the machines.

As an illustration: (which is shown in the graph form later):

100 machines to be serviced will require 12 mechanics in the shop, 8 field mechanics with 8 repair mobile vehicles and a workshop area of 500 sq.m. if 60% of the repairs are to be done in the shop and 40% in the field; keeping constant all the other factors (age, type, number of machines, annual working hours, efficiency level of staff, travelling hours per intervention, number of mechanics per mobile repair shop etc.), but changing the proportion of repair to be done in the shop to 30% and 70% in the field,

there will be a decrease in the number of shop mechanics to 6 from 12 and increase in the number of field servicemen to 13 from 8; a corresponding decrease in the size of the repairshop to 250 sq.m. from 500 sq.m. and an increase in the number of mobile repair vehicles to 13 from 8. The initial investment may not differ very substantially, depending on the type of workshops (250 sq.m. versus 5 mobile repair vehicles) but the operating cost for the mobile shops will be higher.

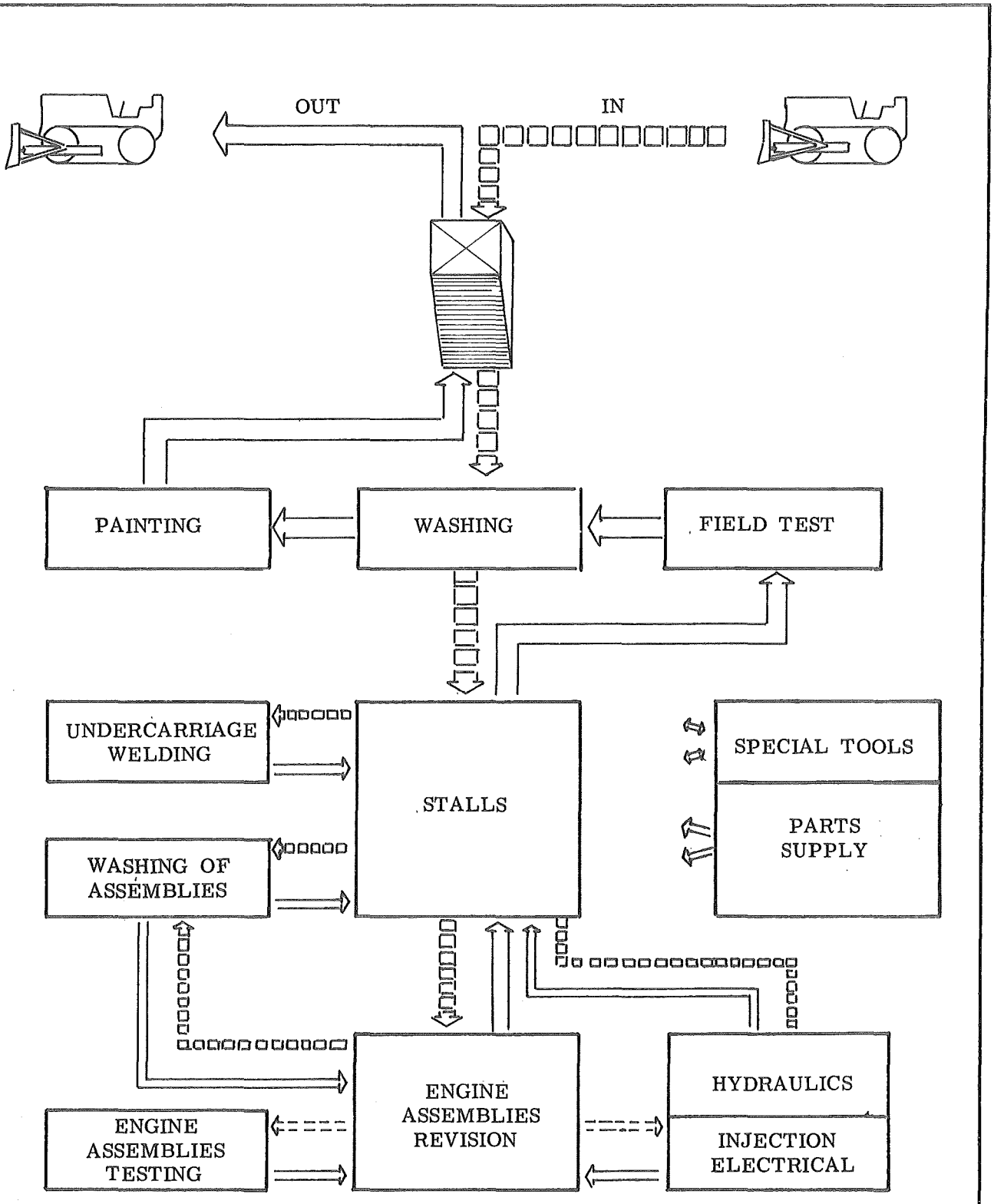
LAY-OUT OF WORK SHOP

Whatever the decision as to fixed or mobile work shop proportions, a good repair shop must be able to repair any machine that is brought in; the exceptions being those mechanical devices or operations that are very specialized and need a higher volume of work than available in this shop to be economical e.g. balancing a turbo charger, rectifying a crankshaft, etc.

The work flow and corresponding lay-out of a work shop should always be, approximately as shown on the next page and on pages 98 through 101.

For the sake of cleanliness, noise control and fire risks, a standard work shop should be organized in several sections. Sometimes, various sections have to be physically separated, location of various sections in relation to each other depends upon the frequency and use of common facilities and equipment which also determine the arrangements of equipment within each section. This facilitates the smooth and economical operation of the work shop.

It is desirable that each mechanic be provided with a complete set of hand tools adapted to his job. The special tools for each are arranged in the vicinity of the specialized area.


OUT
IN
PAINTING
WASHING
FIELD TEST
UNDERCARRIAGE WELDING
WASHING OF ASSEMBLIES
STALLS
SPECIAL TOOLS
PARTS SUPPLY
ENGINE ASSEMBLIES TESTING
ENGINE ASSEMBLIES REVISION
HYDRAULICS
INJECTION ELECTRICAL

Following is a brief description of the order of operations for a machine overhaul.

a) WASHING AND GREASING

Whenever any machine is brought to the work shop for repairs, it should be cleaned and washed before testing. It may seem fastidious and superfluous, but this procedure will greatly facilitate later work and will decidedly increase the overall efficiency of the work shop. At the end of the repairs, it should again be cleaned, greased and if required painted. The area must be equipped with high pressure water hoses and/or steam cleaning equipment.

b) DISASSEMBLING, ASSEMBLING

This section comprises:

i) Engine repair area

ii) Other components repair area

iii) Area of checking operations common to all.

The machine is placed in its bay where it is disassembled; major components are then checked or worked on separately in special rooms for injection equipment, hydraulics, electrical components, engine, undercarriage (if so equipped). Each major component may need, as is the case in general, a more complete cleaning before being disassembled and repaired. Special equipment and checking tools are required to work on disassembled parts, like crankshaft balancing and alignment, connectiong rods and piston weighing, cylinder heads checking and rectifying, if needed, valve grinding, undercarriage disassembly and rebuilding, turning bushes, etc. Each major component is assembled and checked as much as possible before being returned to the machine bay for final assembly.

c) ELECTRICAL, HYDRAULIC, INJECTION TESTING AND REPAIRS

A separate room, specially equipped is required for each of these sections. Batteries charging bench should also be close to these rooms with an arrangement to take out exhaust gases generated during charging.

d) WASHING OF DISASSEMBLED PARTS

All small parts are cleaned before inspection and repairs with grease solvent. Large parts are cleaned with steam and solvent. An exhaust must be provided.

e) UNDERCARRIAGE AND FABRICATION:

All the work related to undercarriage, chassis, blades, buckets, soil contact parts in general, is carried out in this unit. It is equipped with an undercarriage press (180 tons) and a vertical press for correcting bent components (150 tons), as well as rebuilding equipment, cutting and welding equipment, and a metallic structure with adjustment for fixing and welding of fabricated parts.

f) ENGINE TEST:

Before mounting an overhauled engine back in its machine, a test may be run to determine horsepower and fuel consumption. A dynamometer is needed for such a test, which should be installed in a well ventilated, exhaust equipped, soundproof room.

g) PAINTING:

After the repair or overhaul is completed, it is desirable to check the machine in actual working conditions. This should be followed by cleaning and painting. It is necessary to provide proper exhaust arrangements in the painting room.

h) TOOL ROOM:

As already mentioned, it is desirable that every mechanic be provided with a complete set of hand tools adapted to his job, but there are some special tools and equipment that cannot be distributed to each mechanic, due to occasional use, difficulty to keep, too delicate, too expensive, too cumbersome etc. These tools are kept in a tool room and will be made available as needed, against a ticket or identification card.

FIELD SERVICE AND WORK SHOP

Field service plays an extremely important part with regard to machinery difficult to move around. This applies to heavy machinery whose time is too valuable to be spent on the road and similarly to agricultural machinery during seasonal peaks. Field Service is also more convenient to the machinery user, for a continuous and adequate attention to his machines.

In order to provide such a service, a repair and servicing organization needs a certain minimum volume of work in the field to justify the investment in special equipment.

The type of service vehicle to use, its equipment and cost will depend on the area's topographical and climatic characteristics, as well as on communications availavle, distances involved, and of course the types and number of machines to be serviced. A four-wheel drive, diesel powered truck (2-3 ton

load capacity) will be able to reach almost all places where machinery is capable of working. It should be able to carry all the equipment and tools needed (hand and special tools, necessary spares and general equipment) for field repairs, as well as any major components needing replacement or repair work in the main workshop.

Such a truck may not be needed if the machinery is always working very close to all-weather roads. In such cases, service vehicles of other types, which are less expensive, may be used. A truck of the same load capacity but with normal two-wheel drive is cheaper; similarly vans of various capacities, diesel or gasoline powered, even four-wheel drive light vehicles (jeep types) can be used, but these will be less reliable and restricted in their utility.

Illustrations and lists of tools of service vehicles are shown in Appendix 6.

SPARE PARTS

A spare parts store must always be considered as an integral part of a servicing organization. The aim of any servicing organization as already stated, is to have the least "downtime" and if possible none in seasonal peaks. The entire spare parts store set-up should be planned to make this possible at the most economical cost.

Therefore, a parts store must always be equipped with sufficient stocks to provide a vast majority of needed spares, replacements for normal wearing items and for major overhauls. Level of stock in a spare parts store depends on many factors, some of these are quite obvious and clear, while other need more consideration. Proper planning is required to work out the interaction of these factors.

The various factors to be considered are:

(i) Number of machines

(ii) Age, type and state of machines

(iii) Efficiency of operators and level of routine maintenance by the operators

(iv) Working conditions for the machines

(v) Availability of parts ex-stock

(vi) Stock turnover rates

(vii) Lead time for replacement of spare parts.

A servicing organization has directly little or no control over the first four factors, i.e. number and age of machines, efficiency of operators

and field working conditions, still an efficient servicing organization can indirectly influence this to a great extent. These factors are simple and directly related to the spare part requirements[1] and need no elaboration.

The other three factors are closely inter-related and are discussed below:

(a) AVAILABILITY OF PARTS EX-STOCK:

Normally it is acceptable that the main stock should provide 85% of the requested parts, while the maintenance field stock should provide all the wearing items and most of the components on an exchange basis (the faulty assembly is received and a new or reconditioned assembly is made available.

As the machines become old, they will start needing odd parts; generally all the rubber and plastic parts that become friable will need replacement regardless of work performed, also thin metallic sheets are corroded. These form the bulk of the 15% non-available parts, which are not economical to stock, the rest being composed of parts which are needed occasionally due to accidents or unforseeable circumstances. Any attempt to stock these parts may lead to a pile of obsolete, rarely used parts that take up needed space and working capital.

b) TURNOVER RATES:

As a general rule, overall turn-over of 1.5 to 2.0 is realistic and acceptable; below that rate (1.5) the parts availability will be higher, but the capital investment will also be higher. Above 2.0 it generally means that there are not enough parts in stock and off-the-shelf availability will considerably drop, resulting in an inevitable costly machine downtime.

The close relationship between turnover rate and part availability can be illustrated in the following table:

TURNOVER	OFF-THE-SHELF-AVAILABILITY
3.0	50%
2.5	65%
2.0	75%
1.5	85%
1.0	90%
0.8	92%

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(1) FAO Agricultural Development Paper No.66.
"Agricultural Machinery Workshop: Design, Equipment and Management", chap.5 may be referred to for further reading.

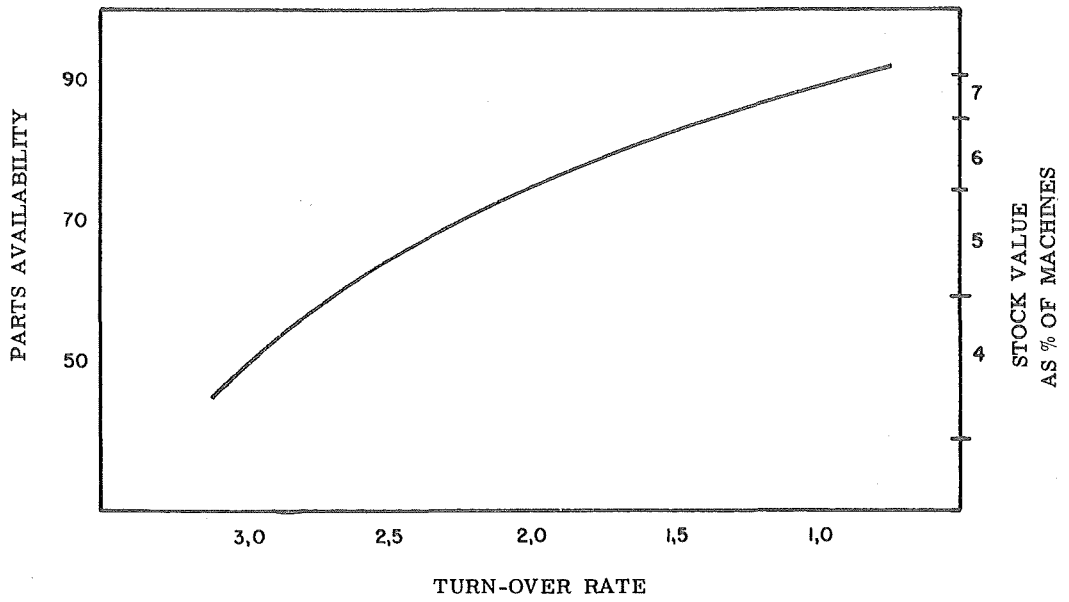
These are only rough indications. Of course, there will be variations, especially when a parts depot is close by; then the parts stocks can be small and have a higher turn-over rate and can then be compared to field maintenance stocks with their normal 3 to 5 turnover rate and an acceptable availability.

This may be converted into figures for better and clearer illustration:

If we consider a machine population of 1,000, with an average price of 30,000 dollars each, acceptable stock value of 8% of the machines, a turnover rate of 1.5 will mean an investment of 1.6 million dollars in spare parts.

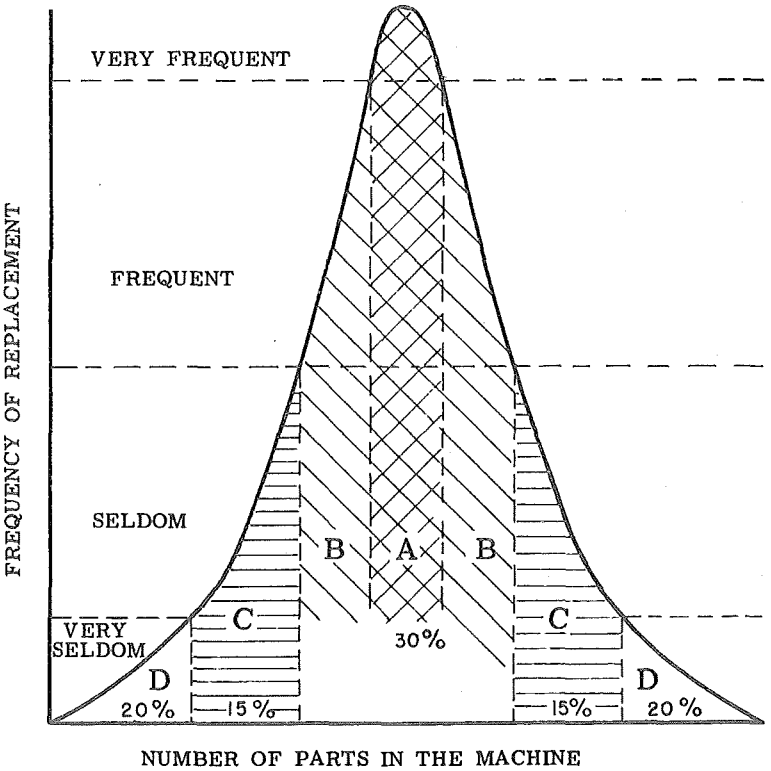
In case, the turn-over rate is changed to 2.5, while everything else remains the same, it will mean an investment of 0.96 million dollars in spare parts, a saving of 640,000 dollars. At the same time, there will be a decrease in off-the-shelf spare parts availability from 80% to 65%, which will mean a machine downtime worth a lot more than 20%. The difference, 20% corresponds to an annual loss of 200 to 400 hours per machine (when they work from 1,000 to 2,000 hours). In terms of value those lost working hours may mean anything, from 1 million to 8 million dollars, if accepting an hourly machine cost from 5-20 dollars.

The close relationship between stock value, stock turnover and parts availability is reflected in the approximate values shown below:



c) LEAD TIME:

Lead time is normally understood as the time interval between ordering from the manufacturer or supplier and having the parts available for use. This varies according to manufacturer's parts availability, transportation time, customs clearance, stocking time (checking, entry, control, distribution). Lead time can vary widely from not less than one month to more than six months, for a bulky stock order. Although orders for a limited number of items can be shipped from the manufacturer's depot in less than 48 hours, local parts availability will depend on transportation and custom clearance procedures. Only through a careful statistical analysis will it be possible to determine what parts should be stocked and at what intervals they should be ordered. The frequency of replacement follows a Grauss-type curve with the following rough characteristics:



Explanation of the curve:

(i) A - represents the fast wearing parts, which need very frequent replacement. These may be about 10% of the total parts in the machine. This will of course vary with the machine, its application, operator habits, maintenance practices. Generally, fast wearing parts are ground contact, work performing tools like ripper tips, cutting edges, plow points, hydraulic hoses and seals, etc.; their life may be less than 100 hours.

(ii) B - represents 20% of the parts which form the machine, needing frequent replacement like seals, under-carriage components, tyres, water hoses, some bearings etc. Frequent replacement indicates more than twice during the economic life of the machine.

Categories A and B marked in the graph, constitute 30% of the machine's components and are responsible for 50% of the frequency. These parts must be stocked at the maintenance and emergency level.

(iii) C - represents 30% of the machine's parts, which are seldom required, that means less than twice in the economic life of the machine. These parts are e.g. ripper shanks, bulldozer blades, major sub-assemblies for engines and transmission, clutches, etc.

These are the parts, which generally constitute the problem area, as they will certainly be needed sometime during the economical life of the machine, but the timing will be determined by factors which cannot always be easily foreseen. These factors are: type of operation, operator's technique, general maintenance, locally available oils and fuels and their handling but the local experience is useful and an efficient service manager and stores controller can do a lot in timing their procurement, without undue overstocking and at the same time keep them available for emergencies.

(iv) D - represents 40% of the total machine parts, which are very seldom if at all required during the economic life of the machine. These parts may be mostly body parts, a vast majority of the engine, transmission gears and cases, radiators, chassis, etc.

Categories C and D are those whose replacement will increase enormously, if and when the machines pass their economical life. The replacement rate for parts in categories A and B is generally directly proportional to the amount of work. Normally parts in categories C and D are bulkier, heavier and more expensive.

The factors which dictate a decision on the level of investment in spare parts have been examined. Now, if an availability level of 85% is agreed then each machine will consume about 5% of its weight in

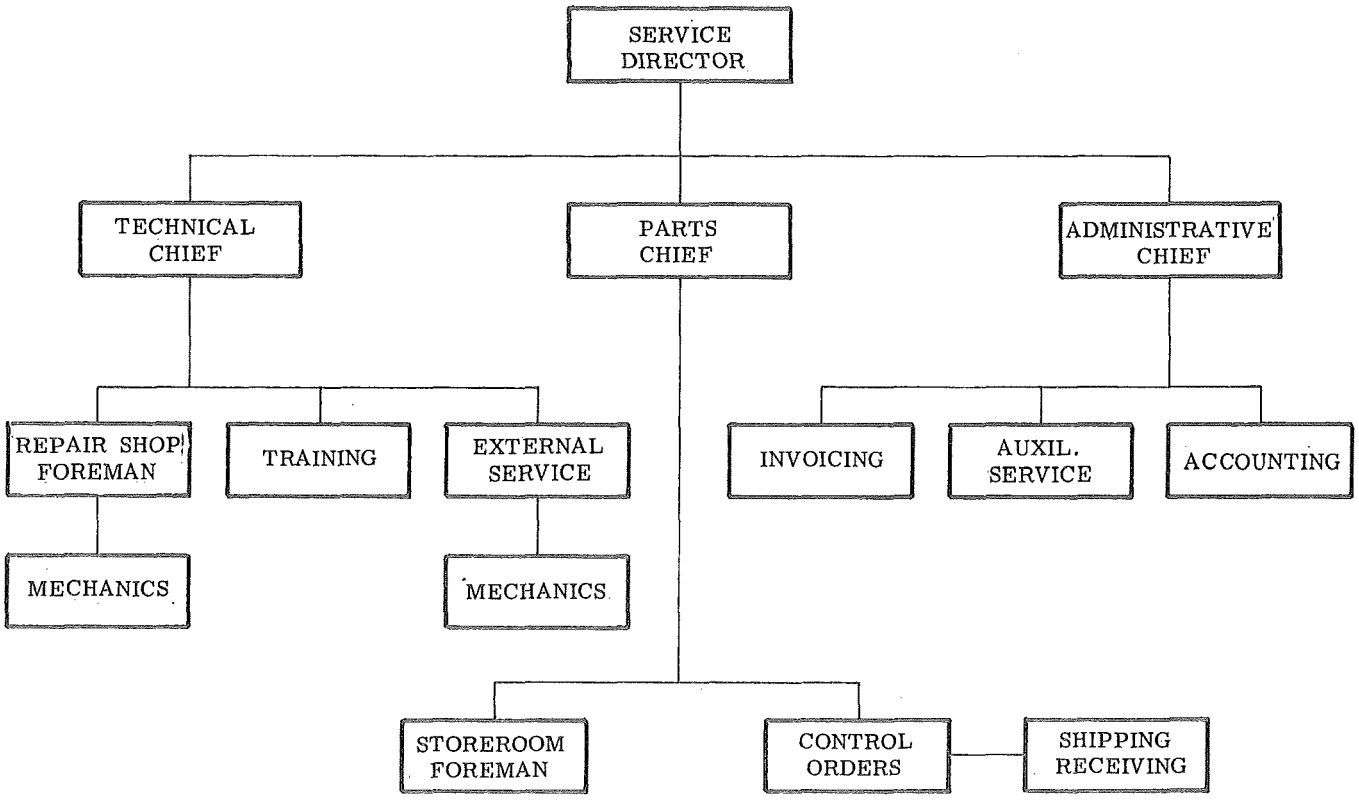
spare parts per year, when it works 2000 hours per year. Unless some special conditions exist, this will mean, referring to the earlier graph, a turn-over of 1.7, and stock value of 6% of the machine's original cost (local taxes may change this figure).

If the average weight of a machine is, say 10 tons, then the average spare parts consumption will be 500 kg/machine/year (5%); the weight of spare parts in stock will be 500/1.7 = 294 kg per machine. The graph indicates, as already seen, a stock value of 6%. If the average price of the machine is taken as 30,000 dollars, this comes to a spare parts stock of 30,000 x 6% = 1800 dollars.

Generally, a surface load of around 150 kg/sq.m. is acceptable; that will lead to 2 sq.m. of store room per machine serviced or spare parts worth 900 dollars per square meter.

STRUCTURE AND DIMENSIONS OF A SERVICING ORGANIZATION

A servicing organization may have a structural set-up as follows:



The organization chart will, of course, be adapted in each case to suit the local conditions and requirements.

DIMENSIONS OF A SERVICING ORGANIZATION

The dimensions of a service and repair organization will depend upon types of machines, their respective numbers, location, age and annual working hours. After that information has been tabulated, a decision must be taken as to what percentage of the servicing will be carried out in the field. This percentage should oscillate between 30% to 80%. It is possible to arrange for repair and servicing below a level of 30% in the field, but it will only be economical in case of very light and manouverable machines, as this will involve practically bringing all the machines to the workshop for repairs. For a level of above 80% repairs in the field, the machines will have to be very simple and have no mechanism requiring specialised tools and skills. It should be considered that even if the machines are not brought into the repair-shop, some components will have to be repaired in the shop.

The following charts can be used to estimate:

(i) Total number of mechanics

(ii) Number of mechanics in the shop

(iii) Number of field mechanics and repair vehicles

(iv) Total repairshop area,

for the following variable factors:

(a) Number of machines to be repaired

(b) Average working hours per annum per machine

(c) Percentage of total work to be carried out within the organization (may be there are services available from other organizations)

(d) Mechanic's efficiency

(e) Percentage of repairs to be carried out within the shop (the remaining repairs will be done in the field).

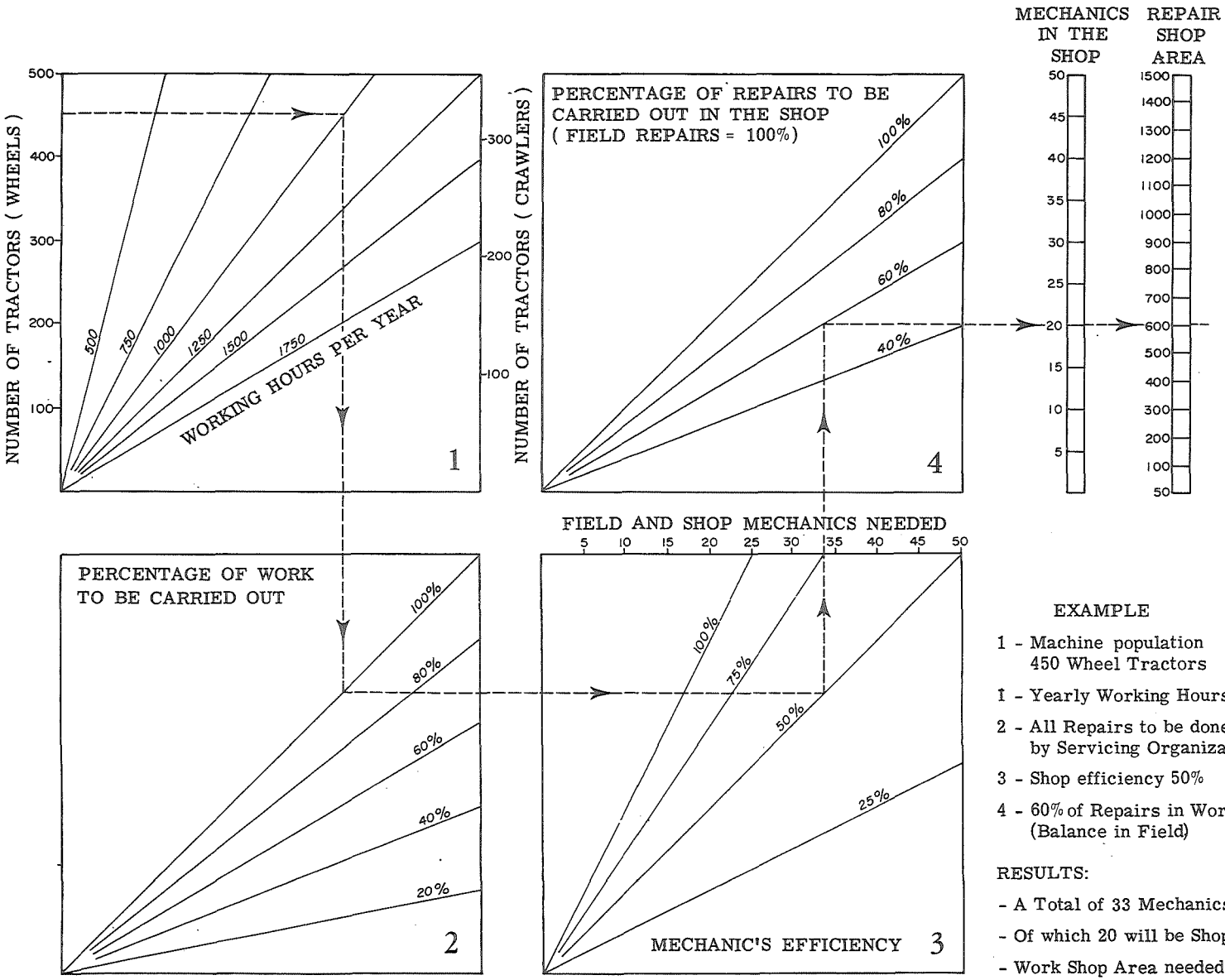
The examples below explain the use of charts.

Example 1 - WHEEL TRACTORS Chart 1.

1.	Machine population	450	
2.	Annual working hours	1000	
3.	Percentage of work to be carried out within the organization	100%	
4.	Mechanics efficiency	50%	
5.	Shop repairs	60%	(balance in the field)

AGRICULTURAL MACHINES

Estimating Work Shop Area - Number of mechanics - Field Repair Vehicles



EXAMPLE

1 - Machine population
450 Wheel Tractors

1 - Yearly Working Hours 1000

2 - All Repairs to be done
by Servicing Organization

3 - Shop efficiency 50%

4 - 60% of Repairs in Work Shop
(Balance in Field)

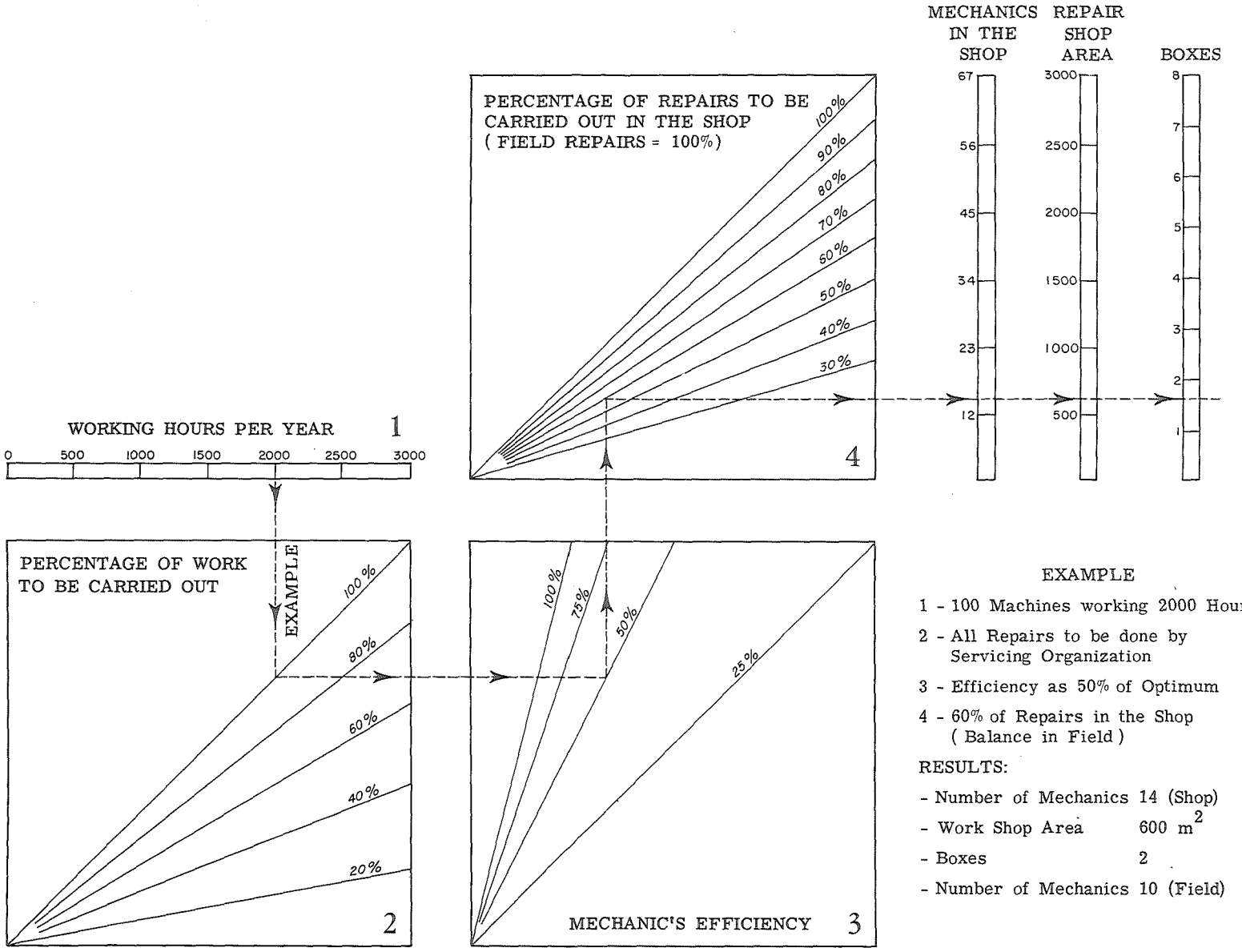
RESULTS:

- A Total of 33 Mechanics will be needed (3)
- Of which 20 will be Shop Mechanics (4)
- Work Shop Area needed 620 m^2

EARTHMOVING MACHINES

FLEET OF 100 MACHINES

Estimating Work Shop Area - Number of Mechanics - Field Service Vehicles



EXAMPLE

1 - 100 Machines working 2000 Hours

2 - All Repairs to be done by Servicing Organization

3 - Efficiency as 50% of Optimum

4 - 60% of Repairs in the Shop (Balance in Field)

RESULTS:

- Number of Mechanics 14 (Shop)
- Work Shop Area 600 m^2
- Boxes 2
- Number of Mechanics 10 (Field)

Results: Read from Chart 1.

1.	Total mechanics required	33	(from Box 3)
2.	Shop Mechanics	20	(Box 4)
3.	Field Mechanics	13	(3-4)
4.	Repair vehicles	13	(One for each field mechanic)
5.	Repairshop area	630 m^2	

Agricultural crawlers should be multiplied by

1.4 and read as wheel tractors in vertical column in Box 1.

Example 2 - EARTHMOVING MACHINES Chart 2.

1.	Machine population	100
2.	Annual working hours	2000
3.	% of repairs carried out internally	100
4.	Mechanics efficiency	50%
5.	Shop repairs	60%

Results: Read from Chart 2.

1.	Number of mechanics	14
2.	Repair area	600 m^2
3.	Number of boxes	2
4.	Number of field mechanics	10
5.	Number of repair vehicles	10

Actual requirements can be worked out from the charts, within certain limits.

NUMERICAL INDICATORS:

The following information can be used as a rough guide to estimate the dimensions of a servicing and repair structure. The figures given are empirical. Cost data is based on prices in 1976. Therefore, some variations must be accepted.

1. Number of mechanics:[1]

Earthmoving	:	1 mechanic per 5-10 machines
Agricultural wheel tractors	:	1 mechanic per 12-30 machines
Agricultural crawler tractors	:	1 mechanic per 8-21 tractors

2. Shop space per mechanic:

Earthmoving:	45 m^2
Agricultural tractors:	35 m^2
Agricultural special machines, like combine harvesters:	40 m^2

3. Investment in equipped repairshop.

Main work shop	US $ 150,000 + 8500 x N
Repair and maintenance shop:	US $ 80,000 + 8500 x N

Where N is the number of mechanics.

$150,000 for main work shop building and necessary fixed equipment and tools.

$80,000 for repair and maintenance shop, as above.

As already mentioned, these are empirical figures based on 1976 prices and subject to wide variations and should only be taken as guidelines:

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(1) It indicates the variation between the two extremes.

Number of mechanics	Area m^2	Repair + maint.shop Investment US $	Main repair shop Investment US $	Calculated US $ /M^2
1	50	90,000		1800
2	80	100,000		1250
3	120	105,000		875
4	160	115,000		720
5	200	125,000		625
6	240	130,000		560
7	280	140,000		500
8	320	150,000		470
9	360	155,000		430
10	400		235,000	590
12	480		250,000	520
14	560		270,000	480
16	640		285,000	450
18	720		300,000	420
20	800		320,000	400
25	1000		360,000	360
30	1200		405,000	340

4. Special tooling for each model to be serviced:

Earthmoving machines:	$ 2,000
Agricultural tractors:	$ 1,500

5. Training material:

At central facilities of large fleets	:	$ 45,000
At main repairshops	:	$ 12,000
At repair and maintenance shops	:	$ 6,000

6. Parts store room:

Earthmoving machines	:	2 m^2 per machine
Agricultural machines:	:	1 m^2 " "

7. Stock value as proportion of original cost of machines:

	Earthmoving	Agricultural
At central depot	About 10%	About 5%
At maintenance store	about 5%	about 2%
Overall stock value	about 6-8%	about 4%

8. Field Service:

One service vehicle for every 40 agricultural tractors.

One service vehicle for every 14 earthmoving machines.

9. Investment in service equipment per field mechanic:

Earthmoving machines	:	$30,000
Agricultural machines	:	$12,000

The figures given above are only indications and should therefore be taken only as guidelines; spares stock value, especially, can vary widely.

PHYSYCAL CHARACTERISTICS OF A WORK SHOP

Whenever a new work shop building has to be put up, there are certain general requirements and characteristics, which have to be met, regardless of the size and number of machines to be serviced. It is essential that these are properly considered during planning. The basic requirements and characteristics are:

(a) Internal free clearance:

There should be enough overhead clearance for the tallest machine to be serviced plus the needed hoist height.

(b) Machine boxes:

The area of each will be established depending upon the size of the largest machine to be serviced. Whenever smaller machines are to be serviced, more than one can be located in each box. The access to each box must be easy. There should be direct entry to the box and a free area in the opposite direction.

(c) Access doors:

Wide and high enough for the largest machine, preferably of the folding or sliding type.

(d) Pit:

It should be long enough to provide access to the whole under-body of the largest machine. When smaller units are to be serviced, more than one machine can be located at the same time. Easy access from both sides is needed.

(e) Injection, hydraulic and electrical:

Separate rooms must be available for these, free of dust and undisturbed by other operations.

(f) Parts washing:

It is convenient to have a separate area, with an exhaust arrangement for taking out fumes and vapours.

(g) Undercarriage:

Undercarriage, ground contact assemblies, chassis, painting, engine testing: By their very nature these operations need separate areas, away from the more commonly used areas because of noise, vapours, etc.

(h) Machine washing:

This area should also be separate for the same reasons as stated above.

(i) Surfacing of the repairshop:

Must be able to withstand heavy traffic and shock loads, according to the types of machines to be serviced.

(j) Loading and unloading platform:

This facility is frequently overlooked but is indispensable.

(k) Lifting and internal transportation system:

Such a system must exist in the boxes, ground contact and chassis area. An overhead crane with lifting capacity of 10 tons is desirable and it should not be less than 6 tons, if the repair-shop is intended for earthmoving machines; otherwise, a crane of lower capacity may do, but should be at least 3 tons. In most cases a mobile, tyred crane, will be convenient.

Each one of these sections has a minimum area requirement, below which it will not be possible to operate efficiently. These are:

Section	Earthmoving Area in m^2	Agricultural Area in m^2
Machine boxes [1] and assemblies repair	Directly proportional to number of machines	
Machine washing	40	40
Machine tools	100	85
Ground contact, undercarriage	50	50
Chassis and fabricated components	100	-
Hydraulics	35	-
Injection and electrical	25	25
Parts washing	25	25
Engine testing	35	35
Tool room	20	20
Offices	20	20
Toilets	0.8 sq.m. per mechanic	
Total	410 m^2 + area for boxes [1] and toilets	260 m^2 + area for boxes and toilets

It has already been stressed that spare parts store be considered as a part of the work shop; it should also be physically integrated in it.

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(1) Also in other terminology "bay".

WORK FLOW IN A WORK SHOP

Unless a machine arrives at the workshop in a clean condition - which is very seldom the case - it must be washed and cleaned right after unloading, i.e. before entering the repairshop. This is one operation which is most often disregarded even though it is easy and not expensive. Once it has been established as a routine practice, it will speed up other operations and also lead to a better quality of service.

Washing is done with high pressure water at 18-20 Kg.

After cleaning and washing, the machine is taken to the box area, where the component to be repaired is taken off the machine and sent to the specialized section. It is only very seldom and in very special cases that it is convenient to send the machine directly to the specialized section. A quick external washing of each component is a good practice, before starting to disassemble.

A lifting and carrying system, minimum capacity of 2-3 tons for agricultural tractors and 5-6 tons for earthmoving machines, must be available to move the components to the specialized sections, also for disassembly and later assembly.

The engine and assemblies section receive the components from the box and the repair can start. Machine tools must be located in the vicinity. Once disassembled, all parts must be washed and de-greased.

Electrical, hydraulic and injection components will be taken to the respective sections for checking and repair. Hydraulic transmission components, torque convertors, hydraulic valves, pumps, etc., together with the electrical components and injection systems can be worked in the same location, since the requirements of neatness and precision are the same.

Undercarriage and fabricated components after disassembly will be taken to the respective sections. There is similarity between undercarriage work, repair of buckets, blades, push arms and generally all fabricated components, therefore these may be put together.

After repairwork is finished, a test may be carried out on the engine. This test should be carried out away from the offices, in a sound-proof room.

All the components are then assembled into the machine, field tested, washed, and painted if needed, and the machine is ready for delivery to the user.

ADMINISTRATIVE PROCEDURES IN A SERVICING ORGANIZATION

NEW MACHINES:

All new machines are delivered by a supplier who must check and make sure that the machines are in perfect working condition. A mechanic of the servicing organization should attend the delivery of each machine and check that all items have been covered.

In case there are no local agents and the machine has been directly purchased from an overseas manufacturer, it may need to be assembled before it can be tested. If it is to be assembled, the servicing organization must appoint a man responsible for such an operation.

When the machine is delivered, whether through the agent or assembled locally, a field trial must be carried out, during which:

All maintenance operations will be pointed out to the machine operator, who becomes responsible for his machine from then on.

Limitations and use of machine, as well as the attachments for the machine, are clearly explained to the operator.

MACHINE DELIVERY FORM:

A declaration form (Annex 1) for delivery is signed by the following:

A responsible person of the receiving entity.

the mechanic who has conducted the field trial.

the operator of the machine.

The declaration form will provide the following information:

Manufacturer

Type of machine

Serial number of the machine

Identification of the receiving entity and its representative

Name of operator.

The declaration form should be prepared in triplicate. One copy will be sent to the receiving entity, another to the servicing organization and triplicate will be retained by the supplier.

HISTORY CARD:

The servicing organization, based on the information supplied, will prepare a "History card" (Annex 2) which will be maintained in the "Central Control". All repairs and interventions will be written on this card, the owner of the machine will be sent a copy. Whenever an intervention on the machine is requested, the mechanic concerned will report in detail and a copy of his report will be sent to the Central Control, to up-date the machine card.

MACHINE RECEPTION/WORK ORDER:

When a machine is brought to the repairshop, it should be received by a fully qualified experienced mechanic, who will issue a Reception Card (Annex 3). The card will indicate the following:

Name and identification of the owner

Identification of the person bringing in the machine

Name of the receptionist

Manufacturer

Type and serial number of the machine

Date of entry

Indicated working hours (hourmeter reading)

Detailed information of the requested repairs

Observations by the receptionist.

The Reception card is signed by the owner or its representative and the receptionist.

One copy of this card is given to the owner. Two copies will be sent to the repair shop office.

The repairshop office will issue a work order basing it on the information on the card; the repair work will be started according to the instructions on the Work Order.

The work order will have an indication of needed operations, and may provide corresponding time to accomplish it.

FLAT RATE INDICATOR (see Appendix 8, page 102):

The most important manufacturers issue a Flat Rate Indicator, which indicates the time required for each repair operation on their machines.

This information provides the basis to estimate the time required for each intervention, which in turn can be utilised to:

Estimate the cost of the repair

Determine the efficiency of the repair shop.

Once the repair work is finished, the same receptionist (who, as already stated, should be a fully qualified mechanic) will check the machine. On the original Reception card, which the repairshop attaches to the Work Oder, he will give approval or any other comments on the repair just finished.

SPARE PARTS SUPPLY FORM (Annex 4):

Any parts needed during the repair will be requested from the parts store by means of a PARTS REQUEST FORM.

The Parts Request Form will be issued in triplicate, and distributed as follows:

Repair shop office

Parts stock control

Accounting (together with work order) for invoicing.

The same procedure will be applied to supplies such as oils, lubricants, cleaning products, or any other articles that are not numbered as spare parts (Annex 5).

Central Control under administration, will keep track of every machine performance, based on the interventions of repair shop and field service.

SPARE PARTS STOCK CONTROL

The total investment in parts is decided by the administration.

In order to minimize the needed investment, the most important single factor undoubtedly is the machine standardization. The number of manufacturers should be kept to the minimum, and the types of machines to as few as possible; machines from the same manufacturer with the most common components should be chosen.

Every possible source of information should be explored and tapped to establish the initial stock i.e. the manufacturer's advice, previous experience with the same type of machines elsewhere, local experience and knowledge of climate, soils and human characteristics etc.

The initial protective stock, advised by the machine manufacturer should be accepted and received with the machines. A normal stock order should be placed at the same time as the initial order for the purchase of machines. It should be arranged to receive these parts no later than six months after the receipt of the machines.

MAXIMUM AND MINIMUM STOCK

For a given number of machines of the same type, performing basically the same work, it is possible to determine the probable consumption of various parts, item by item. The total so obtained divided by the annual turnover rate, should form the maximum stock, to which a safety margin must be added.

For example: If the annual consumption of a certain item is 100 and the aimed turnover is 2, the maximum stock should be 50. In such a case, the quantity for minimum stock is the same.

When the lead time is longer than the period the stock will last, then lead time is used to determine the maximum and minimum stock.

For example: In the above case, when occasionally the lead time stretches to 8 months, then the minimum stock should be:

$$\frac{100}{12} \times 8 = 67$$

In this simple case the maximum stock is also the same.

Minimum stock is generally understood to be the quantity at which new stock must be ordered; at the same time minimum stock should be the quantity which will last till new stock arrives. In an ideal situation, the physical stock should reach zero, when the new stock arrives. In practice, the lead time may oscillate widely, therefore the safety stock is needed to cover such situations.

The limits of the lead time oscillations, as well as the frequency of ordering parts, under local conditions, are the factors which mainly determine the maximum and minimum stocks. This may be restated as follows:

Minimum stock = Lead time in months x number required per month

Maximum stock = [Lead time + Period between order] in months x number required per month.

The above may be taken as guidelines to estimate the maximum and minimum stocks.

As mentioned earlier, 30% of the machine parts are fast wearing and these represent 50% of the total volume of spares needed and have been represented as A and B categories. They do not present problems, as far as stocking is concerned, because their unit cost is likely to be low.

The slow moving parts, already classified as C and D categories may present a problem. Parts in category C are only a problem, if the number of machines is small. When the number of machines is large enough, these can easily be stocked to a satisfactory level within reasonable investment.

Parts in category D are always a problem, because generally there is no regular pattern in consumption per machine e.g. nobody can estimate with any certainty when or how many engine blocks or differential housings are going to be needed. These are the parts, as already stated that start being needed after the machine has reached its limit of economical life.

ADMINISTRATIVE PROCEDURES IN THE SPARE PARTS STORE:

Every part or consuming material that is received by the stores must be accompanied with a Form (Annexure 7), to facilitate physical checking of the item.

The form clearly indicates:

Supplier

Date of arrival

Number and date of corresponding order

List of parts with number and description, on order, already supplied, being supplied and a blank column for checking, which has to be completed.

This form is completed in triplicate, one for the administration, one for the spare parts office and the third for stock control section.

The stock control section introduces the corresponding changes in each one of the Kardex (or any other system) cards.

A control card (Annexure 8) contains the following information:

Number and description of the part

Machine it is used for

Quantity of the same part used in each machine

Weight

Cost (FOB, received)

Minimum stock

Maximum stock

Orders to suppliers (Quantity, date issued, date received, number of order)

In and out movements (number, date)

Progressive yearly total

Up-to-date stock.

After the part has been entered in the control card, it is then placed in the respective location by the storeroom staff.

During this operation, the existing stock is also physically checked and if any discrepancy is found, it should immediately be rectified.

The control card must always be kept up-to-date. If the Control cannot be relied upon for accuracy, it becomes a nuisance and is worse than no control at all.

A Cardex system is convenient because it can be (and is) normally arranged in such a way that a quick look at a drawer will tell immediately how many items are in short supply, when and where ordered, when they should be received. Any other system can be used, of course; care must be taken to avoid systems too complicated which nobody understands and only one man can operate.

Even for a small number of parts in stock a control system is needed.

Any storeroom will supply parts to at least two "customers", the adjoining repair shop and any other auxiliary shop - a field mechanic is considered as such.

Issue of parts can be processed either by a Supply Card (Annex 9) to the repair shop or an Expedition Form (Annex 10) to an outside shop.

The supply card should provide the following information:

Manufacturer, type and serial number of the machine

Working order number

Number, description and quantity of parts.

This will be issued in triplicate, one to the repair shop office, one to the store room office and the third one will be kept with the working order.

A similar procedure will be adopted for the Expedition Forms.

Consuming items may be kept by the Store room or if the importance of the repair shop so advises, by a repair shop stock room.

The repair shop office will, anyway, prepare a monthly order for these items, covering:

Maintenance of buildings

Maintenance of installed systems (sanitary, hydraulic, electric etc.)

Maintenance of vehicles

General maintenance and cleaning

Scrap materials (outgoing)

The cost of these items will be charged by the Administration Office under "General Costs".

The Administration Office will also:

Account for all the working orders, charging the owner of the machine(s)

Account for all the supplies received under general costs

Account for all the field interventions, charging the owner of the machine(s)

Check all the incoming invoices - parts, general costs, consuming items

Control and account for all the employees of the Technical Centre

Prepare and proceed to personnel payment

Account for the general balance of cash.

IV.

STORAGE OF TRACTORS AND AGRICULTURAL MACHINES

It has been repeated a few times before and may be worth repeating once more to emphasize the point, that the objective of a servicing organization is to anticipate breakdowns and avoid machine downtime. The proper storage of tractors and agricultural machinery can appreciably contribute towards the achievement of these objectives.

All agricultural machines are only occupied for part of the year, their work is seasonal. Some of these may only be working from 4 to 6 weeks annually and need to be stored from 10 to 11 months in a year. At times the deterioration in overall working quality of the machine may be more in the storage period than during the actual working Therefore the off-season storage in such cases is very important.

One more point where the machinery can deteriorate fast, which is very costly and annoying but fortunately can be completely eliminated, is the storage of the new machine, between arrival at site and the beginning of the working season. Often new machines have to be ordered for quite sometime before these are required for work, especially in the developing countries. It may not always be possible to synchronize this, so that there is need for storage varying from few weeks to even few months. If few simple precautions are taken, a lot of resultant damage can be avoided.

Generally, all reputable manufacturers of tractors and agricultural machinery make recommendations concerning storage of their machines and these should be strictly followed. Below are provided some general guidelines for such protection during storage for individual items and for complete machines.

TYRES:

Tractors and agricultural machinery mounted on tyres are shipped from the factory with the tyres inflated to a high pressure, for greater stability of the machine during transit.

This high pressure must be reduced to recommended field operating pressures, before unloading off a flat car or truck. Otherwise, it is possible to damage the cords in the tyre, resulting in the tyre carcass failing.

The recommended field operating tyre pressures for tractors and agricultural machinery are available in the operating manuals.

Tyres are perishable items, in a category similar to batteries. Therefore, it is necessary to take certain extra storage precautions to prevent rapid deterioration.

There are certain factors which cause and accelerate deterioration, while tyres are in storage. These factors are: light, heat, air in motion, ozone, oils, dirt and water inside the tyre.

Tyres, whether new or fitted on wheel rims should not be stored in confined areas where electrical devices which produce ozone are working as ozone accelerates "checking" of rubber tyres.

Gasoline and lubricants should not be allowed to come in contact with rubber tyres, especially during storage, as solids, fluids and vapours from these products are readily absorbed by the tyres causing them to rot.

Store tyres out of direct sunlight. Whenever possible, cover with tarpauline.

Major tyre manufacturers recommend that inflation pressure be checked every two weeks during storage.

Tyre " checking" and "cracking" is accelerated when tyres are stored without reducing air pressure to recommended operating pressures.

"Cracks" and "checks" can also result from too low tyre pressures. Therefore it is necessary to ensure that during storage air pressure does not become so low that the weight of the machine "wrinkles" the sidewalls of the tyres. It is recommended that if possible, the machine should be lifted up and put on blocks during storage to take off the weight from the tyres.

BATTERIES:

Batteries should be removed from the tractor and a hydrometer reading taken of every cell.

The specific gravity reading should be 1.250 (full charge). If the reading is below 1.250, place the battery on a charger and bring it up to full charge before placing it in the battery storage room. It should be checked from time to time and brought to full charge, if necessary.

Cover the battery terminals with grease after cleaning. The cable terminals should also be cleaned and coated with grease.

TRACTOR ENGINES:

When a tractor has been in use during the season and it is required to be placed in storage for sometime,it must be completely lubricated in accordance with the lubrication instructions in the Operator's Manual.

Crankcase oil should be inspected and if dilution is apparent, it should be drained, flushed and filled with new motor oil. Check the oil filter. Operate the engine long enough to allow fresh oil to flow to all the internal working parts of the engine.

Cleaning the fuel tank:

Diesel engine tanks:

When the tractor has been in use and it is required to be stored for some time, it is desirable to empty the fuel tank and the following steps may be taken:

1. Run the engine until the coolant is up to operating temperature. Drain the diesel fuel tank and pour 6 to 8 litres of diesel flushing oil - or the equivalent - into the fuel tank.

Note: If flushing oil is not available, a mixture of 50% SAE 10-W engine crankcase oil and 50% pure white kerosene may be used.

2. Start and operate the engine until a blue-white smoke appears at the exhaust. This indicates the regular fuel in the filters has been used up and the flushing oil is being burned. Operate the engine for an additional ten minutes before stopping it.

Repeat these two steps whenever the tractor is to be stored after use or when it remains in storage for over six months.

Gasoline engine tanks:

1. Drain all the fuel from the tank, lines, sediment bowl and carburetor.

Note: If the gum has already formed, it may be dissolved with acetone or a 50-50 mixture of alcohol and benzol.

2. Remove the spark plugs and pour approximately 1 dcl. of a rust preventive oil in each cylinder. Crank the engine several revolutions to coat the cylinder walls with a film of oil.

Repeat these two steps whenever the tractor is to be stored after use or when it remains in storage for more than six months.

LP Gas Engines:

NO FUEL IN FUEL TANK

Step 1. Remove the spark plugs and pour approximately 1 dcl of a rust preventive oil in each cylinder. Crank the engine several revolutions to coat the cylinder walls with a film of oil.

Step 2. Replace the spark plugs.

REPEAT THESE TWO STEPS IF THE TRACTOR REMAINS IN STORAGE OVER 6 MONTHS.

If the tractor is used and returned to storage, prepare the engine as described below.

FUEL IN THE FUEL TANK

Step 1. Drive the tractor to a well ventilated location out of doors.

Step 2. Shut off both the vapour and liquid outlet valves and allow the engine to run out of fuel to stop itself.

Step 3. Attach a hose at least 5 metres to the filler valve of the tank, checking that the other end of the hose is DOWNWIND from the tractor.

Step 4. After the gas is burned and the fuel tank is empty, disconnect the hose.

Step 5. Remove the spark plugs and pour approximately 1 dcl of a Rust Preventative oil in each cylinder. Crank the engine several revolutions before replacing the spark plugs.

Valves:

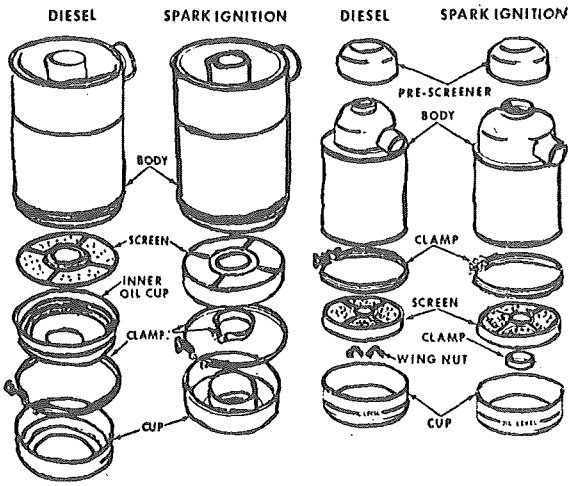
Remove the valve cover and squirt rust preventive oil on the valve stems. A special rust preventive oil must be used as regular lubricating oils drain off too easily leaving the surface susceptible to corrosion.

Check the breather on the valve cover is clean before replacing the cover.

AIR CLEANER:

Oil type:

Remove the air cleaner bowl and clean all sediment from the interior of the bowl. Fill the bowl to the oil level line with clean engine oil, use the same viscosity oil as used in the crankcase.



Dry type:

If the unit is equipped with a dry type air cleaner, the element must be washed or replaced prior to the unit being put in storage.

ENGINE OPENINGS:

Cover the exhaust pipe, air breather and fuel tank openings to keep out moisture and foreign materials. Empty tin cans or waterproof masking tape are useful to cover such openings.

COOLING SYSTEM:

Unless there is anti-freeze in the coolant, drain the radiator and the block while the engine is still hot.

PLACE A WARNING ON THE STEERING WHEEL:

ANTI-FREEZE IN THE COOLANT

or

COOLANT SYSTEM HAS BEEN DRAINED

whichever is applicable.

In hot climates add anti-rust to the water and do not drain.

GEARSHIFT AND PTO LEVERS:

Change the gearshift lever into neutral position as a safety precaution.

Disengage the PTO clutch lever to relieve pressure on the drive plate separator springs.

STORAGE OF COMBINE HARVESTERS:

Combine harvesters are used for a very short period during the year, sometimes only for 4 weeks or so, and need to be stored for the remaining period under cover. Besides the points mentioned earlier for storage of tractor, its engine, tyres, batteries etc., the combines need the following additional attention before storage.

Cleaning:

Regardless of the use the combine has had, it must be cleaned thoroughly before it is stored.

Brush the entire machine with a stiff broom and blow chaff and dirt out of "hard to get places" with an air hose. If the combine is equipped with canvasses, remove and clean them by brushing or using a vacuum cleaner. Dry and wrap them in water-proof paper.

Remove the grain from the bin and clean it thoroughly. Allow rags or portions of a burlap to be pulled through by the tailings auger to clean out all the chaff and dirt. Clean all grain and weed seeds from roto cleaner attachment. Remove all chaff and straw embedded in the sieves. Steam clean the machine. If a detergent is used, be certain the machine is well rinsed before drying.

Drive chains:

Clean the chains with a grease solvent and brush with oil.

Belts:

Relieve the tension on all belts. Clean off any grease and oil with a cloth dampened with gasoline.

Coat the sheaves these belts run in with grease to prevent rusting, but make sure that the grease is completely removed before starting the machine again.

Wrap the variable speed belt with tape or paper to keep out any light.

Augers and elevators:

Coat the inside of the auger and elevator troughs with oil and leave the elevator clean-out door open.

Grain bin:

Coat the bottom of the grain bin with paint or grease and leave the grain bin drain open.

Cutter bar:

If any of the guards are bent, straighten with a sickle guard strasightener. Coat the sickle bar and guards with heavy oil to prevent rusting.

Instructions given in the Operator's Manual should be strictly followed for lubrication and other preparations for storage.

STORAGE OF OTHER AGRICULTURAL EQUIPMENT:

Agricultural equipment for off-season storage may be grouped into different categories for necessary care:

(1) Tillage tools: Plows, harrows, etc.

(2) Seeding machines: Drills, planters

(3) Manure spreaders and fertilizer distributors

(4) Spraying equipment

(5) Mowers, rakes and balers

(6) Forage harvesters

(7) Windrowers

(8) Elevators and blowers.

Instructions provided by manufacturers in the Manuals for storage of their machines should always be followed. Below are given some of the general guidelines to help in this direction.

(1) TILLAGE TOOLS:

Tillage tools after use in the field should be prepared for storage as below:

Use a stiff brush and a paint scraper to remove all caked soil from the machine.

Use a grease solvent to clean surfaces smeared with dirt and oil. If the machine is extremely dirty, clean with a steam cleaner.

Polished surfaces:

After the machine is dry, spray protective varnish on the polished surfaces of coulters, disk blades, plow bottoms, shovels and sweeps.

Spring releases, hitches and trips:

Coat the joints of spring releases, spring hitches and spring trips with a rust preventative oil.

Lubricate the entire machine as described in the Operator's Manual.

If the machine is equipped with tyres, take care as described before.

(2) SEEDING MACHINES:

Instructions below pertain to the storage of drills and planters:

Clean all seed from the hopper.

Operate the unit in gear to sift out any seed that is lying in plates or tubes.

Use an air hose to clean the entire machine, paying particular attention to hoppers, feed cups and agitators.

Wash the entire machine with water.

After the machine is dry, spray a mixture of kerosene and oil on the feed cups, drives below the hopper, disk openers, disk markers, chains and riboon tubes.

Lubricate the entire machine as described in the Operator's Manual and take care of the tyres as mentioned earlier.

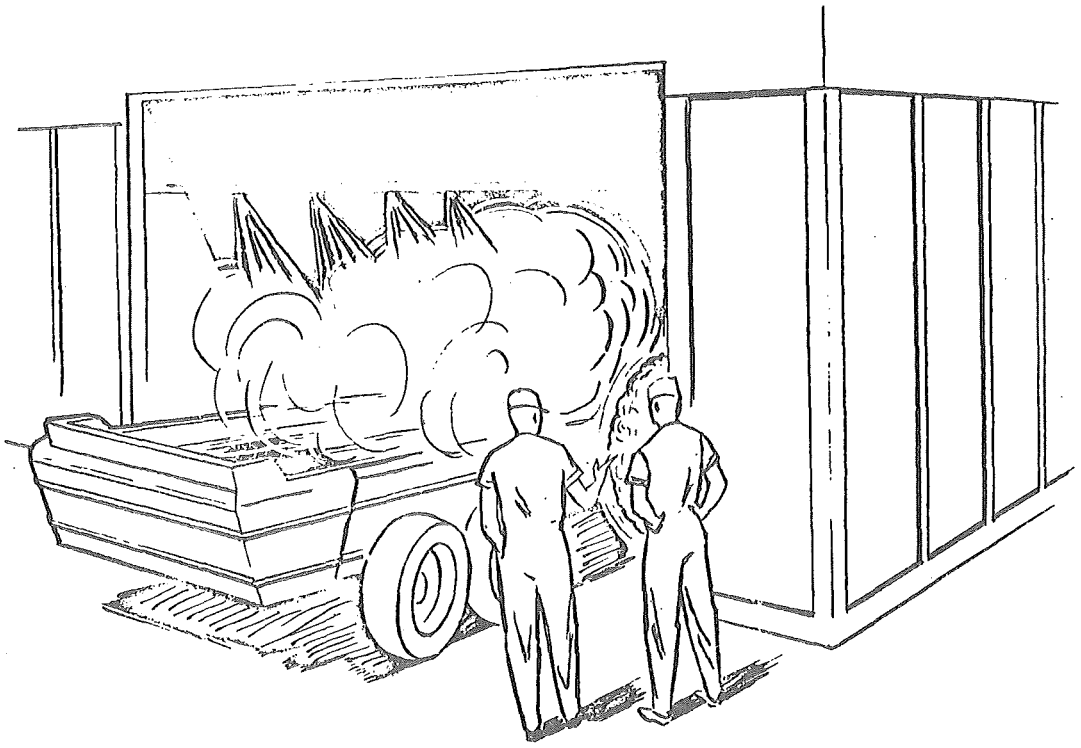
(3) MANURE SPREADERS AND FERTILIZER DISTRIBUTORS:

Immediately after final use of a manure spreader, wash it with water. Make sure all manure is washed off the tyres as the acids in manure will cause the rubber to deteriorate rapidly.

Spray the chains and slip clutch with a rust preventative oil.

Grease the hitch slide.

After washing the spreader, check the oil level in the gear box to be sure that no water has entered the gear box.



Lubricate all fittings as described in the Operator's Manual.

For proper storage of fertilizer distributors, empty all the fertilizer out of the hopper.

Operate the distributor a short distance in gear to sift out as many particles as possible.

Remove the holding pins and lift out the rotors.

Use a broom or stiff brush and clean the entire machine.

Use water and completely flush out the distributor hopper. Push the adjustment lever fully forward and backward several times, to ensure cleaning the fertilizer from between the hopper bottoms and the feed plate.

If it requires an excessive amount of effort to open and close the feed plates, remove the feed plates and check if fertilizer has lodged between the bottom of the hopper and the feed plates. If the fertilizer has lodged in this area, clean off with a stiff brush and wash with clean water.

After the distributor is dry, brush or spray the inside of the hopper and the rotors with a rust preventive oil. Push the feed adjusting lever fully forward and backward until the oil has worked its way between the bottom of the hopper and the feed plate.

Using a good grade of heavy wheel bearing or fibre grease, coat the rotor drive shaft and rotor sleeve ends.

Spray the inside of the hopper with oil.

Lubricate the machine as described in the Operator's Manual.

4. SPRAYING EQUIPMENT:

Spraying equipment can deteriorate very quickly, if proper care is not taken immediately after use and during storage; major repairs or replacements may be needed when the machine has to be used next season.

Flush the unit with clean water and wash the metal parts with solution of washing soda.

Remove the nozzles and boom, disassemble all parts and clean thoroughly.

Clean the tank and remove filters for further washing. The pump should similarly be washed and cleaned.

Treat all metal parts with rust preventative oil.

If the sprayer is fitted with separate engine, treat it as indicated earlier.

Instructions in the operator's Manual and by the chemical supplier must be strictly followed.

5. MOWERS, RAKES AND BALERS:

Certain special precautionary steps should be taken to preserve mower cutter bars, rake gear boxes and baler knotters, besides the general cleaning, care of belts, chains and tyres for storage.

Cutter bar (mowers):

Brush or spray a rust preventative on the sickle bar and guards. Cover the cutter bar so that the personnel working around the machine will not be injured.

Gear box (Rakes):

Check that the gear box is filled to the proper level with correct lubricant. Do not allow water to drain into the gear box during storage.

Knotter (Baler):

Remove all twine or wire and foreign material from the knotter or twister. Lubricate all the fittings and brush or spray a rust preventative oil on the inverted gears and tying mechanism.

Bale Chamber:

Relieve tension on the chamber tension springs. Check that all the hay has been removed during the cleaning operation and coat the bottom of the chamber with a thick grease. Squirt oil on the threaded portion of the bale chamber tension device.

Place the pick up in the fully raised position and relieve all tensions from the balance spring.

Lubricate the machine as described in the Operator's Manual.

6. FORAGE HARVESTERS:

Clean the entire machine with a stiff brush and water. Make sure that all sap and juices are rinsed off the machine. If necessary, use a steam cleaner to remove gum and grime that has dried on the machine. After the complete cleaning and drying of the machine, remove the attachment head from the base unit and store it inside. This can be simplified by leaving the attachment head mounted on its storage truck. Also store the base unit inside utilizing the anti-trip stand provided with the machine.

Lubricate the machine as described in the Operator's Manual and take care of tyres, belts, etc. as described earlier.

7. WINDROWERS:

Windrowers should be stored inside to prevent deterioration of polished and bearing surfaces. The unit should be thoroughly cleaned. All belts should be loosened and all chains cleaned and oiled.

If the windrower is engine equipped follow the storage instructions listed under engines.

The sickle on row crop and cutter bar units must be coated with a rust preventative oil.

If the attachment used has been a cutter bar unit equipped with a draper, remove it, clean thoroughly and store in a dark place.

Paint any surfaces chipped or scratched during use.

Take care of tyres as described earlier.

(8) ELEVATORS AND BLOWERS:

The following information deals mainly with storing an elevator or forage blower after they have been used; however similar precautions must be taken on new equipment that remains in storage for six months or more.

Cleaning:

When a used elevator is stored, first use a stiff brush and air hose to thoroughly clean it. If the material is of a succulent type ensilage with a lot of grass juices, wash the entire machine with water.

Belts:

Relieve tension on all belts and wipe off any grease or oil with a cloth dampened with gasoline.

Conveyor chain:

Coat the floor of the elevator and the entire chain with oil.

Jump clutch:

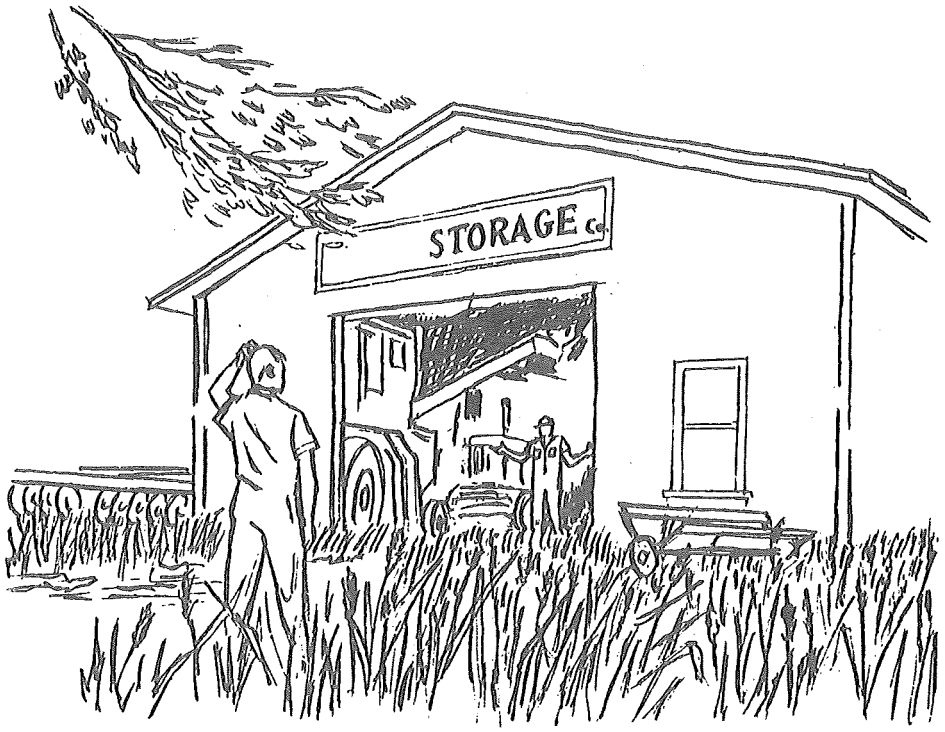
Oil the jump clutch to prevent it from "freezing" to rust.

Cables and truss rods:

If the elevator is equipped with cables and truss rods, protect by brushing with oil.

Feeder hopper:

Place the feeder hopper in the raised position and open the clean-out door to allow any moisture to drain out. If the elevator is equipped with a safety chain, secure it as a safety precaution.



ANNEX 1

MACHINE DELIVERY

DATE _____

MACHINE _____ TYPE _____ MODEL _____

CHASSIS SERIAL NUMBER _____ ENGINE SERIAL NUMBER _____

ATTACHMENTS: _____ DELIVERED BY: _____

_____ RECEIVED BY: _____

_____ _____

The above machine has been delivered in good working order.

Operation and maintenance have been explained as per attached check list.

RECEIVER'S REPRESENTATIVE DELIVERER REPRESENTATIVE SERVICING REPRESENTATIVE

ANNEX 2

MACHINE HISTORY CARD

MACHINE TYPE _____ MODEL _____ CHASSIS No _____

DATE DELIVERED _____ OWNER _____

ACCESSORIES: _____ ADDRESS: _____

MECHANICAL INTERVENTIONS

Date	Place	Description	Caused by: (a)	Machine Hours	Cost	Spare Cost

ANNEX 3

MACHINE RECEPTION/WORK ORDER

SERVICE CENTER _____ DATE_____RECEPTIONIST_____

MACHINE MODEL _____ CHASSIS No. _____ ENGINE No _____

ACCESSORIES _____

LOOSE ASSEMBLY _____ O W N E R

HOURS _____ DATE ACQUIRED _____ NAME_____

REPAIR _____ ADDRESS _____

OWNER REQUESTS BUDGET ☐yes ☐no
REPAIR TO BE FINISHED ON _____

Description	Mechanic Number	Date	Hours worked	Spares Cost	Cost Total

SERVICE CENTER _____ DATE _____ ORDER No_____

THE MACHINE _____ IS AUTHORIZED TO

CASHIER LEAVE

SERVICE MANAGER GATE CONTROL

_____ OUT AT _____ HOURS _____ GUARD

ANNEX 4

SUPPLY FORM

INVOICE No. ________________	INVOICE OF PARTS SUPPLIED
Date ________________	Dispatched by ________________
To: ________________	Adress ________________
________________	Your order ________ of ________
________________	Payment ________________
________________	No. of packs
________________	

Total weight	Net weight	Packaging Cost $	Cost of transport. $

No. of part	Description	Ordered	Quantity	Supplied

ANNEX 5

ITEM REQUEST FORM

DATE _____

60. SUPPLY OF PARTS TO REPAIRSHOP No. _____

WORK ORDER No. _____

OWNER _____

MATERIALS	Quantity
Requested by _____	Checked by:
Weight _____ Net weight _____	
Packs _____ Type of machine: _____	

RETURN DULY SIGNED

We have received your supply as in No. _____

Date _____ Signed _____

ANNEX 6

STORE RECEIPT FORM

INCOMING MATERIAL _____ No _____

SUPPLIER _____

DATE _____ ORDER No. _____ FROM _____

_____ PACKS _____ No. _____

WEIGHT Kg _____ NET WEIGHT _____

Part No. Model	Description	Date of Order	Quantity			
			Order	Already rec'd	Declared	Checked

INVOICE No.

Checked by Storeroom NOTE

SPARE PARTS STOCK CONTROL

SERVICE CENTER	TRACTOR MODEL _ _ _ _ _ _ _ _ _ PART No. _ _ _ _ _	
	DESCRIPTION _	
CATEGORY	MODIFICATIONS AND REMARKS _ _ _ _ _ _ _ _	Q.ty per machine _ _ _ _ _
MINIMUM STOCK	YEARLY CONSUMPTION	
DATE		Yearly use _ _ _ _ _
MAX.		
MINIM.		

ORDERS											
Date											
Order No											
Q.ty											
Supplied											

BALANCE		
Date		
Customer		
Q.ty		

DATE	DOCUMENT NUMBER	IN	OUT part.	OUT progr.	STOCK	DATE	DOCUMENT NUMBER	IN	OUT part.	OUT progr.	STOCK

Example 1. APPENDIX I

EXAMPLE OF ESTIMATED SERVICING ORGANIZATION SET-UP FOR A FLEET OF 100 MACHINES (1)

The example below is based on the quantitative guidelines (2) stated in this publication for determining the requirements of a servicing organization in two cases:

(i) A fleet of 100 earthmoving machines

(ii) A fleet of 100 agricultural tractors.

In both cases two extremes have been considered:

A - No service infrastructure exists in area of operations

B - Good infrastructure and ready availability of services, spares and qualified manpower.

---

(1) Machine prices are based on FOB values, Feb.1976. The average earthmoving machine is supposed to be worth US $50,000, while the average agricultural machine including accessories is worth US $15,000.

(2) Quantitative guidelines, as already stated, are based on empirical data, and should be taken as such. The requirements for each case would have to be worked out considering the local conditions, facilities and needs.

Appendix 1

	Earthmoving		Agricultural	
	A	B	A	B
Number of shop mechanics	6	3	4	2
Number of field mechanics	6	3	5	3
TOTAL	12	6	9	5
Shop covered area in sq.m.	240	120	160	80
Cost of shop in US$	130,000	105,000	110,000	100,000
Special tools (for 10 types of tractors)	20,000	20,0000	15,000	15,000
Training equipment in US$	15,000	10,000	12,000	6,000
Field vehicles US$ 15,000 each	90,000	45,000	75,000	45,000
Area of stores building in sq.m.	200	100	150	75
Cost store building	40,000	20,000	30,000	15,000
Stock value % of machine cost	10	5	15	3
Stock value in US$	500,000	250,000	225,000	45,000
TOTAL	795,000	450,000	467,000	226,000
% of B to A	100	57	100	48

In this example, all repair work in cases A will be performed within the servicing organization, while in cases B, major overhauls will be possible within the servicing organization but specialized operations (rectifying crankshafts, cylinder liners, hydraulic cylinders, resurfacing cylinder heads, correcting large fabricated parts, etc.) will be executed outside; this will constitute about 20% of the total work.

Efficiency of service is taken as 50% and 75% in cases A and B respectively; field servicemen in cases A are likely to lose 35% of their time in travelling while B 20%; Repairs in the shop and field will be equally divided, i.e. 50% each.

For agricultural machines in case B, the better operation techniques and proper maintenance by the drivers are supposed to reduce the interventions required by the mechanics to 50%, as compared to case A. Similarly the space required for stores due to reduced needed stock, is also less in B than in A.

Total number of staff required in the above cases is:

Appendix 1

	Earthmoving		Agricultural	
	A	B	A	B
Shop mechanics	6	3	4	2
Shop foremen	1	-	1	-
Helpers	2	2	2	1
Field mechanics	6	3	5	3
Drivers	6	3	5	3
Training	1	-	-	-
Spare parts section	6	4	5	2
Auxiliary	6	5	4	4
Administration	5	5	5	4
Service Manager	1	1	1	1
	40	20	32	20

Taking an average annual salary of US$ 2,000[1] and US $ 4,000 for A and B respectively. The following fixed costs would be computed: (all figures are in US$).

	Earthmoving		Agricultural	
	A	B	A	B
Salaries	80,000	104,000	64,000	80,000
Essential supplies cost	50,000	50,000	50,000	50,000
10% Depreciation of fixed investment	79,500	45,000	46,700	22,600
10% interest on average capital investment[2]	43,700	24,700	25,700	12,400
	253,200	223,700	186,400	165,000

(1) Generally in areas where infrastructures are not developed as in cases A, the salaries are low and have been assumed to be an average of US$ 2,000 per annum; in areas where infrastructures are developed the salaries are higher, as in case B.

(2) Average capital investment has been computed using the formula:

$$C_{av} = \frac{N + 1}{2 N} \times C$$

The following indicators [1] emerge on perusal of the above: (All costs are in US$)

	Earthmoving		Agricultural	
	A	B	A	B
1. Total investment in machines	5,000,000	5,000,000	1,500,000	1,500,000
2. Fixed investment in servicing	795,000	450,000	467,000	226,000
3. Fixed servicing investment as % of total machine investment	15.9	9.0	31.1	15.1
4. Fixed investment in servicing per machine	7,950	4,500	4,670	2,260
5. Fixed servicing operating cost	253,200	223,700	186,400	165,000
6. Fixed servicing cost per hour of machine work [2]	1.27	1.12 [3]	1.86	1.65 [3]
7. Ratio of serviceman/machine	.4	.2	.3	.2

Perusal of the indicators in the table above reveal that:

(a) Earthmoving machines need higher total fixed investment for servicing than agricultural tractors.

(b) Whereas, when this is expressed as % of total investment in machines, the figures are much higher for agricultural tractors.

(c) Fixed investment in servicing per machine is higher for earthmovers than agricultural tractors.

---

(1) These figures are only indicators and will vary according to location and time.

(2) Calculations based on earlier assumption that each earthmoving machine likely to work an average of 2,000 hours and agricultural wheel tractor 1,000 hours per annum.

(3) There will be extra variable costs for external specialized repairs.

(d) Fixed servicing operating cost is higher for earthmovers than agricultural tractors.

(e) Whereas, fixed servicing operating cost per hour of machine work is higher for agricultural tractors than earthmovers.

(f) Agricultural machines require less servicing manpower than earthmovers in areas where infrastructures are not developed, whereas it is same where good intrastructures exist.

(g) Areas without an established mechanical infrastructure require more total investment in servicing organization than the areas where adequate infrastructure exists, as well as per machine as percentage of total machine cost.

Example 2. APPENDIX 2

SERVICING STRUCTURE FOR MIXED, LARGE FLEET

This example has been selected to work out the numerical data for the establishment of a servicing organization, for a large, mixed fleet of earth-moving and agricultural tractors - crawler and four-wheel, and related equipment.

The field work for a fleet of this kind may be very wide ranging: land clearing, land levelling for irrigation , water control structures, terraces, drains and canals, plowing, harrowing, seeding, weed control and other cultural practices, opening of access road, farm roads and their maintenance and many other agricultural operations.

The machines in this mixed fleet have been taken as:

Earthmovers:

6	-	150 HP bulldozers
15	-	100 HP bulldozers
1	-	80 HP bulldozer
1	-	65 HP motorgrader

Agricultural tractors:

100	-	48 HP four-wheel drive tractors
80	-	80 HP farm crawlers
TOTAL 203		

Other machines in the fleet are:

15	-	3 cu.m. scrapers
30	-	gasoil burners
15	-	double drum ditchers
5	-	offset ditchers
25	-	three furrow mouldboard plows
3	-	harrows
10	-	land levellers.

Prior to initiating the planning of a servicing organization, it is necessary to collect certain information and assume other related conditions, which should be kept in view during the planning exercise. Some of these conditions may alter later, but it should be possible to make adjustments, without affecting the basic structure, if there has been proper prior planning.

Many of these factors may be obvious, while some may have to be presumed. It is assumed that the following conditions exist at the planning stage:

1. these machines will work approximately within a circle of 50 Km.

2. there is no servicing structure existing in the area for such a fleet; there is no service backing in the country.

3. in view of this, the servicing organization will be responsible for all servicing.

4. the machines on average will annually work:

Earthmovers	:	2,000 hours
Farm crawlers	:	1,500 hours
Wheel tractors	:	1,000 hours.

After getting the above information, the following additional assumptions have been made:

1. The efficiency of the mechanics will be 50%

2. The total repair hours required will be equally split between the shop and field service.

3. The expected off-the-shelf parts availability will be 85%.

Numerical calculations:

The average prices [1] for the machines in this fleet have been calculated as below:

Machine Description	Unit Price US $	No. in Fleet	Total Cost US $
Earthmovers:			
150 HP Bulldozers	66,000	6	400,000
100 HP Bulldozers	50,000	15	750,000
80 HP Bulldozer	35,000	1	35,000
65 HP Motor-grader	32,000	1	32,000
	Total	23	1,217,000
	Average cost		52,900
Agricultural tractors:			
48 HP 4 W.D.	12,000	100	1,200,000
80 HP farm crawlers	23,000	80	1,840,000
	Total	180	3,040,000
	Average cost:		16,890
Equipment:			
3 cu.m. scrapers	3,800	15	57,000
Gasoil burners	1,000	30	30,000
Double drum ditchers	3,000	15	45,000
Off-set ditchers	4,000	5	20,000
Three furrow mould board plows	3,800	25	95,000
Harrows	3,700	3	11,000
Land levellers	2,500	10	25,000
	Total	17 [1]	283,000
Total capital investment on machinery			4,540,000

(1) Based on FOB prices February, 1976, calculated equivalent to 17 agricultural tractors.

Applying the rough factors indicated previously, the following results are obtained:

Machines	Number	Factor		Mechanics needed
Earthmoving (EM)	23	8	$\frac{23}{8}$	2.87
Agricultural Tractors (wheels)	100	15	$\frac{100}{15}$	6.66
Agricultural Tractors (crawlers)	80	$\frac{15}{1.4}$	$\frac{80 \times 1.4}{15}$	7.46
Agricultural Equipment	17 (1)	15	$\frac{17}{15}$	1.13
			TOTAL	18.12

If the mechanics efficiency is considered as 50%, the servicemen needed are 18.12x2 = 36.24 say 36 mechanics.

According to our previous assumptions, this will come to 18 shop mechanics and 20 field mechanics (Two extra field mechanics, as some time will be wasted in travelling).

Shop space in m^2:

Machines	Number	Space mechanic	Total space
EM	3	45	135
Agricultural	15	35	525
TOTAL	18		660

Parts store space:

Machines	Number	Store space/machine	Space required in m^2
EM	23	2 m^2	46
Agricultural	198	1 m^2	198
TOTAL			244

(1) Average value of a farm tractor according to our calculations is US$ 16,890, therefore the equipment is worth equivalent to the value of 17 farm tractors.

Appendix 2

Space required for parts store may also be estimated by using the initial cost of machine and percentage valuein spare parts stocks:

Machine	Initial cost US $	% Spares stock to initial cost	Value of spares stock US $
EM	1,217,000	10	121,700
Agri-cultural	3,323,000	15	498,450
			620,150

Applying the indicators for relationship between spares stock value and store space requirements, the following results emerge:

Machines	Spares stock value US $	Stock space reqd. $1000 spares stock	Area required m^2	Spares turnover	Stores Room required m^2
EM	121,700	1 m^2	122	1.7	72
Agric.	498,450	0.5 m^2	250	1.7	147
				TOTAL	219

The two methods of calculation approximately give the same results, a store area of 220 m^2 may be provided.

The fixed investment needed for the service organization can be computed from the above information, as follows:

		US $
Repairshop 150,000 + 8500 x 18	=	303,000
Field Service equipment 15,000 x 20	=	300,000
Store room 220 x 200	=	44,000
Value parts stock (1.7 turnover rate for 620,000)	=	365,000
Special tools 4 x 2000 + 2 x 1500	=	11,000
Training	=	45,000
TOTAL		1,068,000
General administration (facilities, vehicles, furniture, etc.)	=	53,400
		1,121,400

Appendix 2

Staff requirements:

Repairs:

Shop mechanics	18
Shop foremen	3
Helpers	4
Repairshop office	2
Field mechanics	20
Drivers/helpers	20
Training	1
Service Chief	1

Parts stores:

Storeroom staff	5
Parts control section	2
Parts office	2
Stores chief	1

Administration:

Accounts	3
Secretary	1
Director	1

Auxiliary services:

Drivers	3
Guards	2
Helpers	3
Chief guard	1
TOTAL	93

Fixed operating costs:

These will be, like in the previous example, limited to salaries, supplies (water, energy, communication, general maintenance etc.), depreciation and interest.

Salaries have been arbitrarily fixed at an average of US $ 2,000 per year per employee, and are expected to vary widely.

		US $
Salaries 93 x 2,000	=	186,000
Supplies	=	50,000
Depreciation at 10% of investment	=	112,000
Interest 10% on average capital investment	=	61,700
		410,700

Persual of the above indicators reveal that:

(1) Investment in servicing structure as % of investment in machines = $\frac{1,121,400}{4,540,000}$ = 24.7

(2) Service operating cost per hour of machine work US $ = $\frac{410,700}{23 \times 2,000 + 100 \times 1,000 + 80 \times 1500}$

$= \frac{410,700}{226,000}$

= 1.54

APPENDIX III

LIST OF BASIC EQUIPMENT (1)

A - MAIN REPAIRSHOP

B - REPAIRSHOP, AVERAGE

C - SMALL REPAIRSHOP

			* A	B	C
A - LIFTING AND MOVING EQUIPMENT					
1)	Mobile Bridge with chain hoist	Capacity kg. 5,000	1	1	1
2)	Hydraulic boom crane	" " 1.000	1	-	-
3)	" jacks (dolly)	" " 15.000	1	-	-
4)	Adjustable stands for tractors		16	8	4
5)	Wooden blocks		10	6	2
6)	4 wheels platform trucks	" " 1.000	2	1	1
B - COMPRESSED AIR EQUIPMENT					
1)	Electric air compressor	Press. 7-8 kg/cm Deliv. 1/m 1900 Cap. tank 1. 500	2	1	1
2)	Air valves - air pipes length	6.5 m.	x	x	x
3)	Wall hose reel with pipe		x	x	x
4)	Filters and lubricators for comp/air		x	x	x
5)	Air nozzle		x	x	x
6)	Inflator gauge		1	1	1
C - LUBRICATION (Grease/oil) EQUIPMENT					
1)	Air compressed automatic grease pump		1	1	-
2)	High pressure grease hand pump		1	1	2
3)	Equipment for distribution/measurement (oil)		1	-	-
4)	Waist oils drums		4	2	2

(1) For supplementary information, refer to:
FAO Agricultural Development Paper No.66.
"Agricultural Machinery Workshop: Design, Equipment and Management", chap.6.

* Quantity to be decided by the Service Manager.

Appendix 3

		A	B	C
D - PAINT SHOP EQUIPMENT				
1)	Painting equipment (complete) Pressure feed/paint depurator/hoses/ spray guns/tank caps 1.	1	-	-
2)	Painting equipment for small and medium repairshops with hoses/spray guns	-	1	1
3)	Set of accessories for painting	1	1	1
4)	Shelves for paints and accessories	1	1	-
5)	Metal board for airing parts	4	2	2
E - WELDING/FORGING SHO EQUIPMENT				
1)	Metal forge - one fire-aspirator-ventilator	-	1	1
2)	Forging accessories (anvil - block - vice tongs, etc.)	1	1	1
3)	Electric welding set 500 amp and accessories	1	1	1
4)	Oxy-acetylene welding set with cylinders truck pressure reduction - press.hoses/welding/ cutting torch	1	1	1
5)	Hack sawing machine Cap.200 mm.	1	-	-
6)	Hand shear for steel plates/steel sections	1	-	-
7)	Electric welding benches	1	1	1
8)	Oxy-acetylene welding benches	1	1	1
F - MACHINE TOOLS				
1)	Center lathe (medium) Dist.Centers 200 mm. Center height 250 mm.	1	1	-
2)	Electric column drilling machine up to Ø 10 mm.	1	-	-
3)	" " " " up to Ø 22 mm.	1	1	1
4)	Radial drilling machine. Range 1000 mm. up to Ø 35 mm. with accessories	1	-	-
5)	Grinding machine (column) Ø stone 200 mm.	1	1	1
6)	Lathe grinding machine in/ex.	1	-	-

Appendix 3

		A	B	C
G - WASHING BAY EQUIPMENT (TRACTORS)				
1)	High pressure electric pump (water) flow 4÷6 m^3 /h press. 18÷20 kg/cm^3	1	1	-
2)	Hoses with nozzles	1	1	1
3)	Accessories for washing bay	1	1	1
H - WASHING BAY EQUIPMENT (PARTS)				
1)	Steam washing mach.	1	1	-
2)	Washing tank with gasoil or kerosene	1	1	1
3)	Metal platform for parts	4	2	-
4)	Metal baskets for parts	10	6	3
5)	Accessories for above	1	1	1
I - TRACTORS BOX - DETACH/RE-ATTACH ASSEMBLY				
1)	Large working benches with vice	5	3	2
2)	Metal platform for parts	5	3	2
3)	Roller tool chests	5	3	2
4)	Tank for radiator's water	2	1	1
5)	Creepers	1	1	1
6	Series of ex/pipe gas hoses	x	x	x
J - TRACKS OVERHAUL EQUIPMENT				
1)	Power hydraulic press (2 cylinders) 180 ton 16 HP-M751400	1	-	-
2)	" " " (1 cylinder) 95 ton 3 CV	-	1	1
3)	Hand " " portable 95 ton	1	1	1
4)	Track pulley	1	-	-

Appendix 3

		A	B	C
5)	Special equipment for tracks overhaul			
	for press 1	1	-	-
	" " 2	1	1	1
	" " 3			
6)	Pneumatic strewer complete	1	-	-

K - ENGINE AND ASSEMBLY OVERHAUL EQUIPMENT

1)	Engine overhaul revolving stand	2	1	1
2)	Light engine and assembly revolving stand	2	1	1
3)	Differentials overhaul stand	1	-	-
4)	Parts container large	3	1	1
	small	2	1	1
5)	Working bench with vice	6	3	3
6)	Parts storage board m. 0.5 x 1	10	8	5
7)	Connecting rod testing bench complete	1	1	1
8)	Face plate m/m 500x900 complete	1	1	1
9)	Connecting rods & piston balancing equipment - complete	1	-	-
10)	Valve refacer - complete	1	1	-
11)	Cylinder head flattening equipment	1	-	-
12)	Piston and bearing heating set	1	-	-
13)	Vertical hydraulic press ton 100 complete			
	powered	1	-	-
	hand		1	1
14)	Hand hydraulic press 10 ton complete	1	-	-
15)	Cylinder and cylinder liner boring mach.	x		
16)	Crankshaft grinding mach.	x		
17)	Cylinder and cylinder liner honing mach.	x		
18)	Shelf for tools and accessories	2	1	-
		1	1	1

Appendix 3

		A	B	C
L - HYDRAULIC SYSTEM OVERHAUL EQUIPMENT				
	1) Electric motor to drive hydraulic pumps 65/50 Kw.			
or	2) Diesel engine 85 CV	1	-	-
	3) Electric motor to drive hydraulic systems and Servo-controls 4/3 Kw.	1	-	-
	4) Pump delivery control (5-400 l/min.) for 1-2-3	1	-	-
	5) Hydraulic lifting system test bench	1	-	-
	6) Hydraulic cylinders test bench	1	-	-
	7) Gear box overhaul revolving stand	1	-	-
	8) Large parts containers	1	-	-
	9) Flapping washing tank for parts	1	-	-
	10) Stand shelf for various equipment	1	-	-
	11) Metal board for parts mt. 1 x 0.5	2	-	-
	12) Tool board	2	-	-
	13) General and specific set of tools for assembly and disassembly	x	1	1
	14) Specific instrument set for hydraulic equipment	x	—	-
M - INJECTION PUMP AND ELECTRIC SYSTEMS OVERHAUL EQUIPMENT				
	2) Injector hand test pump	1	1	1
	3) Electric test bench	1	-	-
	4) Battery recharger for 4 batt.	1	-	-
	2 batt.	-	1	1
	5) Quick battery recharger	1	-	-
	6) Cabinet with aspirator for in-charge battery	1	1	1
	7) Board for battery in-charge	1	1	1
	8) Working bench with vice for pumpist and electrician	2	-	-

Appendix 3

		A	B	C
9)	Shelf for storage diesel pump/injectors and electric equipment	2	-	-
10)	Screw press 4 ton complete	1	-	-
11)	Gasoline-cleaning tank	1	-	-
12)	Battery hand truck	1	-	-
13)	Generic/special tool set for assembly - DISASSEMBLY CONTROL	x		

N - ENGINE BRAKE TEST BENCH

1)	Hydraulic brake complete with tank/fixing devices measurement instruments etc.	1	-	-
2)	Working bench with vice	1	-	-
3)	Cabinet for equipment	1	-	-
4)	Wheeled tank with hand pump for transfer fuel	1	-	-

O - GENERIC/SPECIFIC VARIOUS EQUIPMENT

a)	for Workshop:			
1)	Tool chest complete	10	5	3
2)	Generic tool set of frequent use to be held on the tool board	x	x	x
3)	Specific tool set for frequent use to be held on the tool board	x	x	x
4)	Various equipment sets for: Machine box and particular check on face plate	x	x	x
b)	for Tool Store:			
1)	Shelves for Equipment	x	x	x
2)	Instruments for measurement and control	x	x	x
3)	Different spanners and extractors	x	x	x
4)	Instruments, tools and accessories for mechanical works	x	x	x

Appendix 3

		A	B	C
5)	Various auxiliary sets	x	x	x
6)	Specific equipment	x	x	x
7)	General use and supply items	x	x	x

P - MISCELLANEOUS

1)	Metal scrap metallic containers	5	3	3
2)	Fuel and lubricants racks	-	-	-
3)	Fire figchting buckets	4	3	2
4)	Waste oil drums	2	2	1
5)	Stand desk	2	1	1

APPENDIX IV

COMPLEMENTARY TOOLS FOR WORKSHOP

1) Shelves for Equipment:
   - Lower shelf element
   - Upper " "
   - Corner " "
   - Drawer shelf
   - Bench

2) Measurement and Control Instruments:
   - Double felxible meter
   - Set of 2 outside calipers (mm. 0.50) length mm.300 and 850
   - 6 sets outside micrometers (cent.) 0÷150 mm.
   - Inside micrometers 0÷125 mm.
   - 3 sets reamers (cent.) from 18 to 150 mm.
   - Magnetic support for dial gauge
   - Metric/inch screw pitch gauge
   - Angle protractor
   - 2 sets 90 squares back and simple 200 x 300 mm.
   - Set of 3 hermaphrodite caliper inside/outside length 200 mm.
   - Control ruler
   - Graded steel ruler 2000 x 50 x 10 mm.
   - Set of 3 spring torque-meter 1-5-30 kg.
   - Torque screw driver 0÷25 kg
   - Set of torque wrenches 1-6-12-36-75-120-200 kg
   - Set of 2 torque multipliers 275-550 kg
   - Tachometer up to 1000 RPM
   - Engine compression gauge (Diesel and gasoline)
   - Metallic thermometer up to 150 C
   - Set of manometers - 8-25-75-250 kg/sq.cm. for testing hydraulic systems
   - Electric tester
   - Set of containers for liquid measurements (2 litre/1 litre/ 1/2 litre etc.)

Appendix 4

3) Various Spanners and Extractors:

- Set box spanners from 22 - 50 mm.
  46 - 80 mm.
  3/8" - 1 1/4"
  7/8" - 2"
- Set combined spanners 1/4"- 1 1/8"
- Set Allen keys 4 - 36 mm.
- Set articulated T spanners 10-22 mm.
- Set of 3 hook spanners 40-100 mm.
- Oil filter special spanner
- Set box spanners up to 2"
- Set of 3 extractors for broken screws Ø 3÷24 mm.
- Set of 3 extractors for studs Ø 5÷25 mm.

4) Equipment, Tools, Accessories for Mechanic Works:

- Mobile generator/welding set (electrodes Ø 3.25)
- Set of 3 hand drill machine Ø 8-13-23
- Pneumatic lapping machine Ø stones 40 mm.
- Disc angled electrolapping machine Ø disc 200 mm.
- Sets twist drill Ø 1 to Ø 35
- Twist drill spindle 1 to 13 mm.
- Sets conic box production 1/2 - 2/3 - 3/4
- Sharpening/weld drosser equipment (to be attached to 1 double grading machine Ø 200 mm. (above)
- Series adjustable hand reamers Ø 10.5 - Ø 45 mm.
- Complete sets of metric tabs/dies Ø 3 - Ø 45
- Series of re-threading files metric/inch internal/external
- Hand hack saw and blades
- Series of files, oil stones, dry stones
- Series of scrapers
- Series of scissors, shears, cutting nippers, hollow punchers
- Electro and gasoline soldering irons

Appendix 4

5) Complementary Tools:

- Series of hand and screw clamps
- Pliers (pipe bending - server rings)
- Series of punches (lettres/numbers)
- Electric pencil
- Series portable electric torches
- Series of filtered funnels
- Series of mechanics identification numbers

6) Special Equipment:

- Inserting valves seats tool
- pneumatic blades grinder
- All the equipment that is fragile, expensive, most in need of care, not frequently used, difficult to keep in the workshop equipment.

7) Stock Equipment

For the fast wearing tools such as: chisels, brushes, punches, soft hammers, vice cups, saw benders, etc. and for most important specific tools such as: special extractors etc. a stock of items is held to replace or repair them.

MECHANIC'S TOOL KIT

The hand tools suggested under this heading and listed here are those normally required by a mechanic for maintenance and repairs in the field and the shops. Special tools and service aids must be available from the shop tool racks and the tool room to supplement the tools in the kit.

All spanners are detailed in the three main standards and the tool kit should be supplied with spanners of the particular standard of threads and bolts used on the machine to be serviced.

The tools must be supplied in tool boxes, preferably of the expanding type, with good locking devices.

Items 1 to 16 cover standard tools normally carried by the mechanic in his box.

All steel tools must be made of high grade alloy steel forgings suitably heat treated.

The spanner openings listed are nominal. All spanners must be machined to sizes within the permissible tolerances.

Tools finished in black, dull bronze, dull or bright nickel or chromium are acceptable.

STANDARD TOOLS IN EXPANDING TOOL BOX

1) Spanners, open end: One each

a) Miniature or ignition set. These may be made of pressed tempered steel in sets or singly in chromium-alloy steel, single or double end. The pairing of sizes may be in accordance with manufacturers' standard.

i) American Standard Nominal opening:	ii) British Standard Size of bolt:	iii) Metric standard Norminal opening:
5/32"; 3/16"	BA No.6; 5; 4; 3; 2;	4; 4.5; 5; 5.5; 6;
1/4"; 5/16"	1; 0	7; 8; 9 mm.
11/32"; 3/8"	BSW.1/8"; 3/16"	

Appendix 5

b) Standard set: double end, 15°. One each
Made of chrome alloy forgings. The pairing of the openings may be in accordance with manufacturers standards.

i) American Standard Nominal opening	ii) British Standard size of bolt	iii) Metric Standard Nominal opening
3/8" - 7/16"	3/16" - 1/4" short	8-9)
1/2" - 9/16")	5/16" - 3/8")	10-11)
19/3" - 5/8"	7/16" - 1/2"	13-14
11/16" - 3/4"	9/16" - 5/8"	17-19
25/32" - 13/16"	11/16" - 3/4"	22-24
7/8" - 15/16"	13/16" - 7/8"	27-30
1" - 1.1/16"		32-36
1.1/8" - 1.1/4"		

c) Tappet type; One pair each size
Made of chrome alloy forgings. The pairing of the openings may be in accordance with manufacturers standards.

i) American Standard Nominal Opening	ii) British Standard Size of Bolt	iii) Metric Standard Norminal Opening
7/16" - 1/2"	3/16" - 1/4"	11 - 13 mm.
9/16" - 5/8"	5/16" - 3/8"	14 - 15 mm.
11/16" - 3/4"		17 - 19 mm.

2) Spanners Ring Type.

a) Standard set double end, offset. One each.
Made of chrome alloy forgings; the pairing of the openings may be in accordance with manufacturers standards.

i) American Standard Nominal Opening	ii) British Standard Size of bolt	iii) Metric Standard Norminal Opening
5/16" - 3/8")	1/8" - 3/16")	8 9) short
7/16" - 1/2")	1/4" - 5/16")	10 - 11)
9/16" - 19/32"	3/8" - 7/16"	13 - 14 mm.
5/8" - 11/16"	1/2" - 9/16"	17 - 19 mm.
3/4" - 25/32"	5/8" - 11/16"	22 - 24 mm.
13/16" - 7/8"	3/4" - 13/16"	27 - 30 mm.
15/16" - 1"	7/8"	
1.1/16" - 1.1/8"		

3) 1/2" square Drive Tools and Socket Spanners. One set
Made of chrome alloy steel

a) Drive Tools:

Ratchet, reversible	Extension Bar Short
Speeder Handle	Extension Bar Long
Nut spinner	Stud Extractor
Sliding "T" handle	Screw Driver sockets 1/2" and 3/4" blades
:	Converter 1/2" to 3/(" and 3/4" to 1/2"
Universal Joint	

Appendix 5

Sockets, extra deep, for spark plugs, 12 point
Nominal openings: 5/8"; 13/16"; 7/8"; 15/16"; 1"; 1.1/8"
Sockets,s, standard, 12 point.

b) American Standard Nominal Opening	c) British Standard Size of Bolt	d) Metric Standard Norminal Opening
3/8"; 7/16"; 1/2"	1/8"; 3/16"; 1/4"	10; 11; 12
9/16"; 19/32"; 5/8";	5/16"; 3/8"; 7/16"	13. 14; 15
11/16"; 25/32; 13/16"	12"; 9/16"; 5/8";	17; 19; 22
7/8"; 15/16"; 1";	3/4";	24; 27; 30 mm.

4) Hexagon Hollow Head Spanners (Allen Wrenches) One set made of chrome alloy steel

a) American Standard Nominal Opening	b) British Standard Nom. size of bolt	c) Metric Standard Nominal Opening
3/32"; 1/8"	1/4"; 5/16" 5	4; 5 mm.
5/32"; 3/16"	3/8"; 7/16"	6; 8 mm.
7/32"; 5/16"	1/2"	10 mm.
3/8"		

5) Adjustable spanners, single end, made of chrome alloy steel. One each.
   a) 6" Nominal size, max jaw opening approx. 3/4"
   b) 12" Nominal size, max jaw opening approx. 1.3/8"

6) Pipe Spanner, (Stillson or similar) made of alloy steel
   a) for pipes up to 1" One

7) Drifts, made of Brass one each
   a) Approx. 3/8" diameter x 6" long
   b) Approx. 5/8" diameter x 6" long

8) Pry Bar, Punches, Chisels in Alloy Steel, one each
   a) Pry Bar, approx. 18" long, 5/8" stock;
   b) Starter Punch, approx. 3/8" stock, 1/8" point
   c) " " " 1/2" " 1/4" "
   d) Pin Punch, 1/8" point
   e) " " 1/4" "
   f) Center punch, approx. 3/8" stock
   g) Scriber "L" shape
   h) Chisel, flat, approx. 1/2" edge
   i) " " " " 3/4" "

9) Pliers and Cutters, in Alloy Steel. One Each
   a) Self grip plier, approx. 7"
   b) Diagonal cutter, 6"
   c) Combination pliers, with insulated grips, approx. 6"
   d) Slip joint pliers, water pump type 9"
   e) Tin snips approx. 10"

10) Scrapers, Carbon Steel. One each
   a) Flexible carbon scraper approx. 9" long
   b) Gasket scraper, blade approx. 1" wide

Appendix 5

c) Putty knife, approx. 1.1/4" x 7"
d) Triangular hollow ground scraper, approx. 6"
e) Spoon type scraper approx. 6"

11) Screw drivers, Alloy Steel, One each
a) Machinists, blade approx. 4" long, tip 1/4" wide)
b) " " " 8" " " 3/8" ") with square shank
c) " " " 10" " " 1/2" ")
d) Carburettor type, blade 1" long, tip 1/4" wide
e) Electricians, blade 3" long, 1/8" wide.

12) Hammers, one each
a) Ball peen approx. 1/2 lb.
b) Cross peen 2 lb.

13) Files, with wooden handles, one each
a) Flat, 10", second cut
b) Round, 8", second cut
c) Threesquare; 6" smooth
d) Contact file approx. 5" long
e) Thread Restoring file for:
i) American Thread)
ii) British thread) One each to match thread standards on machines
iii) Metric thread) serviced.

14) Hacksaw and blades
a) Hacksaw frame with pistol grip for 10" and 12" blades, one
b) Hacksaw blades, 18 teeth per inch, size 12",
c) Hacksaw blades, 32 teeth per inch, size 12",

15) Measuring Instruments, one
a) Vernier parallel caliper, measuring range approx. 6" with cross horns for internal measurements and with depth gauge graduation in inches and millimeters with vernier to read to 1/20 mm. and to 1/128". Execution in rustless steel preferred.
b) Rule, steel, preferably stainless, 12" long. English and Metric graduation, one side only; machine divided, one
c) Tape rule, flexible, 6" long, graduated in inches and metric, stainless, one
d) Feeler gauge, ten blades, tapered, 4" long
i) Blades from 1.1/2 to 25 thousands") one each to match machine
ii) Blades from 0.05 to 0.80 mm.) standard to be serviced

16) Oil Can, pump type, 1/4 litre capacity, preferably with swivel.

APPENDIX VI

EXAMPLES OF SERVICE VEHICLES

The tools carried by the service vehicles follow the indications below, forming a complete set in the heavier vehicles and being necessarily reduced according to the needs and possibilities in the medium and small vehicles.

SERVICE EQUIPMENT (Informative list)

Plants, machines, miscellaneous equipment.

— Hand-operated hoist - 1000/1600 kg (2205/3527 lbs.) capacity offering the possibility to lift the load and transfer it inside the van.
— Oxy-acetylene welding and torch-cutting equipment.
— Electric arc welding set (200 amp).
— Air compressor and accessories.
— Bench and portable electric drills.
— Bench and portable electric grinders.
— Hand-operated hydraulic press, 95-ton capacity.
— Electric power generator set driven by the vehicle P.T.O. (10 KVA).

Universal tools.

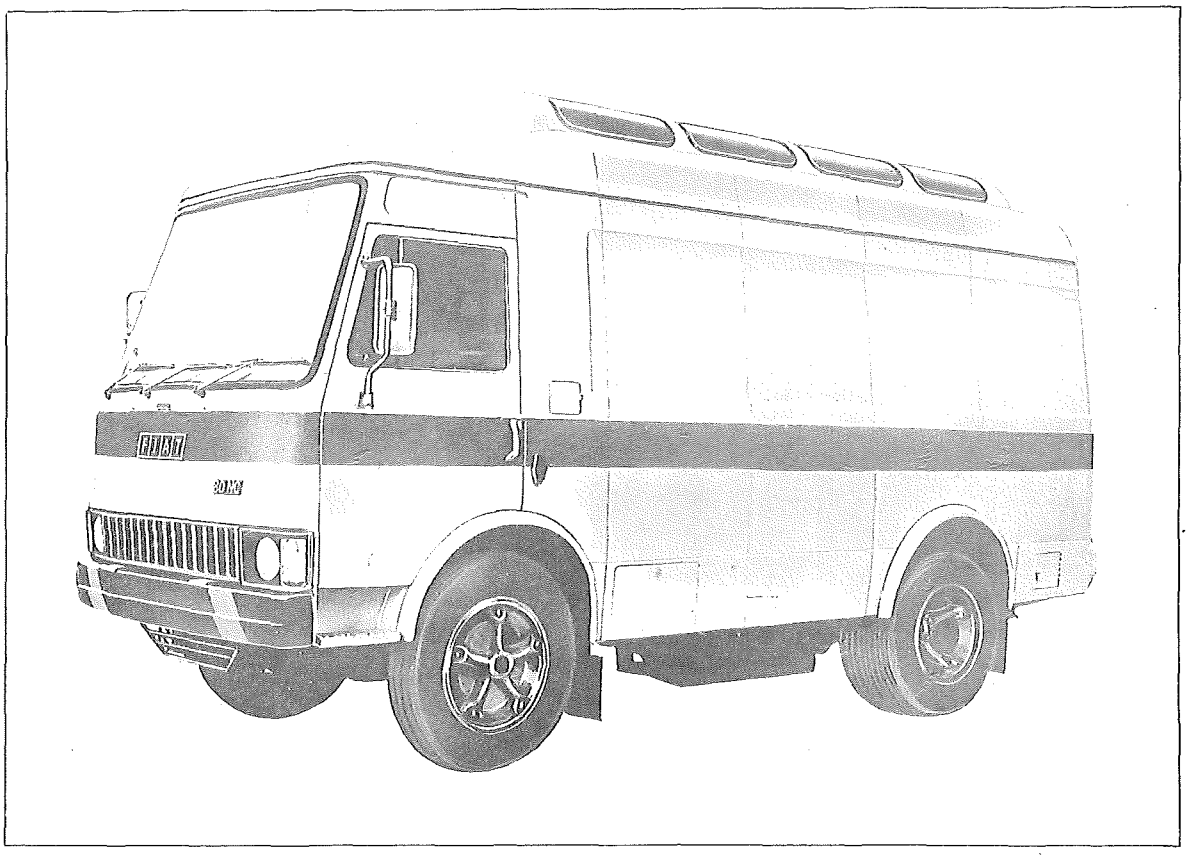
— Jacks, shop stand, lifting hooks.
— Wrench set, pliers, hammers, chisels, punches, crowbars.
— Torque wrenches and multipliers.
— Universal puller set.
— Sets of drills, taps and dies.
— Measuring instruments and check gauges.
— Parts washing tank, parts bins.
— Welder, portable lamp, fire extinguisher, first aid kit.

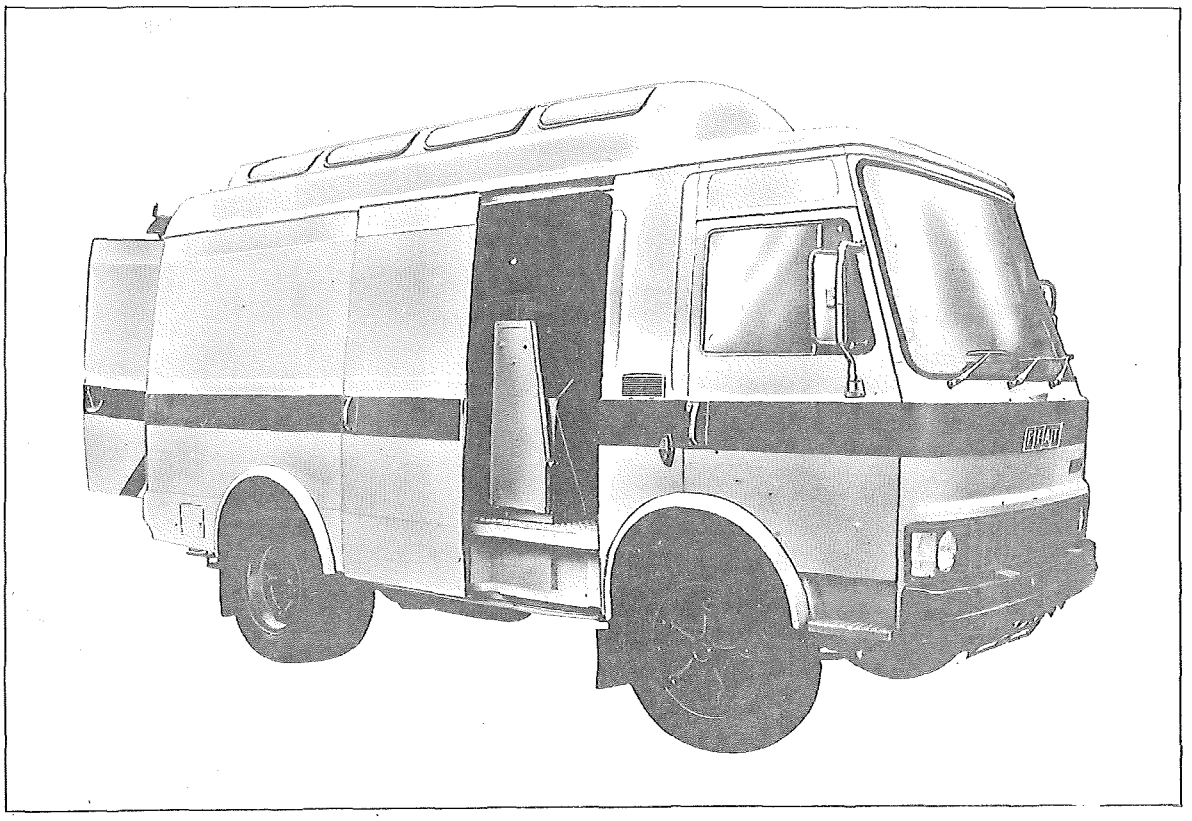
Specialized tools

— Specialized tool sets to be selected according to the type and model vehicle to be serviced:
pullers, hooks, stops, brackets, special wrenches, milling cutters, valve seats, hand-press accessories, etc.

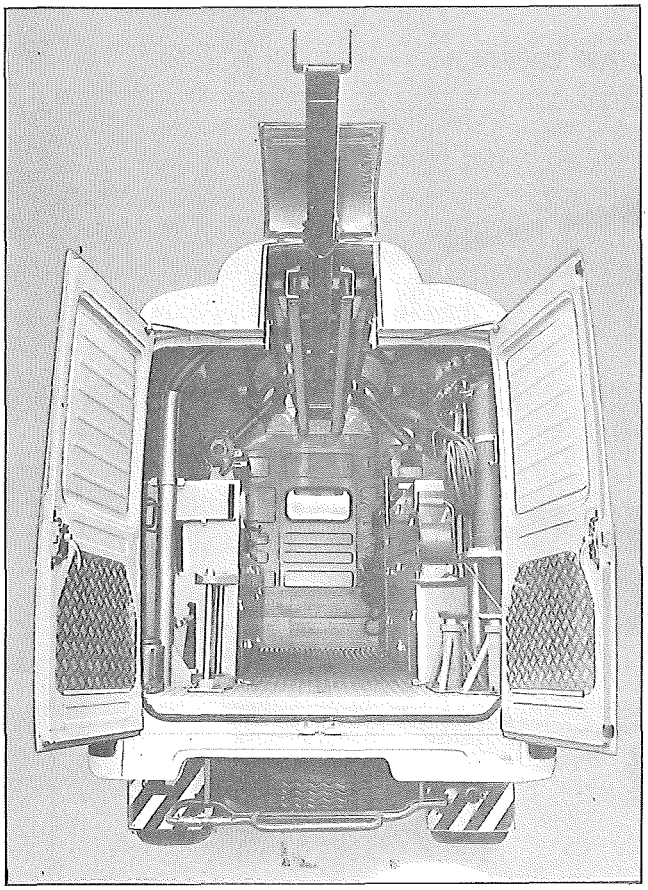
Appendix 6

HEAVY VAN, 2x4, 3 TON CAPACITY



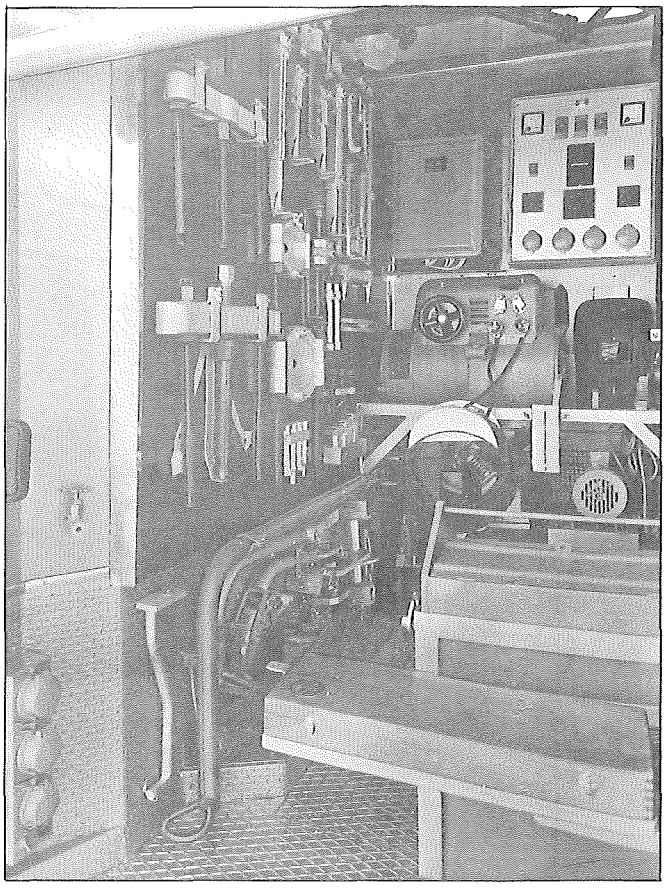


Appendix 6



HEAVY VAN, 2x4

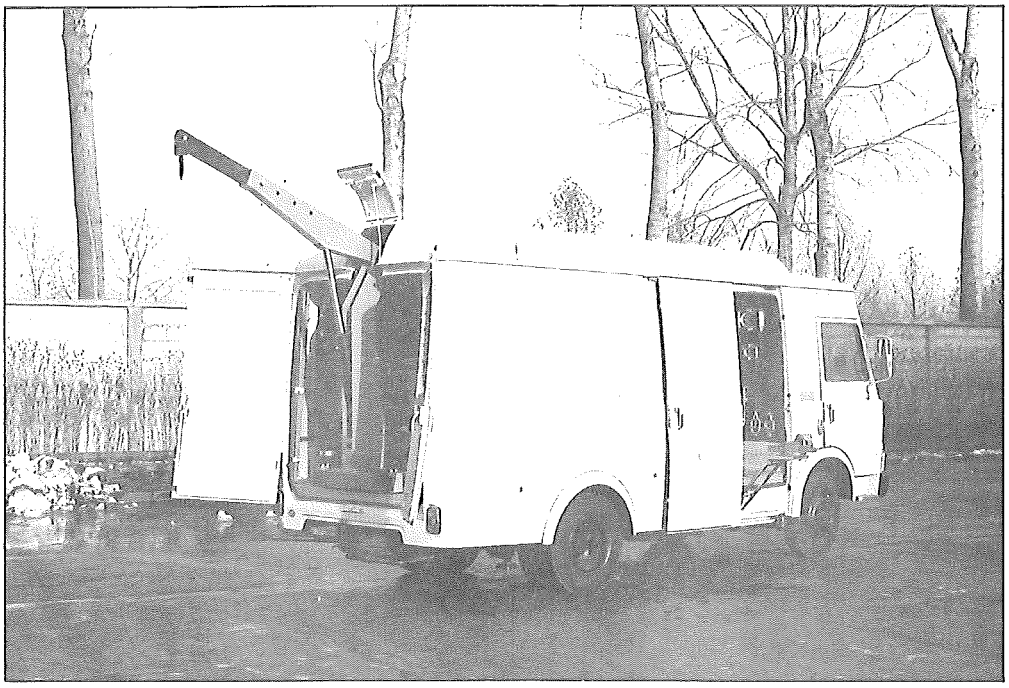
REAR



INSIDE

Appendix 6

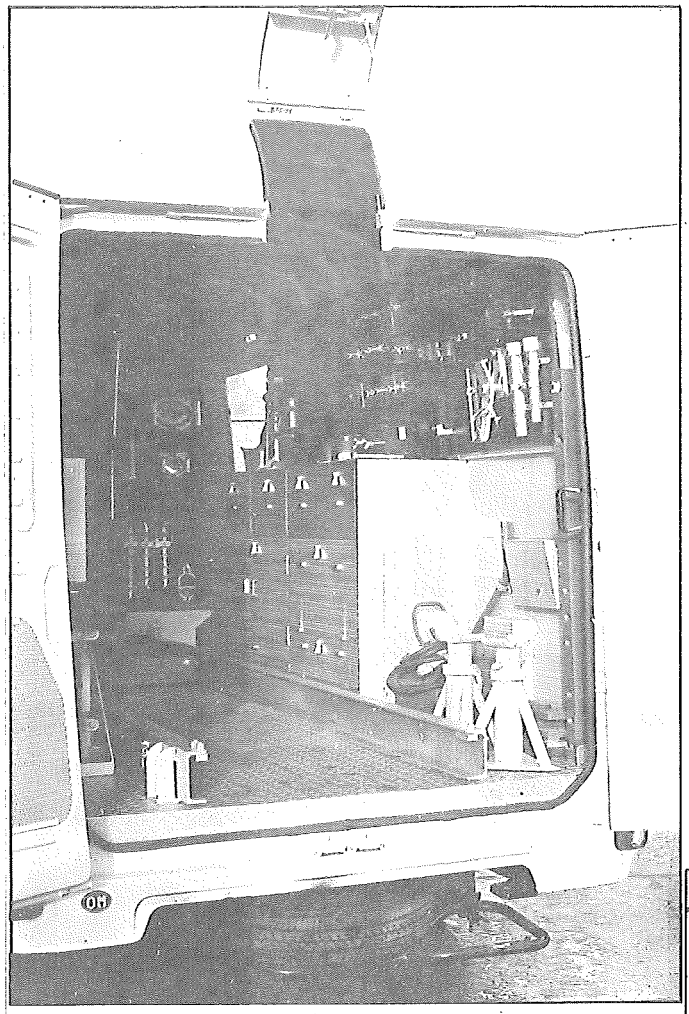
MEDIUM VAN, 2x4, 2 TON CAPACITY



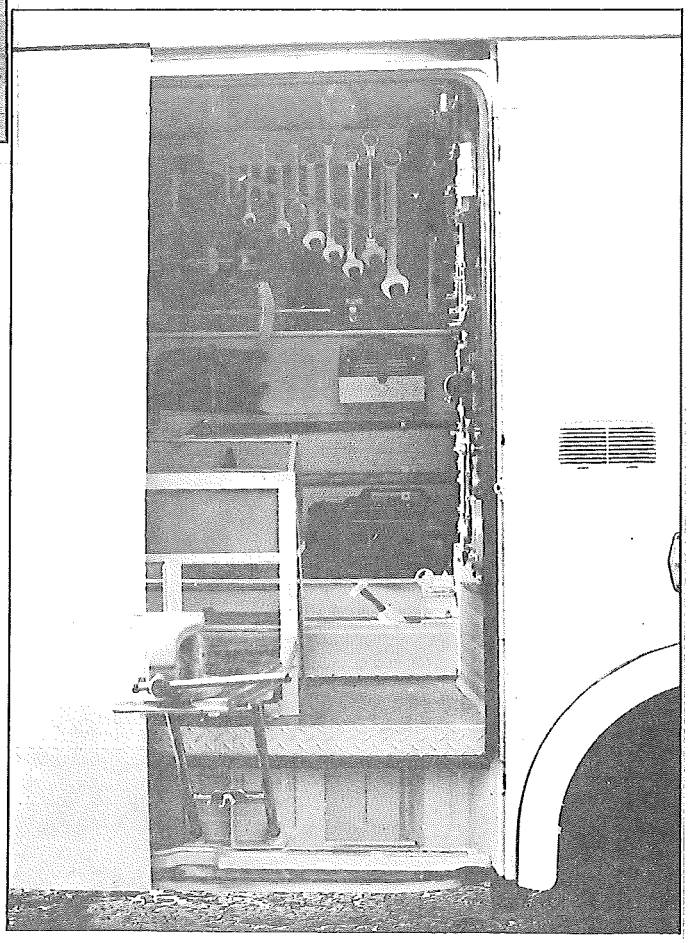
Appendix 6

MEDIUM VAN, 2x4

INSIDE

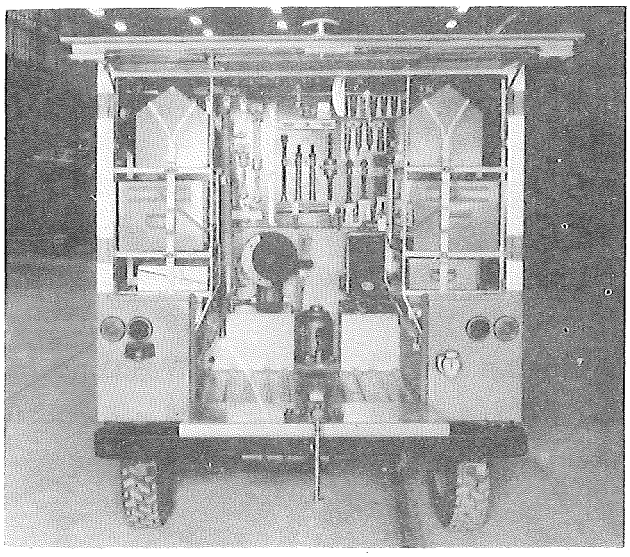


LATERAL



Appendix 6

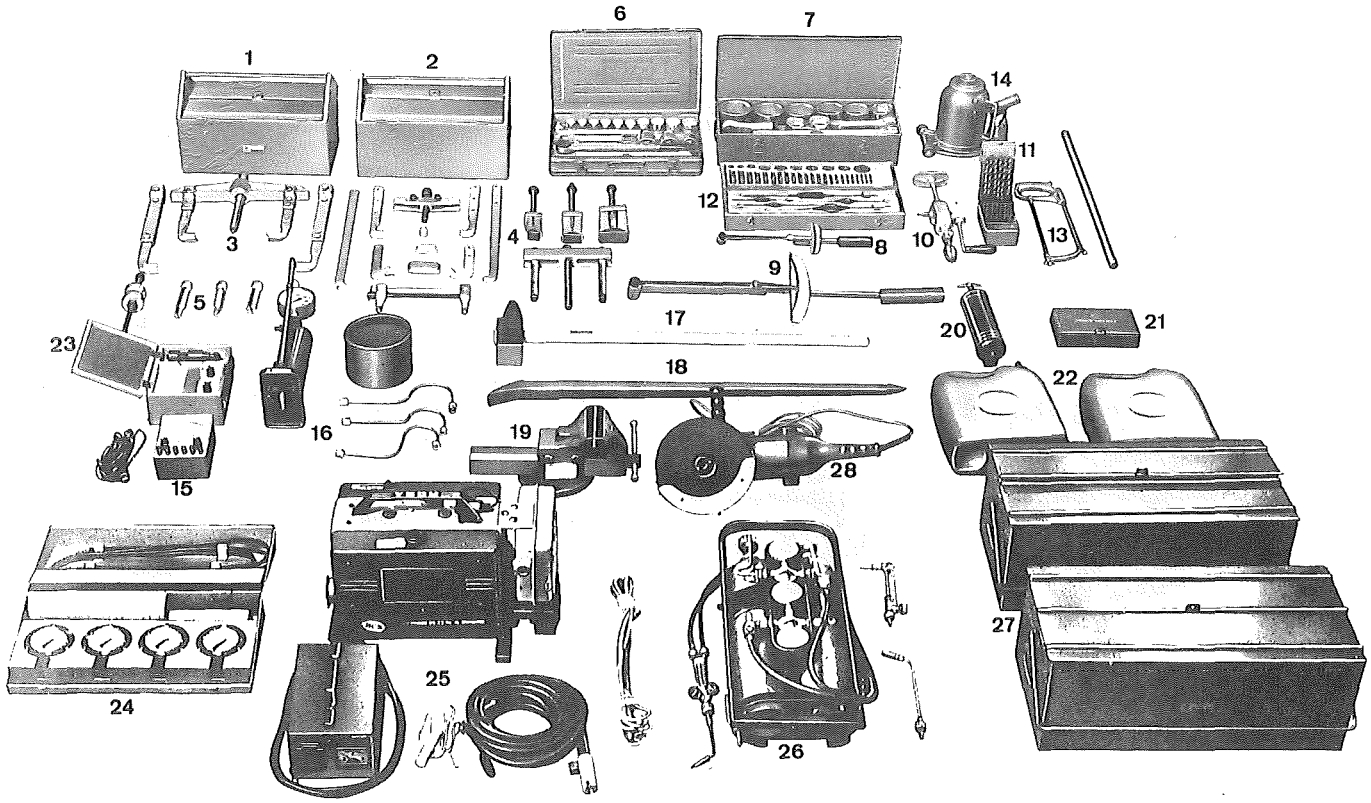
LIGHT VEHICLE, 4x4 (JEEP TYPE)



Appendix 6

EXAMPLE OF GENERAL TOOLS INSTALLED IN A LIGHT VEHICLE, 4x4

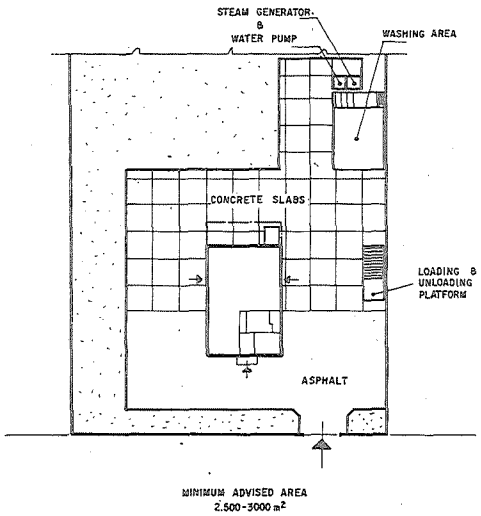
SPECIFIC TOOLS MAY BE ADDED AS SEEN FIT

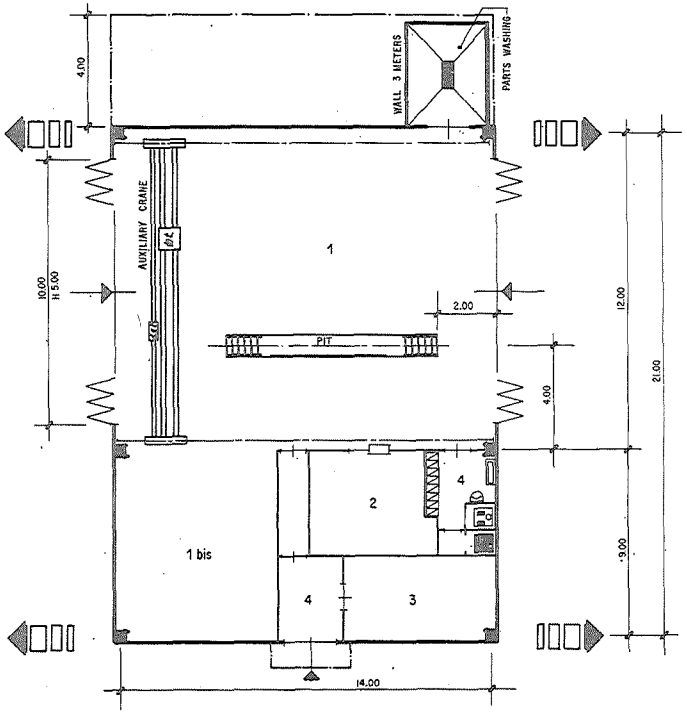


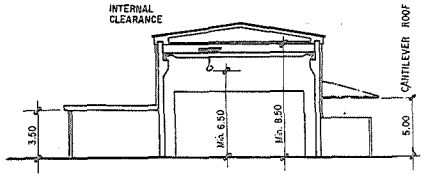
1 - Tool box, general purpose tools
2 - Tool box, general purpose tools
3,4,5 - Pullers
6,7 - Medium and large size socket and wrench set
8,9 - Torque wrenches
10 - Hand drill
11 - Drill joints set
12 - Partial set of threading dies and taps
13 - Hacksaw
14 - Hydraulic jack, 15 ton
15 - Tester, electric
16 - Hand pump, hydraulic test
17 - Sledge hammer
18 - Crowbar
19 - Vice
20 - Fire extinguisher
21 - First-aid kit
22 - Gasoline and water canister
23 - Electric RPM counter
24 - Pressure test set, hydraulic
25 - Electric welder (2000 W)
26 - Torch welding and cutting set
27 - Container for equipment and spares
28 - Electric grinder

APPENDIX VII

The following are some examples of typical facilities for a servicing organization. Even though local adaptions will have to be made, the general lay-out should be kept as long as possible.

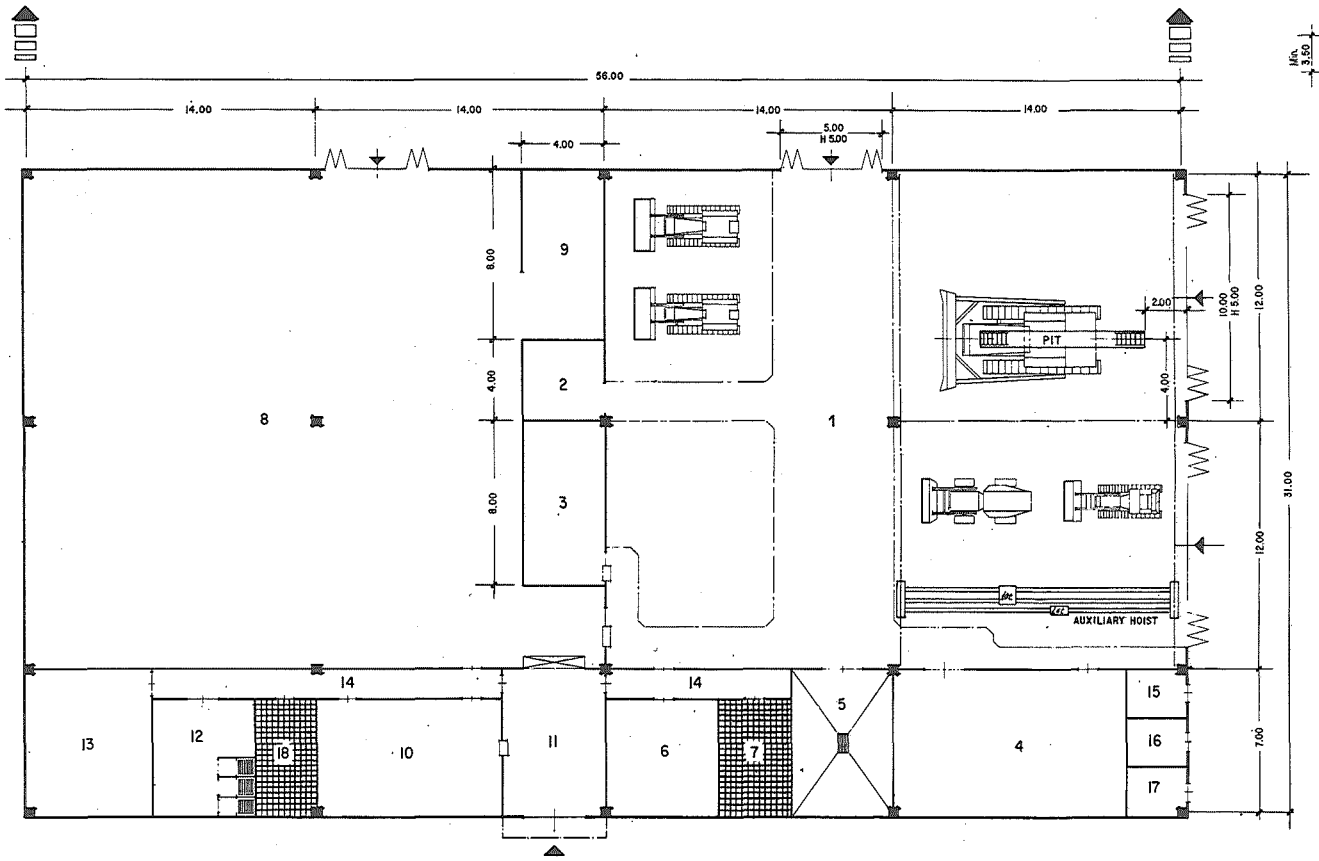


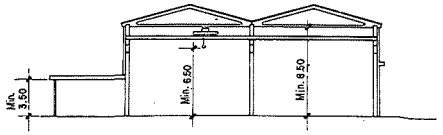


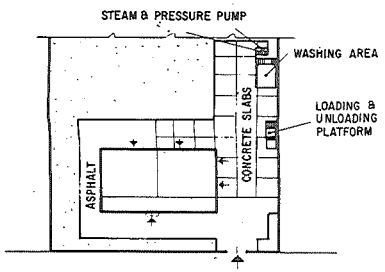


1	– WORKSHOP (BOX AREA)	168m²
1bis	– WORKSHOP (ASSEMBLIES REPAIR)	42
	TOTAL	210
2	– SPARES AND TOOLS STORE	18
3	– OFFICE	17
4	– SERVICES & OTHER	49
	TOTAL	84
	TOTAL COVERED AREA	294
	CANTILEVER ROOF AREA	56

EXAMPLE OF MINI-TYPE REPAIRSHOP







MINIMUM ADVISED AREA
12.000-15.000 m²

AREAS

1 –	WORKSHOP (BOXES & ASSEMBLIES REPAIR)	672m²
2 –	WORKSHOP TOOLS	15
3 –	TOOL ROOM	32
4 –	HYD., ELECTRICAL & INJECTOR AREA	77
5 –	PARTS WASHING	35
6 –	WORKSHOP OFFICE	30
7 –	TOILETS	18
	TOTAL	880

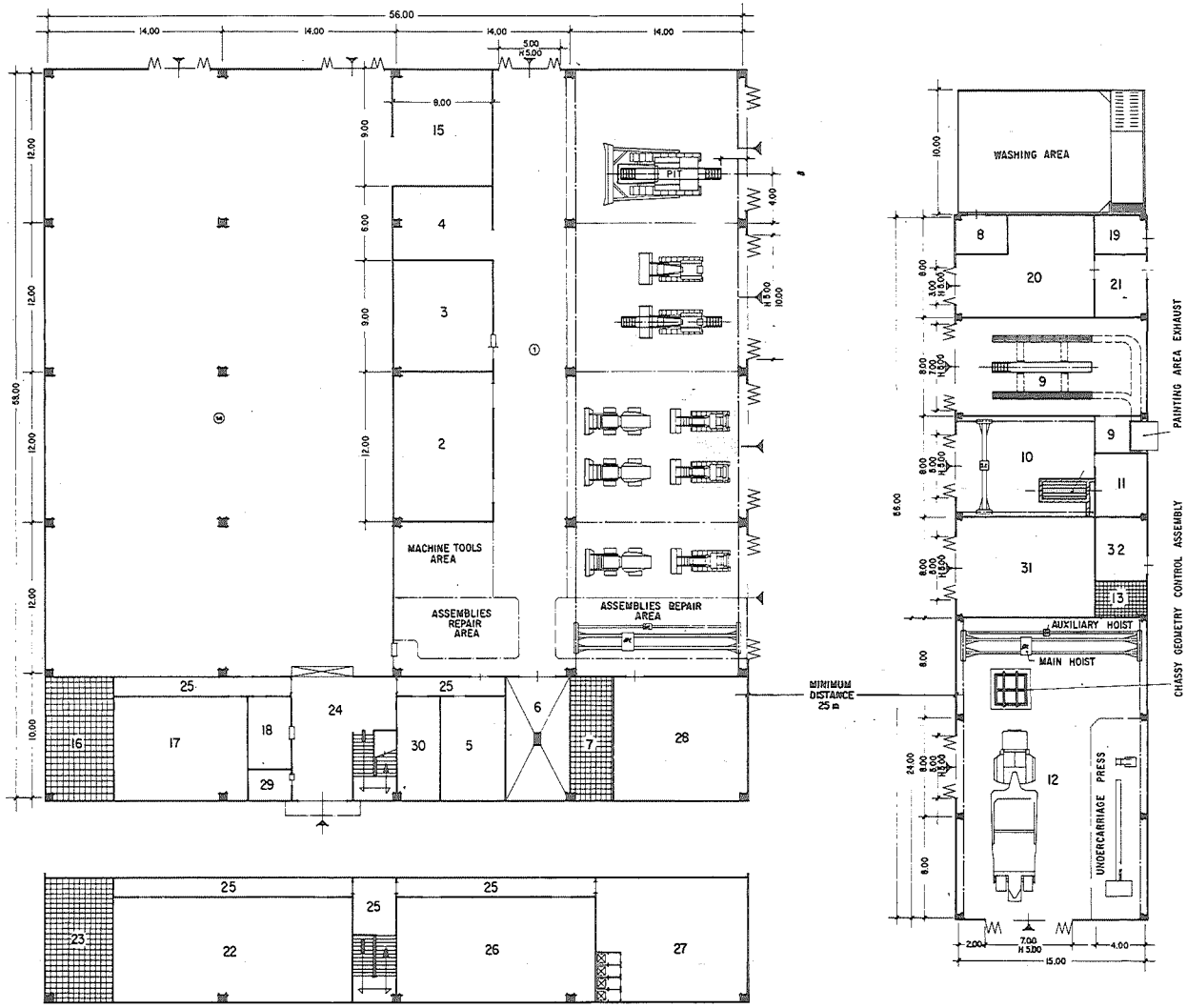
SPARE PARTS AREA

8 –	STORE	592
9 –	PACKING AREA	32
10 –	SPARES OFFICE	50
	TOTAL	674

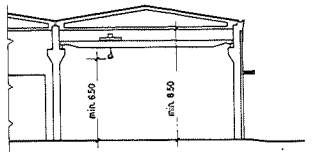
OTHER AREAS

11 –	HALL	35
12 –	LOCKER ROOM	28
13 –	CANTEEN	42
14 –	CORRIDORS	38
15 –	AIR COMPRESSORS	7
16 –	GENERATOR	7
17 –	POWER ROOM	7
18 –	TOILETS	18
	TOTAL	132
	TOTAL COVERED AREA	1 736

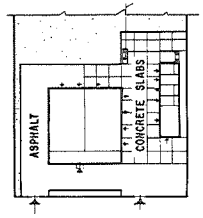
EXAMPLE OF SMALL-TYPE SERVICE CENTRE



WORKSHOP INSIDE CLEARANCE



LOADING & UNLOADING PLATFORM

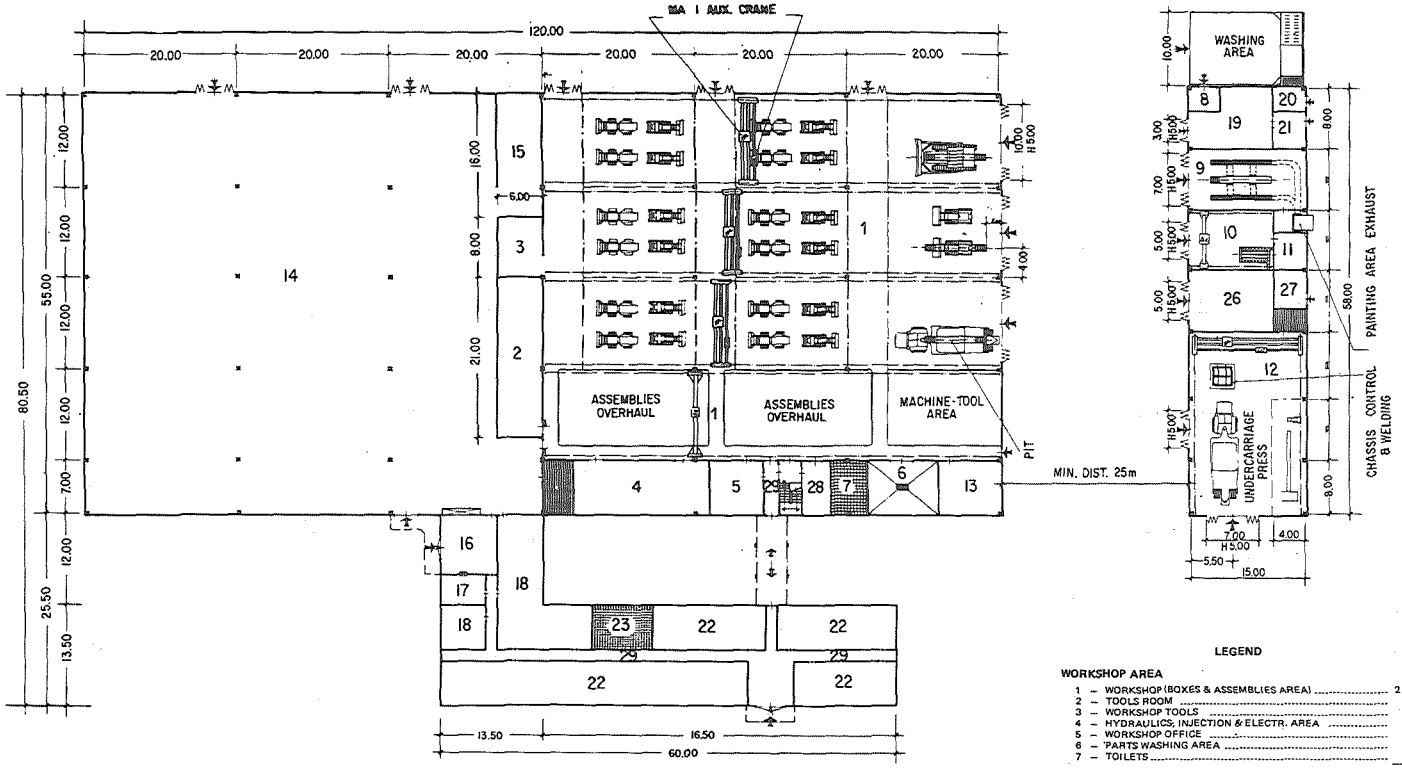


MINIMUM ADVISED AREA
25.000/30.000 m²

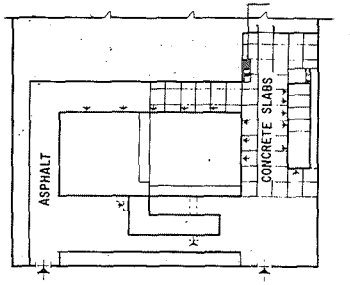
LEGEND

WORKSHOP AREA		
1 – WORKSHOP		1 088 m²
2 – HYD. INJECTION & ELECTRICAL		88
3 – TOOL ROOM		72
4 – WORKSHOP TOOLS		48
5 – WORKSHOP OFFICE		44
6 – PARTS WASHING AREA		50
7 – TOILETS		35
	TOTAL	1 491
OTHER AREAS		
8 – STEAM & WATER PUMPS		12
9 – PAINTING AREA		132
10 – ENGINE TEST ROOM		88
11 – AIR COMPRESSOR		20
12 – UNDERCARRIAGE & CHASSIS		360
13 – TOILETS		12
	TOTAL	624
	TOTAL WORKSHOP	2 025
SPARE PARTS AREA		
14 – STOREROOM		1 334
15 – PACKING AREA		72
16 – TOILETS		55
17 – PARTS OFFICE		94
18 – PARTS OFFICE		21
19 – DEPOT		12
20 – LUBRICANTS		76
21 – PAINT DEPOT		20
	TOTAL	1 694
OFFICES AREA		
22 – OFFICES		162
23 – TOILETS		55
	TOTAL	217
OTHER		
24 – HALL		25
25 – CORRIDORS		114
26 – CANTEEN		136
27 – LOCKER ROOM		120
28 – CLASSROOM		110
29 – GUARDS		9
30 – INFIRMARY		30
31 – GENERATOR		88
32 – POWER ROOM		20
	TOTAL	712
	TOTAL COVERED AREA	4 088

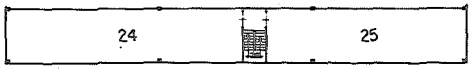
EXAMPLE OF MEDIUM-TYPE SERVICE CENTRE



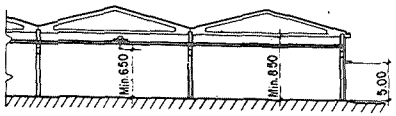
MINIMUM ADVISED AREA
40 - 50.000m²



1st FLOOR



INSIDE CLEARANCES



VI.

LEGEND

WORKSHOP AREA

1	– WORKSHOP (BOXES & ASSEMBLIES AREA)	2 880m²
2	– TOOLS ROOM	126
3	– WORKSHOP TOOLS	48
4	– HYDRAULICS, INJECTION & ELECTR. AREA	126
5	– WORKSHOP OFFICE	49
6	– PARTS WASHING AREA	63
7	– TOILETS	35
	TOTAL	3 327

AUX. AREAS

8	– STEAM & PUMPS WASHING	12
9	– PAINTING	120
10	– ENGINE TESTING	88
11	– AIR COMPRESSED	20
12	– UNDERCARRIAGE & FABRICATED AREA	372
13	– CLASSROOM	56
	TOTAL	668
	WORKSHOP TOTAL	3 995

SPARE PARTS

14	– STORE	3 030
15	– PACKING AREA	96
16	– 17 – 18, – OFFICES	228
19	– LUBRICANTS	76
20	– DEPOT	12
21	– PAINT DEPOT	20
	TOTAL	3 462

OFFICES

22	– MANAGEMENT OFFICES	510
23	– TOILETS	48
	TOTAL	548

OTHER AREAS

24	– CANTEEN	217
25	– LOCKER ROOM	182
26	– GENERATOR	88
27	– POWER HOUSE	20
28	– INFIRMARY	28
29	– CORRIDORS	282
	TOTAL	817
	TOTAL COVERED AREA	8 412

EXAMPLE OF LARGE-TYPE SERVICE CENTRE

APPENDIX VIII

Example of Flat Rate Indicator, taken from one manufacturer publication. Designation of operations (first column on the left) has been replaced by simpler symbols; models of tractors have also been replaced - last 9 columns on the right. Times shown in hours.

		TRACTOR MODELS							
OPERATION NUMBER	ENGINE Crankcase and Cylinder Heads	A B	C	D E F G	H I J	L M	N	P	Q
1	Cylinder liners hone and polish; crankcase stripped on bench (liners removed on models L, M, N, P, Q)	2.00	2.00	2.75	3.50	2.75	3.50	4.50	4.50
2	Cylinder liners - Hone and polish to .10 mm; crankcase removed on bench.	1.00	1.00	1.25	1.50	1.25	1.50	2.00	2.00
3	As above for one liner only	.75	.75	.75	.75	.75	.75	.75	.75
4	Cylinder liners - Replacement, crankcase on bench. Rehone and hone not included.	1.00	1.00	1.50	2.00	2.00	2.50	3.00	3.00
5	Cylinder head - Remove and replace; engine on tractor - and/or new gasket. Adjust tappets included;	3.00	3.00	4.00	4.00	4.75	4.75	5.50	6.00
6	As above, engine on bench.	1.75	1.75	2.00	2.00	2.50	2.50	3.50	4.00

../...

7	Water pump - Remove and replace.	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
8	As above, radiator removed.	.75	.75	.75	.75	.75	.75	.75	.75
9	Clutch - Remove, replace, adjust.	6.50	5.00	5.00	5.00	6.00	6.75	7.00	7.00
10	As above, engine removed.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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