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PRESENTING TECHNICAL INFORMATION TO MAINTAINERS

by

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We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

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FOREWORD

The term "technical communication" is widely used at this time to describe the process of transferring technical information from person to person and in the context of this symposium it applies in particular to two situations. Firstly, it applies to the transfer of technical information from the designer of engineering equipment to the actual user or maintainer and, secondly, to the transfer of information through a factory personnel heirarchy i.e. from chief engineer to maintenance engineers, lubrication personnel, electrical staff, etc. This paper describes how technical communications can be made more effective by ensuring that the recipient is presented with only the essential information, in detailed form and correctly structured to ensure full understanding in the shortest possible time.

1. THE DEVELOPMENT OF MAINTENANCE SYSTEMS

It is widely believed that improved maintenance systems are in widespread use in the industrially-developed countries and indeed there are some excellent systems in use, knowledge of which can be of great value to the developing nations. However, there are very many industrial situations in which reliance is still upon the old craftsman (old John in the maintenance office) who is reputedly able to fix everything. It is in fact the long industrial history of some heavy industries in particular which encourages this old way of life and militates against the modern methods.

The factors influencing the decision to introduce modern methods in many industries include:-

1. The employment of young highly-trained management with new ideas.
2. The use of increasingly sophisticated equipment, requiring skilled attention.
3. The disappearance of the old maintenance craftsmen.
4. The economics of business management in a competitive market.
5. The rising maintenance costs caused by:-
   - (a) Union practices and modern working conditions.
   - (b) Increased staffing levels when replacing the craftsmen.
   - (c) The rising cost of spares and materials.
   - (d) The high maintenance costs on some modern equipment.

This last point is quite important as not only is much of the modern equipment more sophisticated, but many designs have neglected the Design-Out-Maintenance techniques which become so important as costs rise. This highlights the question as to whether corrective maintenance should be operated on a repair level (using local skills to isolate faults to the smallest component requiring replacement) or a replacement (using units supplied by the equipment manufacturer) basis.

It is probably true to say that the U.S.A. leads in evaluating the cost of repair maintenance against the cost of maintenance on a replacement basis. Rising labour rates and overhead costs will certainly tend to increase the use of replacement items and possibly make redundant the workshop repair bench for small item servicing.

Of course, this is very much dependent upon the selection of a maintenance philosophy for engineering equipment at the design stage, and later in this paper I refer to a development management system to achieve this. The cost of spare parts and spare units must also be controlled by the manufacturer if the scales are not to tip back again, allowing repair labour costs to under-cut by substantial margins the cost of the replacement items.

Industrial management tends to react to higher maintenance costs by establishing rules and codes of conduct for maintainers, and this has led to productivity agreements, work specifications, standardised practices and to various forms of maintenance control. Reference to some of these is made in this paper.

It seems certain that the developing countries are passing through most of the phases experienced by their predecessors, when establishing an industry-based environment. It is likely that the first generation of maintainers (trained to a large extent by visiting technicians) will be expanded rapidly by the very pace of assisted development and that the problems, those that require systemised practices as answers, will arise over a a much-shortened time cycle than previously experienced.

It is suggested that, if the emphasis is placed on answering the question, "What do maintainers need so that they are sufficiently informed to do their jobs?", some of the other, more difficult questions may not arise, or may be easier to answer. It is against the background of widely-varied practices, difficult labour-relations in certain areas and rising maintenance costs, that experts in technical communications are looking at:-

(1) The improvement of technical information for maintainers.
(2) The design of communications systems for maintenance.
(3) The improvement of maintainer performance.

In the first category, the general trend is towards, firstly, ensuring that information is supplied for all equipment and, secondly, that such information is graphical, not too bulky and with short information-access times. The first of these points is being resolved as pressure on suppliers mounts and purchasers of engineering equipment insist on adequate information. Unfortunately, it has proved only too easy to meet these request with volumes of written information, hardly suitable for use in workshops. Thus, the discovery of bulky, text-orientated technical manuals covered in the dust of neglect in so many industrial locations has prompted attention to our second point - the design and structure of technical information. The cry for technical information may have been answered in some industries, but the way in which it has been answered is not always producing ideal results.

In the second category - the design of communications systems for maintenance - many systems have been devised and this paper will deal with some of them. The issue of technical instruction, the control of stores, and the planning and recording of work throughout the maintenance operation is vital to maintenance efficiency.

In the third category - the improvement of maintainer performance - attention has given to the training of maintainers and also to the use of maintenance aids. In the U.K. the establishment of Training Boards for the various industries has led to formalised training practices based on training programmes and manuals written by practical experts in these fields. The use of maintenance aids, particularly in improving fault-finding performance, is attracting much mention at this time and two of the methods used (algorithms and maintenance dependency charts) are described in this paper. Many manufacturers and many operators of important services (such as power stations and TV studios) are concerned with the amount of "down-time" occuring during fault location and are employing communications consultants to analyse the maintainers' requirements and to prepare this type of maintenance aid.

2. MAINTENANCE CONTROL

It is not the purpose of this paper to describe all the planning and control systems which have been developed for the operation of preventive and corrective maintenance. These range from simple card-file systems through electro-mechanical card-selection machines to computer-controlled systems for one plant or a group of plants. In general, most of these systems are concerned with:-

(a) Identifying the requirements of maintenance.
(b) Triggering the periodic maintenance actions.
(c) Providing technical information or instructions.
(d) Establishing a maintenance record.

Figure 1 snows the documentation stages of a typical planned maintenance system and the maintenance requirements are described at the left of the diagram. The central part of the diagram shows the programming and control functions which "trigger" the maintenance activities. At the right side of the diagram the information is being provided for the maintainer. At the top of the diagram are the master maintenance records. The "trigger" also informs the stores when spare parts and materials are required, and advises the production controllers when plant is to be taken out of service.

Figure 2 shows a manually-operated "trigger" system in which the "operator" of the maintenance system selects from filing cabinets the instruction cards for the scheduled maintenance. These cards are allocated by the foreman/controller to the maintainers, who [illegible]e responsible for doing the work and for returning the instruction cards and record sheets to the file system. The depth of information provided on the instruction cards may be varied according to the complexity of the tasks and the skills level of the available labour. Figure 3 shows the simple type of instruction card issued for inspection and preventive maintenance activities where the grade of labour is high and comprehensive technical manuals are issued for use directly on the job. Where lower skills levels are available, or where the technical manuals are inadequate or not available, the instruction cards are both detailed and illustrated.

The "trigger" function can be provided by an electro-mechanical machine of the type used for other card sorting and printing purposes. Each maintenance task is coded on a plastic or a metal plate and the machine is easily programmed to print out the required grades or types of work. This may be electrical or mechanical, weekly or monthly, etc. In the example shown (fig. 4) the machine is set to print out a six-part work card, whose appearance in the maintenance control department signifies the need for action as follows:-

Part 1 of the card - indicates that stores are required and initiates preparation of spares package.

Part 2 - passes to production control to initiate shut-down.

Parts 3,4,5 and 6 - instruct the maintainer, who signs part 4 and initiates corrective maintenance with parts 5 and 6 if required.

In this particular system the record system consists of a three-part card which not only lists the plant details, and provides a work and costs history, but also contains a master shedule as a reference in case any of the printing plates are mislaid.

It is usual in such a system to reduce the amount of information printed on the work cards and to issue separate work instruction sheets when these are necessary. The work cards are recorded and then destroyed but the detailed instruction sheets are filed and made available to the maintainers when the next "trigger" occurs. To ensure their serviceability these instruction sheets are frequently printed on plastic material or printed on stiff card which is laminated or sealed in plastic bags.

Perhaps the ultimate in maintenance control is when "triggering" is by computer programme, computer print-outs being sent simultaneously to the maintenance control office, to the maintenance stores and to production control. Or receipt of the instruction, the complete spares and tools package can be assembled, the plasticised work instruction sheets can be issued, and the required labour force allocated. On completion the costs are computed and the records updated. Such a system can be operated for a group of factories or public utilities from a central maintenance control computer. In this latter case the detailed work instruction sheets would be issued locally, from filing systems in the maintenance departments.

3. MAINTENANCE PLANNING

3. 1. Work Schedules

For accuracy in maintenance control and costing it is essential that work schedules are prepared (fig. 5). There are a number of ways to prepare planning systems based on work schedules and it is not suggested that the system shown is suitable for every situation. The example shown is based on a vehicle servicing plan, and is part of the master schedule for a rear axle service on a vehicle showing three of the major activities: adjusting the brakes, checking drums and shoes and checking the brake mechanism. Each of the activities is divided into a series of tasks, some of which are repeated in more than one activity. For example, in both activities 1 and 2 it is necessary to carry out task A1 (raise car and remove wheels).

Task sheets (as shown in fig. 6) can be prepared for each activity. Each task, A1-A2 etc., is timed to completion and the necessary trade skills and total work times for cost purposes are shown. Any special tools or large tools required for the task are listed.

On the task sheet for activity 2, the reader may be referred to sheet 1 for details of A1, A2 and A3. Alternatively, if it is desirable to make each task sheet complete, to avoid cross-referencing, full details of all items may be included. Adequate technical information or references to such information, is needed at each stage of work.

3. 2. Programming

When all the activities have been identified a numbered sequence programme (fig. 7) is prepared which shows the order in which the activities are to be applied to the equipment. It can be seen that in this example a critical path has emerged between activity 1 and activity 34, with the remaining activities arranged in accordance with their relationship to this path.

For accurate timing, the sequence programme is translated into a network plan (fig. 8) in which the times obtained from the task sheets are converted to working days. This network (which does not represent the master schedule of the rear axle referred to earlier) shows a series of activities as boxes, each box containing the activity number, the work time in days, the latest possible starting time and the earliest possible starting time. In the first box, we see activity number 1, with a work time of 28 days. Activities numbers 2 and 3 can commence together at day 28, in fact activity 2 is part of the critical path and must start on day 28. Activity 3 is less critical as it takes only 7 days and can therefore start on day 28, 29, etc., to day 35. This activity is said to have a "slack time" of 7 days.

Finally, for weekly programming purposes the bar chart (fig. 9) provides a convenient indication. Each vertical column shows a 7 - day period and the slack times are clearly shown. The top horizontal line shows the critical path and the remaining horizontal lines show the grouping of activities, some of which (for example; 8, 14, 15, 16) are interdependent.

This type of planning is vital for programming "shut-down" maintenance when plant is to be deliberately closed for periodic maintenance or when maintenance is to be carried out during a works holiday period. A slip in such a programme means lost production and it is therefore vital that the work is scheduled and that the necessary task sheets, spares information and other documents are prepared.

[illegible]. THE NEED FOR TECHNICAL INFORMATION

The maintenance system for a particular plant installation must be based on sound technical information if it is to be effective. The maintainer needs to be told:-

1. The name of the equipment and the names of any associated equipment and test gear.
2. How to install it (if not already installed).
3. How it works.
4. How to test its performance.
5. How to maintain it.
6. How to diagnose faults.
7. How to repair it.
8. How to identify the component parts.

It is probably the practice of writing a synopsis of information in this way, which has led to the production of maintenance manuals containing chapters in this order, or on large systems, to the production of individual volumes of information in this order. A problem frequently arises then in the amount of cross-referencing needed when a maintainer is engaged on a particular task. If the machine is suspect he needs part 4 (testing), part 6 (fault-diagnosis) and then may need reference to parts 3, 4, 7 and 8 during the repair and replacement phases. The answer to such a communications problem could well be the four-page package of information (see fig. 14).

Part 5, the maintenance instructions, should always be self-contained. One maintenance manual supplied recently with a road-making machine contained an excellent preventive maintenance table but at every step the maintainer was referred elsewhere in the book for precise instructions. Thus, a mechanic with oily fingers is committed to a constant cross-referencing action in a paper book, not only wasting time but also quickly destroying the book itself. A typical text-orientated manual, printed on soft paper and not suitable for use in workshops, is shown in fig. 10.

The quantity of information supplied has to be controlled. In many management situations the problem of communication has become more acute as the volume of information disseminated has risen. The right amount of information, presented in the right way, with a minimum of cross-referencing and a maximum of illustrations is what the maintainer needs. The following pages describe some of the methods used in presenting maintenance information, with the object of improving technical communication.

This technical information must, of course, be structured to conform with the requirements of the selected systems for maintenance planning and control.

5. BASIC TYPES OF TECHNICAL INFORMATION

This paper now describes some basic types of technical information provided for maintenance. These include:

the technical manual.
the work specification.
aids to fault-diagnosis.
lubrication charts.
spares information.

5.1. The Technical Manual

The value of technical manuals in the support of engineering equipment has been recognised by an increasing number of companies, producing a wider range of products, as we have progressed through the 1960's into the 1970's. Many manufacturers of small items, such as electronic instruments, provide a 20-page manual containing technical details, repair instructions and a spares list. A military radar system will be provided with two or three volumes of operating, maintenance and spares data. An atomic power station or a warship will have technical literature costing hundreds of thousands of pounds sterling. However, there are still many manufacturers who do not supply technical information, or who feel that a few production drawings assembled in a file are sufficient.

Unfortunately, when manuals are provided the information contained in many of them shows undue emphasis on descriptive text and not enough attention to the structuring of the information for maintenance usage. The reasons for this are:-

(1) Technical authors are employed to write manuals and, quite naturally, authors concentrate on the use of words.

(2) The descriptive information is collected from source (the development departments) more easily than is servicing data, routine maintenance and fault-diagnosis instructions.

(3) Standard text books are usually text-orientated and the same publishing techniques have been adopted for maintenance manuals.

(4) Many commercial technical manuals follow early military patterns where the descriptive text was necessary for use in training schools.

The modern technical manual must use pictures rather than words wherever possible to enable the maintainer to find the information quickly and at the same time to reduce the weight of information he has to carry when at work. As far as possible, text pages are eliminated (this also reduces translation costs) and, if additional descriptive information is required for training or other purposes, it is contained in separate volumes.

Figure 11 shows how the operation of an electro-mechanical item can be described fully in one illustration. The use of two whole pages of text and illustrations to describe the operation of such an item has been quite common in the past. Figure 11 requires only one-half page of the technical manual and is adequate for instructional uses in addition to maintenance purposes.

Figure 12 illustrates another technique for reducing the bulk in technical manuals. The electronic circuit shown is described in sufficient detail by a Block Text Diagram, related to the circuit diagram. The necessary text and drawing appear on one page and the text in the blocks is adequate for a trained engineer. There is no requirement for pages of description, such as "...the wiper arm of potentiometer RVI, rated at 5 Kohms is connected through capacitor C13 in series with resistor R14 to..." The engineer can see this himself from the diagram, and can obtain the knowledge in a much reduced time.

Figure 13 shows again how translation costs can be reduced by the use of illustrations in an algorithmic presentation of overhaul instructions. A full understanding by the maintainer is achieved very quickly with this style of information and all safety aspects are included.

Figure 14 shows how technical information on a small item of equipment, or on each unit within a large system, can be produced in a 4-page format. This may be printed on a plastic sheet or on linen-reinforced paper for industrial use. Page I contains the installation information, specification, safety notes and list of test gear. Page 2 contains the description (as a block text diagram), the schematic circuit diagram and the test data. Page 3 contains the maintenance and fault-diagnosis information and page 4 contains repair and spares data. The production of information in this way, provides easy-to-carry, ready-reference information and is a substitute for the common practice of engineers in tearing out the most useful pages of a technical manual to carry with them when working.

A considerable amount of work has been done in designing methods of presenting information for a multi-racial readership and Fig. 15 shows how a sequence of illustrations, produced by technical artists from a sequence of photographs taken in the workshop can provide a clear guide to servicing and overhaul tasks.

Finally, I refer to the interesting developments in the British Ministry of Defence in producing new types of illustrated technical manuals for maintainers of equipment on Naval service. A standard form of technical manual is used for all types of equipment (electrical, mechanical, hydraulic, etc.) with the information presented as Block Text Diagrams, Block Schematic Diagrams and Maintenance Dependency Charts (see fig. 22), the mechanical, electrical or electronic data is presented as a second block diagram of similar layout but containing circuit information, and the maintenance and fault-diagnosis information is presented as a maintenance dependency chart (see fig. 22). Tests by U. K. military authorities have proved that technician-level personnel can diagnose faults in complex electronic equipment in about half the time taken by higher-grade artificer-level staff, if maintenance dependency charts are provided and a few hours training is given in their use. The maintenance dependency chart is described later in this paper.

5.2. <u>Work Specifications</u>

The requirement for written and illustrated specifications on maintenance work is well known and has been accepted readily where:

complex equipment has to be maintained,
the required grades of labour are difficult to recruit,
the maintainer is operating from a mobile base,
the maintainer task is at a remote station, or
where the maintenance staff have multi-function roles.

Additional incentive to the production of work specifications is given where work is to be measured and productivity agreements applied.

Specifications can be prepared for overhaul, preventive or corrective maintenance. If more than one type of specification is to be prepared for a piece of equipment, it is recommended that the 'overhaul' specification is written first. This sets the pattern for the dismantling and re-assembly work, which can be copied into the other specifications or a cross-reference made.

A specification will include such items as:-

Details of the task and its location.
Equipment and materials needed.
Inspections and checks.
Special items requiring attention.
Precautions and safety notices.
Final functional testing.

Figure 16 shows part of a page from a preventive maintenance specification. The workers are mobile, servicing equipment over a large area, and a productivity bonus system is operated. Figure 17 is part of an overhaul specification in a power station in which equipment is taken out of service and transported to workshops for overhaul. Complete instructions for the handling and transportation are given. Figure 18 is part of a corrective maintenance specification. The equipment is serviced in location and is calibrated in accordance with the specification.

Figure 19 shows another type of preventive maintenance specification, in which reference is made to the maintenance manual should any part be found in need of replacement. Figure 20 shows an illustration specially designed for inclusion in a work specification. The illustration is designed to show clearly all the parts referred to in the specification. Fitters of appropriate skills level can assemble plant to these drawings but an "exploded" view (see fig. 26) is sometimes necessary to make assembly routines quite clear. Many types of application require work specifications to be printed on plastic materials to make them durable in a workshop environment.

. 3. Fault-diagnosis Information

With down-time for an electrical turbine reaching 1,000 pounds sterling per hour the prompt and accurate location of faults is vital. It is also of paramount importance in a mass-production process where hundreds of cartons of food or large numbers of motor tyres are produced per hour. An equipment fault taking 5 minutes to rectify should not take more than 3 minutes to locate. If the diagnostic time is 40 minutes the total down-time is clearly 45 minutes. With this in mind, plant manager in the U.K. are allocating sums of money (sometimes called Maintenance Improvement Budgets) to the preparation of technical information speciall designed to reduce fault-diagnosis times. Typical examples are shown as figures 21 and 22.

Figure 21 is an algorithm. The symbols used indicate an instruc ion, a question and a conclusion. Algorithms are used for operator procedures and for training schools. It is sometimes said that the algorithm reproduces a telephone coversation between the maintenance worker and his foreman. The various steps of the algorithm follow the form:-

"Have you tried ----------?"
"Yes!"
"What happened?"
"The red light became bright"
"Well, now try -----------?"

and so on until the fault is located. Good algorithms, in the maintenance manual or printed on plastic and attached to the machine, remind the maintainer to follow a logical pattern and thus to find the fault in the shortest possible time.

Figure 22 is a maintenance dependency chart; another aid to rapid fault diagnosis. In the maintenance dependency chart a vertical column is given to each input, output, test-point or internal functional element of the system and a dependency line structure is designed to show how these are related and how they depend on each other. The access points and test-points are numbered and are referred to a table of signal specifications which defines the ideal values to be expected at these points. The fault-diagnosis routine takes the maintainer through the system in a methodical way until the measured signal is found to be absent or incorrect.

A great advantage of this type of chart is that it permits the "half-split" method to be used, as shown in figure 23. Tests can be made at appropriate points so that the fault is isolated to one-half of the system, then one-quarter and so on, without passing through the whole series of tests from the inputs to the outputs. This reduces the diagnostic time considerably.

It has been found convenient in certain circumstances to use a combination of algorithms and maintenance dependency charts. On complex telecommunications systems algorithms are used to isolate the fault to a certain level and then maintenance dependency charts are used at the lowest levels, down to component failure and replacement. Both types of document are extremely useful for multi-purpose maintenance staff (for example, on merchant ships), where the maintainer is not instructed in every detail of every piece of equipment, but is taught how to use the charts, in accordance with the maintenance philosophy and the spares provisioning, for various types of equipment throughout the ship.

The maintenance dependency chart is probably the nearest approach at this time to the ideal international maintenance chart, applicable to most types of equipment and readily translated and understood.

5.4. Lubrication Charts

The use of lubrication charts is well known practice in industry and in some countries these are provided by the oil companies. The example shown (fig. 24) does not conform to the standard practice for lubrication symbols, but is an interesting example of how technical illustrations can be added to make the meaning clear in any language.

The chart shows four activity periods (annual, monthly, weekly, daily), colour guides to the grade of lubricant to be used, and pictures to indicate the method of application. The importance of using a technical communications specialist, in conjunction with maintenance specialists, when designing information for maintainer use cannot be over-emphasised. An explanation of the symbols used is given in figure 25. This type of chart is particularly suitable for international usage.

5.5. Spares Information

It is essential that all grades of maintenance staff, including the clerks and other workers in the maintenance stores departments, have ready access to detailed lists of available spare parts together with explanatory illustrations. These illustrations show each component part and give its reference numbers and details. Frequently, these illustrations are coded to the work specifications, so that they can be used to guide dismantling and re-assembly work. Usually, the "exploded" type of illustration is used as shown in fig. 26.

Copies of these illustrations can be coded with reference to a planned maintenance system and supplied to the engineering stores, so that a storekeeper can be forewarned to assemble the necessary range of spares required for the forecast maintenance programme.

6. MICROFILMED INFORMATION

There is much talk of microfilm in the presentation of technical information for maintainers and, indeed, some use of this technique has been made by the airlines. When information is distributed about the world (for example, aircraft maintenance information at over-night stopping points) and is subject to frequent modification and updating, it is found convenient to use microforms. The main reason for this use are:-

1. Microfilmed information is light in weight and is easily distributed by airmail or other means.

2. The microfilming of numerous pages of data is so rapid that is a simple matter to modify the information and distribute a whole new set of data. This avoids the use of local skilled labour at remote stations in amending and updating technical information manually.

One difficulty in the use of microforms has been overcome recently by the development of cheap viewing devices costing about £50 sterling. For some years viewing machines tended to cost about 300 pounds sterling each and this restricted their use in quantity.

Users of microfilm have found that the structure of the information has to be considered before filming. It is not sufficient to remove the pages of a maintenance manual and place them in sequence before the camera. The problems of cross-referencing have to be considered, as do the information access problems when the various types of maintenance task are undertaken. Again there is need for a communications specialist to examine the structure of the information and to assess the users' needs.

7. STANDARD TECHNICAL VOCABULARY

In technical information situations where text is either necessary, or is used as normal practice, the use of standardised technical terms reduces both translation and comprehension problems. The developed countries have failed through time to establish common technical terms for engineering parts (there are four different names for one shaft in an auto gearbox) and some discipline is required at source if information is to be passed successfully between countries.

With action instructions, such as "bleed the braking system" it has been found useful to teach the recognition of the basic English phrases rather than to attempt translation. The basic action of "bleeding" a brake system is well understood by skilled technicians and can be taught quite quickly. Attempts to translate this have (depending on the translator) produced some odd results.

Two of the large international companies have done useful work in producing limited standard technical vocabularies for their multi-national maintenance technicians. Action words such as "tighten" or "remove" are included, together with standardised part names. A good deal of work remains to be done and I should be interested to hear more about the work of international bodies in this area, with particular reference to maintainer problems.

8. AUTOMATIC TESTING

Over a period of many years in the U. K. we have come to accept widespread use of automatic test equipment. This ranges from a digital check-out trolley for military aircraft (performing hundreds of programmed tests automatically between flights) to a portable analyser instrument or a built-in performance tester in a process plant installation. These machines have similar problems to the nationals of our various countries in that one machine speaks one language(computer programme language), another machine uses a different language, and so on. None of these languages can be used by man, if the machine breaks down, without translation.

However, work is proceeding on the use of a man/machine compatible language, an extract from which is reproduced below. This is part of a typical test instruction programme.

```
75   MEASURE, (TIME INTERVAL) $

76   REMOVE DC VOLTAGE, CHX HI J4-6
     LO J4-8 $

77   START WHEN, (VOLTAGE), DC SIGNAL
     LT 0.5V, MAX TIME 2s, CHX HI J4-6
     LO J4-8 $

78   STOP WHEN, (FREQ), AC SIGNAL UL
     18.2 MHz LL 18.2 MHz, MAX TIME 5s
     CHX HI JI-I LO JI-0 $

79   COMPARE, 'MEASUREMENT', LT 2.5s $

80   GO TO, STEP 45 IF NOGO $

45   DISPLAY, MESSAGE, RHE RX FAILED
     TO TUNE ON CHANNEL 17 WITHIN 2.5s $
```

This type of programme can be compiled automatically into machine code and can be understood by humans for manual testing. A short period of tuition enables maintainers to recognise that CNX means "connexion", LT means "less than", etc. There is almost certainly a case for combining research in this area with that on a standard technical vocabulary.

9. CONCLUSION

This paper discusses the control, planning and information of maintenance staff. It is necessary in conclusion to discuss on what input data the maintenance system shall be based. The data sour is usually the design and development department of the company which is manufacturing the equipment and inadequate disclosure of data from this source will seriously affect maintenance efficiency.

9. 1. Development Documentation System

With maintenance problems in mind, the American and British Military authorities have recently devoted considerable attentio to the development of a discipline for engineering designers, which encourages the development of a maintenance philosophy at the time the equipment is designed. The specification for this is now published in the U. K. under the title:- D. D. S. (Development Documentation System). Some military authorities are now imposing this discipline on their suppliers. The system includes the use of D. O. M. (design-out-maintenance), D. I. T. A. (design-in-test-points and alarms) and provides for the calculation of M. T. B. F. (mean times between failures) and M.T. T. R. (mean times to repair) for each item throughout the desig life cycle. Thus, a maintenance philosophy is designed into the system. For those readers who also operate research and development departme this discipline may also be applicable to your products, both improving design and reducing costs.

9. 2. Technical Information for New Plant

When purchasing new plant, pressure on manufacturers and suppliers of engineering equipment is necessary to ensure that installations in develo ing countries are adequately supported by technical information for comm ioning, for the staff training programme, and for maintenance and repair throughout the life cycle of the plant. It is still somewhat rare for servic ing schedules to be supplied, so that the basis of a planned maintenance system can be established. Even in the developed countries, the supply of maintenance data is often inadequate. At a recent conference of printing engineers in the U.K. a resolution was passed that manufacturers of printing machines should be asked to provide scheduled maintenance information with their products. Members said, "We get this with motor cars, why not with printing machines?".

Figure 27 shows how, at the time of manufacture, the information, specifications and drawings from a design and development office can be used not only for manufacture of the equipment but also for the production of training, technical manuals, and maintenance data to the level required by the customer. Obviously, the lists on the diagram show most of the possible types of information available and a selection can be made from these to align with the maintenance policy, the environment and the requirements of the staff.

Very few manufacturers will supply this comprehensive information as they feel that its cost would price their product out of the market. The purchaser must specify the requirement and must be prepared to pay the additional cost, knowing that it will reduce the commissioning time, improve plant utilisation, reduce maintenance costs and simplify staff training. This last point is important when one considers the practice of manufacturers in fulfilling a training requirement by sending technicians to guide the first-generation of users by standing next to them day-by-day. This is one-generation training, and does not provide for the training of subsequent generations. The "TRAINING" block on the diagram contains as its first item "TASK ANALYSIS" and it is important that operator and maintainer tasks are analysed and that correctly-structured training information is prepared. To be effective, training (as with maintenance) needs structured, planned, technical information as its base. The problem in large installations (such as ports and power stations) is that the main contractor will tend to adopt the philosophy that his concern is with earth-moving and concrete, not with engineering equipment. This is wrong. What frequently happens is that the various ancillary equipment is sub-contracted on a lowest tender basis to many companies, who will often supply very little technical information. At the conclusion of the contract, the main contractor assembles this information, which is almost always unbalanced and badly structured into books which are supplied to site. Surely what is needed here is for the purchaser to demand an integrated information system, based if necessary on a communication consultant's recommendations, and for the main contractor to discipline his sub-contractors to supplying data to the required level. This discipline is well-established in the military and aviation fields and now requires application (to an appropriate level) in the plant industry.

There have been occasions when exporters of equipment to the developing countries have been able to use existing military technical manuals prepared for the same equipment on previous contracts. However, the military technical manual, and in particular the method of updating it, is frequently quite unsuitable for civil use. One manufacturer recently discovered that a total of 480 clerical man/days was needed to update a set of military manuals and to incorporate all the various service ammendments before they could be issued. A maintenance engineer in a developing country is not at all pleased if he is working on a MK 21 fuel pump and is issued with a bulky handbook on a MK 2 pump with nineteen amendment documents. This is even more difficult to translate than an individual manual.

When small plant is purchased, the user should specify his maintenance information needs (having in mind the skills level of his employees and the control system to be used. When purchasing large plant installations, technical communications and information needs should be discussed at the consultancy stage before final equipment contracts are prepared.

9.3. <u>Technical Information for Existing Plant</u>

The problem of maintenance and fault-finding on existing plant have already been mentioned in this paper and it is true that many companies are finding it profitable to apply a Maintenance Improvement Budget to the provision of documentation for the improvement of maintainer performance. Specialist advice is of course required before adopting any particular plan for controlling maintenance or for improving technical information.

It is often difficult to quantify the savings in operation costs by introducing good technical information systems because of the lack of precise "before" and "after" plant maintenance cost records. The most frequent causes of interest in maintenance improvement are:-

Worsening "down-time" figures.
Difficulties in recruiting trained maintainers.
Public pressures on service industries.

For all types of existing plant the supply of graphic, work-orientated information is a significant factor in improving maintenance and maintainer performance.

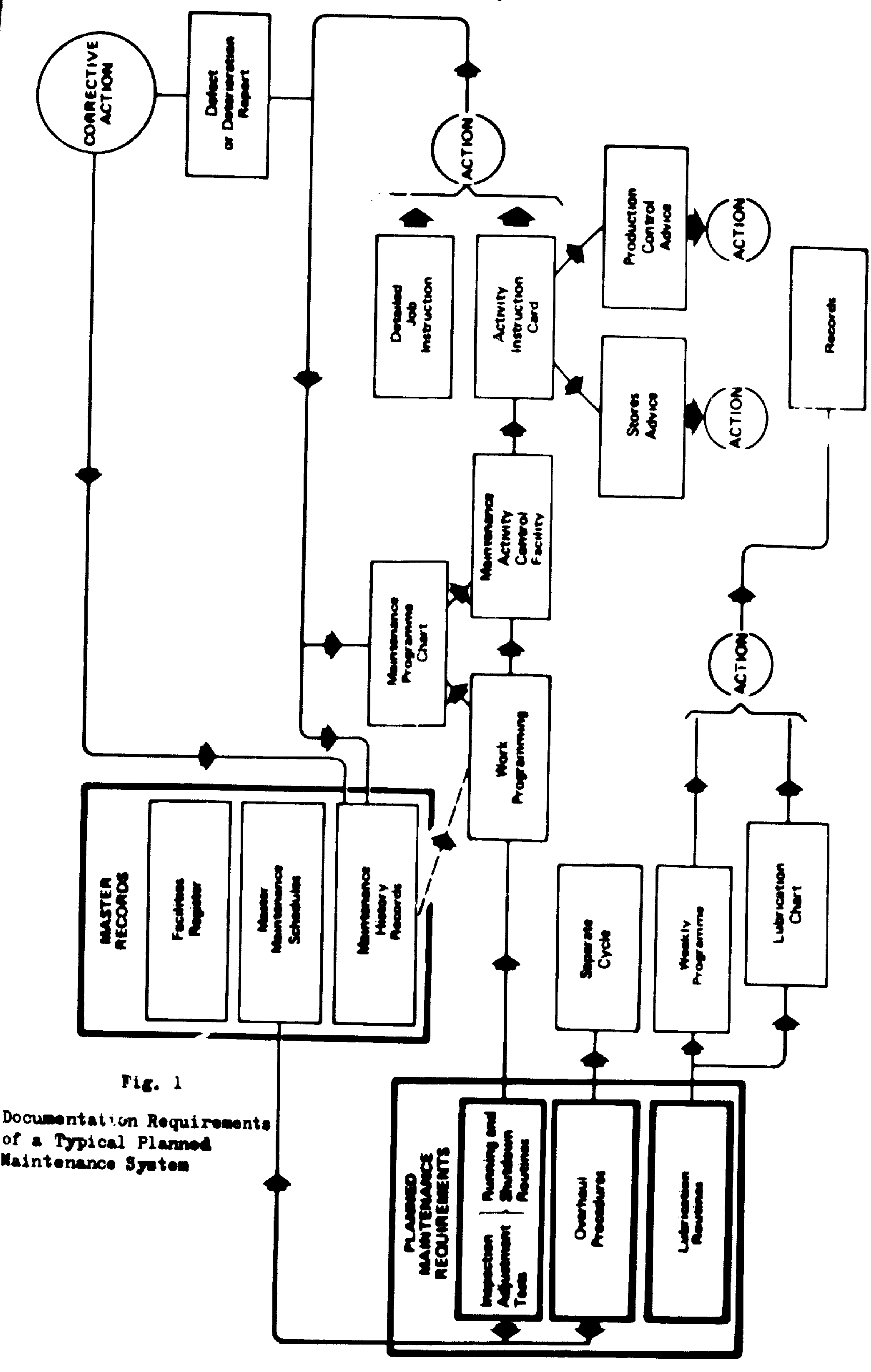


DIAGRAM SHOWING DOCUMENTATION STAGES OF A TYPICAL PLANNED MAINTENANCE SYSTEM.

Fig. 1

Documentation Requirements of a Typical Planned Maintenance System

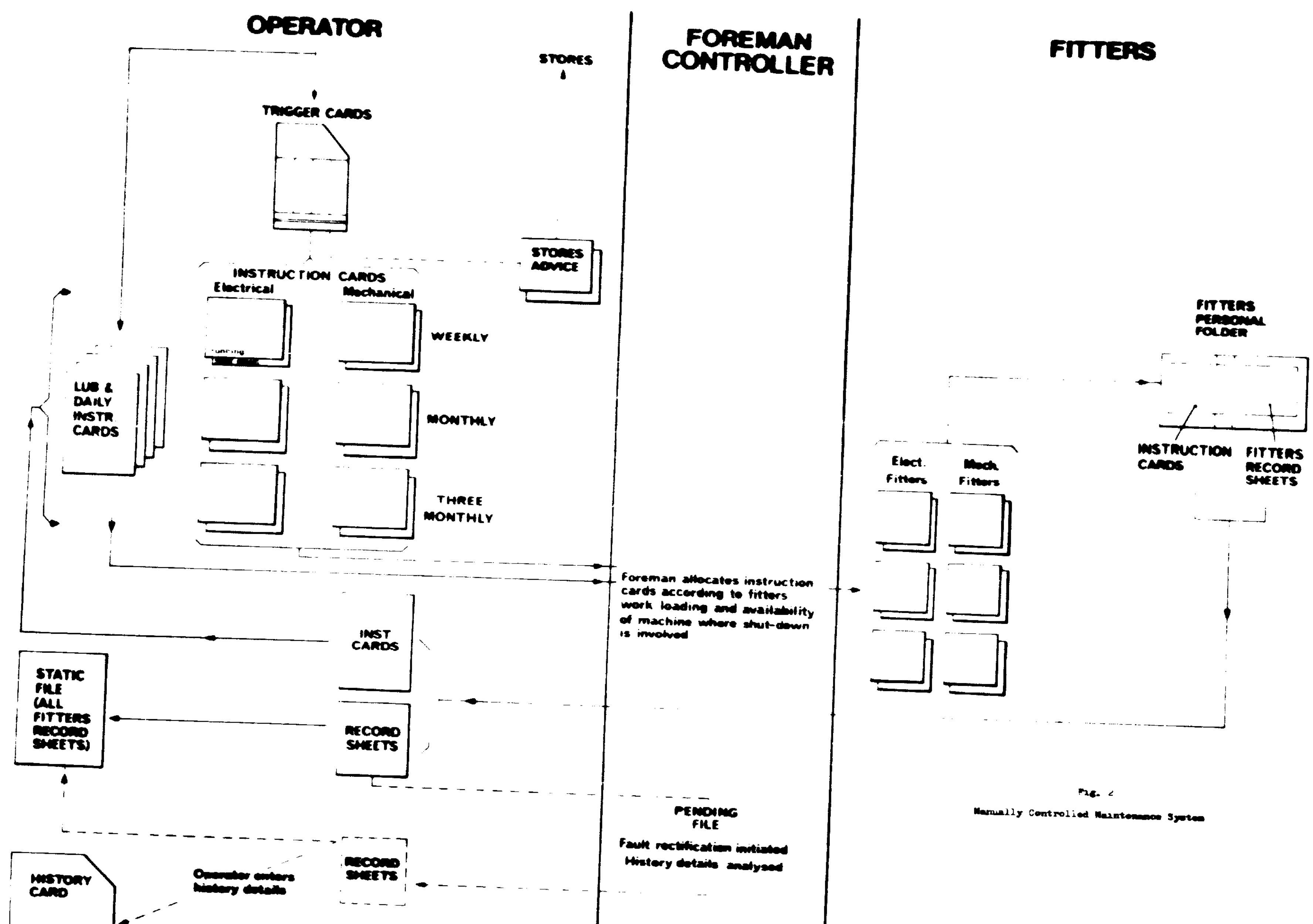


Fig. 2

Manually Controlled Maintenance System

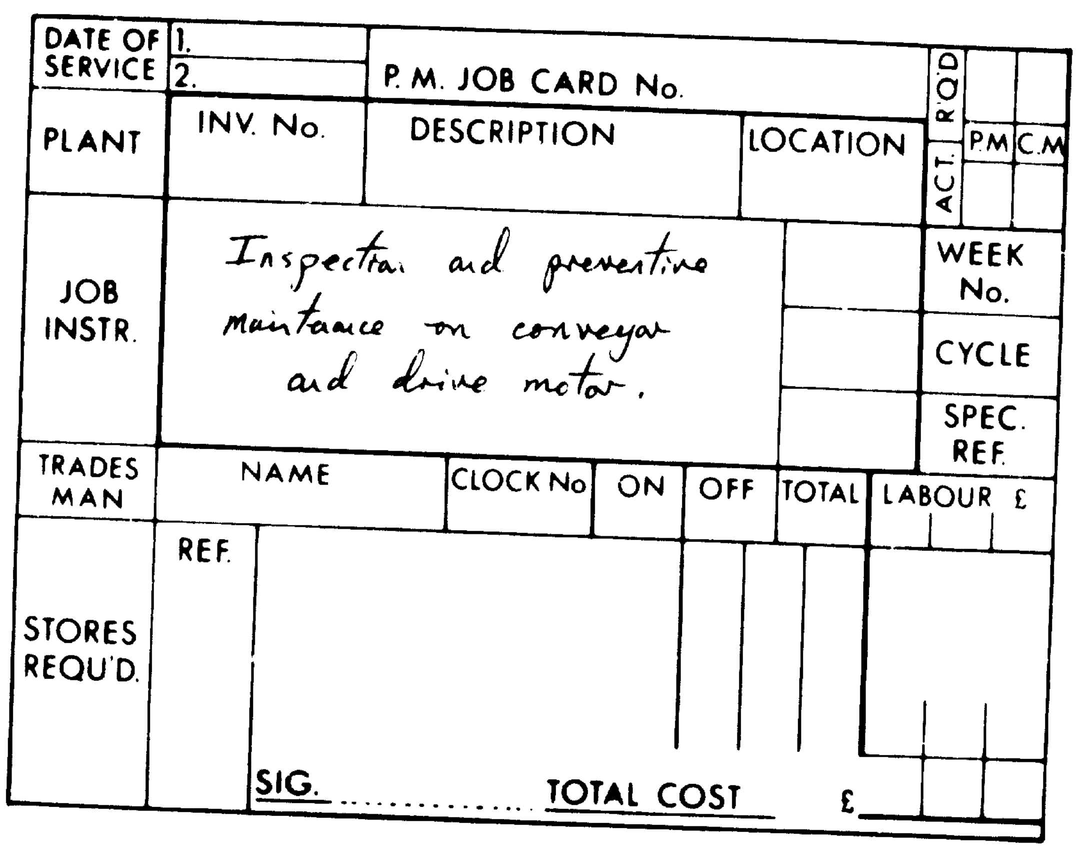


Fig 3.

Simplified Work Instruction Card

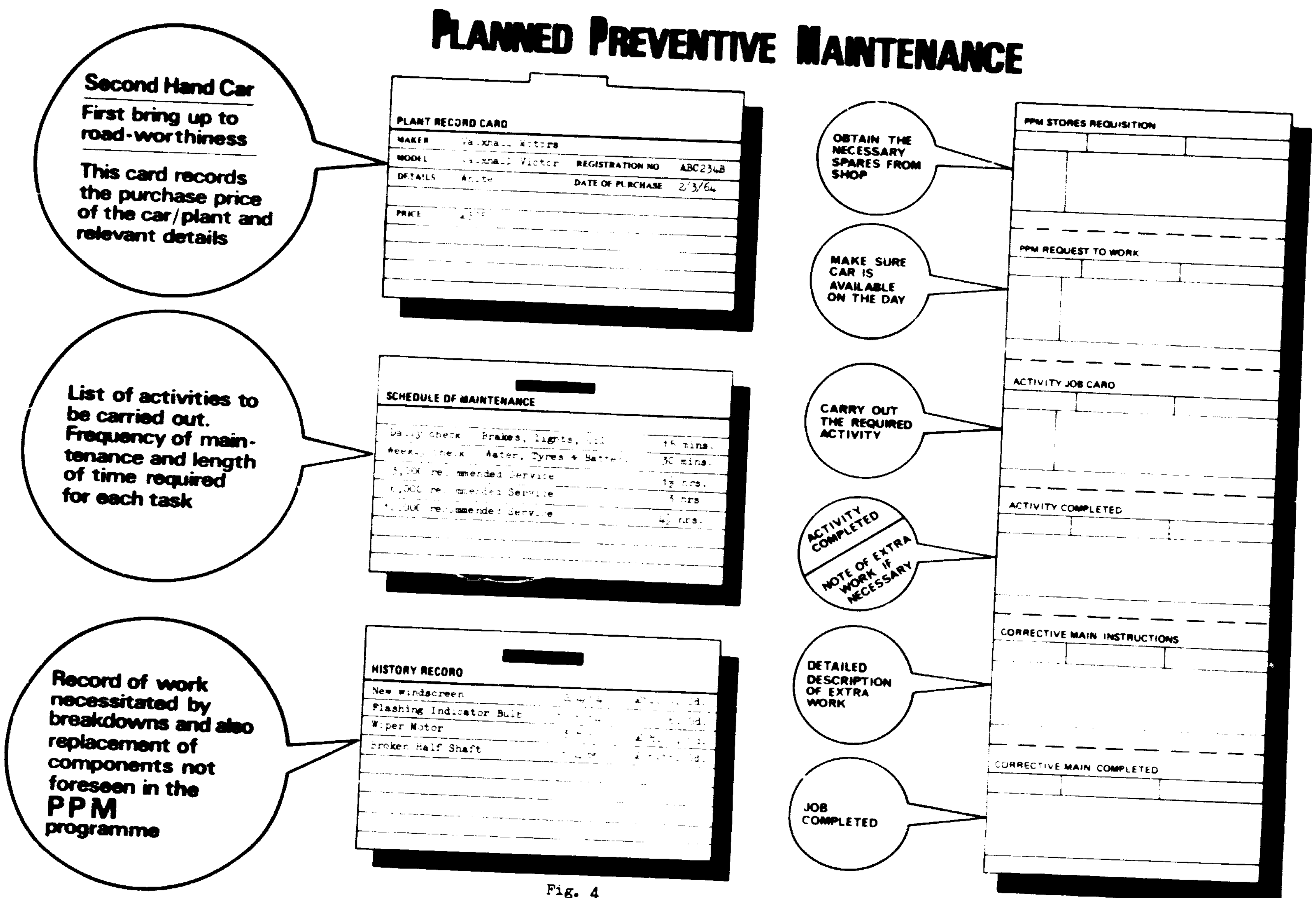


Fig. 4

Maintenance System Based on Sorter/Printer Machine

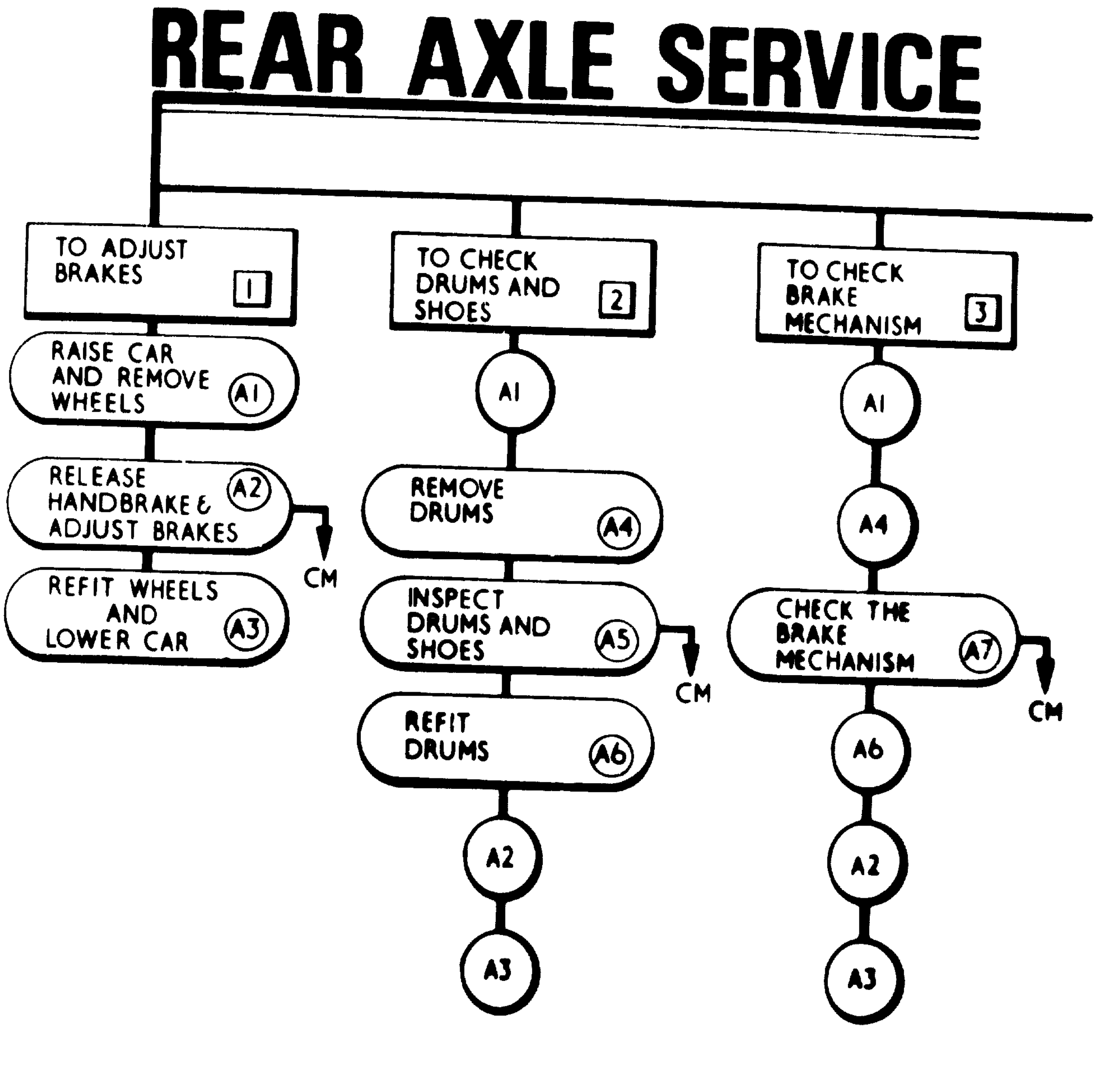


Fig 5.

Master Work Schedule

OVERHAUL OR INSPECTION TASK	MASTER SCHEDULE ACTIVITIES	TRADES MEN/MAN HOURS				SPECIAL TOOLS MATERIALS AND SPARES
		M	E	I	Time to complete	
1 To adjust brakes	A1					
	1. Remove hub cap and slacken nuts (4)	1 / ¼			¼	Wheel brace
	2. Place hydraulic jack under differential box and raise car	1 / ¼			¼	Hydraulic jack
	3. Remove nuts (4) and remove wheel	2 / ¼			⅛	
	A2					
	1. Turn brake adjuster full clockwise; turn anti-clockwise one notch. Ensure that wheel movement is free.	2 / ½			¼	Cranked brake adjuster. No.L60872
	A3					
	1. Refit wheel and tighten nuts (4)	2 / ½			¼	
	2. Lower car and remove jack	1 / ¼			¼	
	3. Tighten nuts and refit hub caps	1 / ¼			½	

Fig.6

Task Sheet for Vehicle Servicing

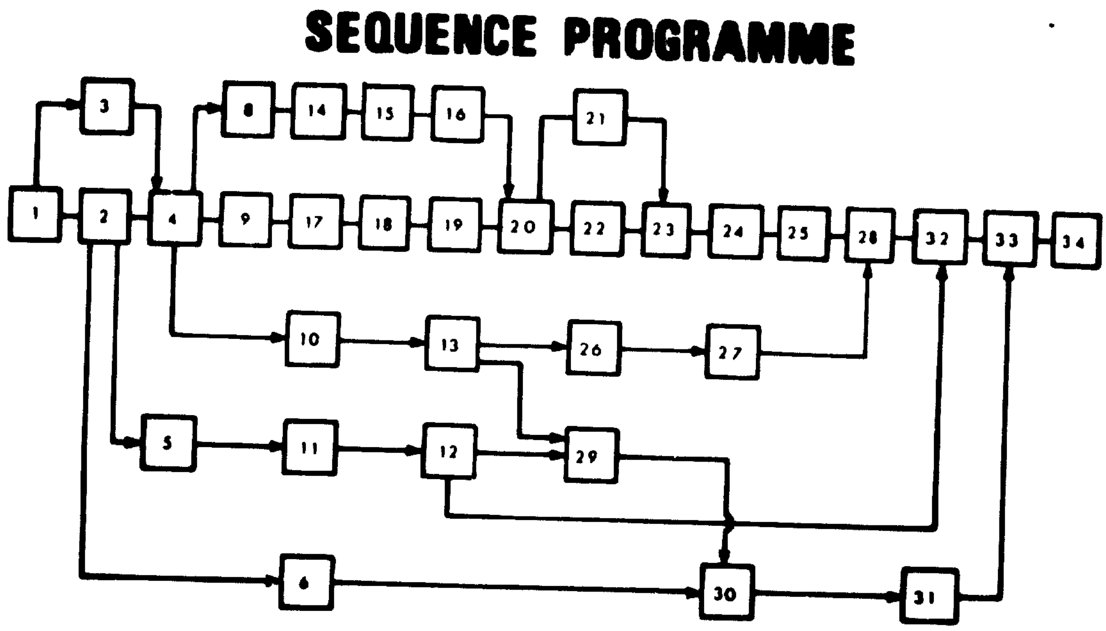


Fig. 7

Work Sequence Programme

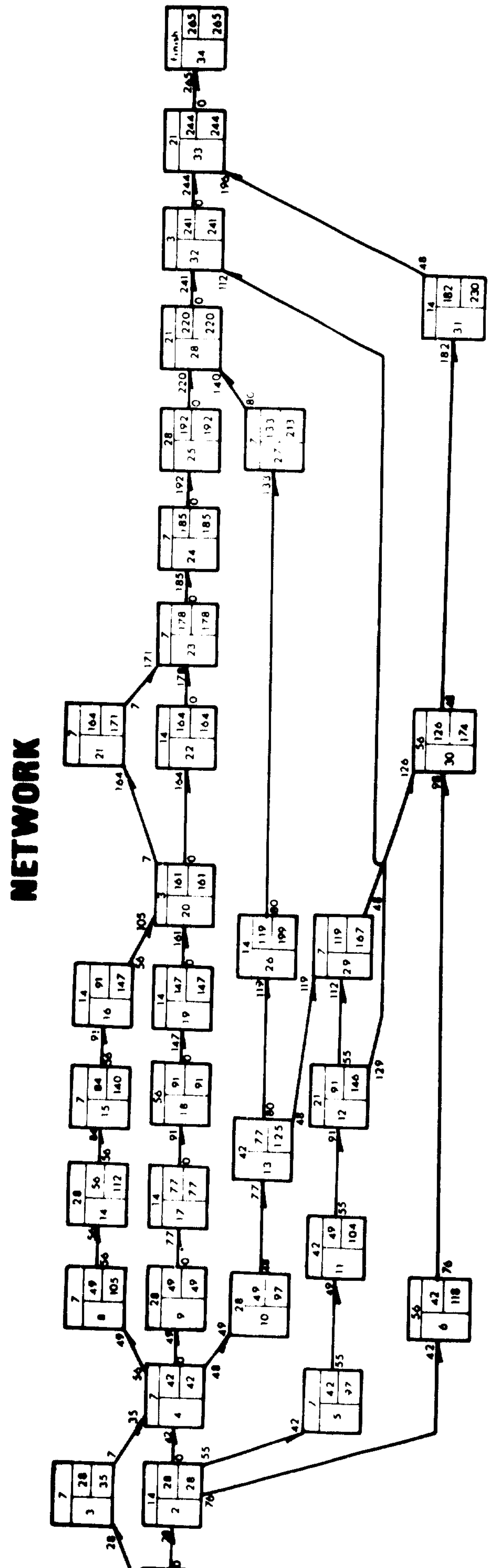


Fig. 8

Network Plan

..vicing

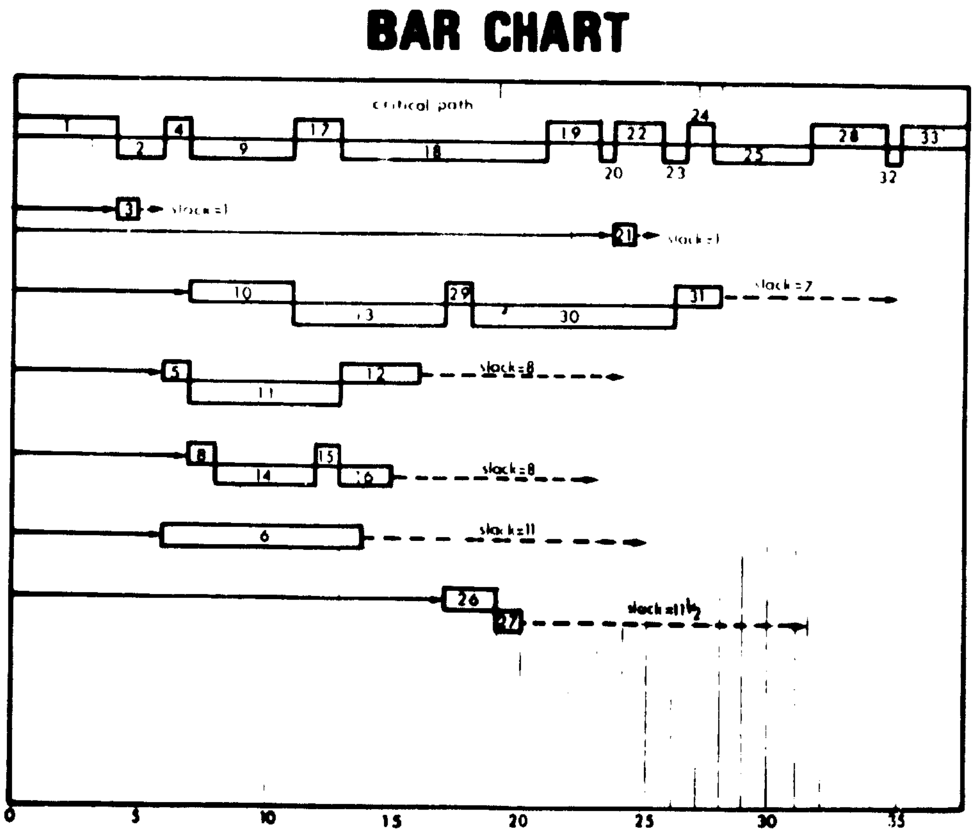


Fig. 9

Bar Chart for Maintenance Planning

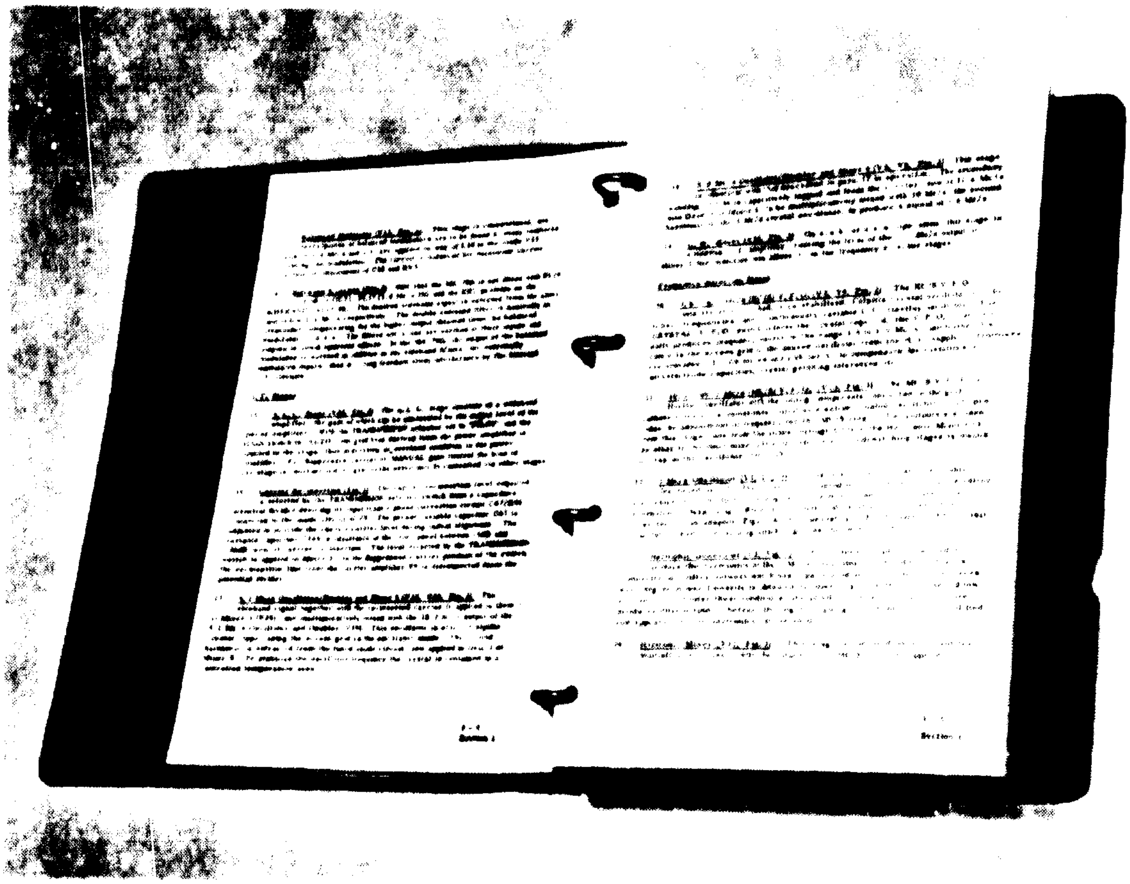


Fig. 10

Typical Text-Orientated Manual

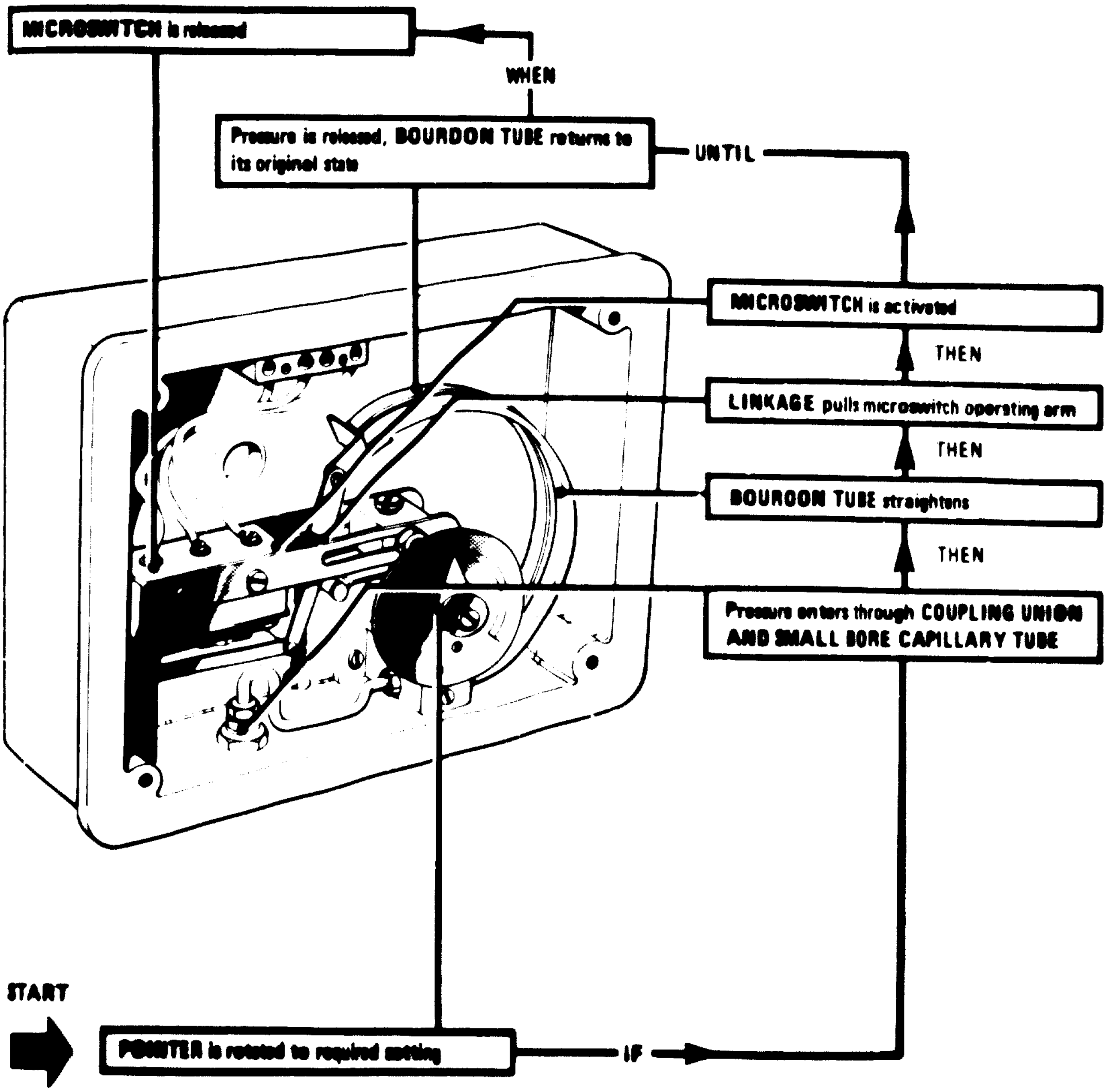


Fig. 11

Description of Operation Switch

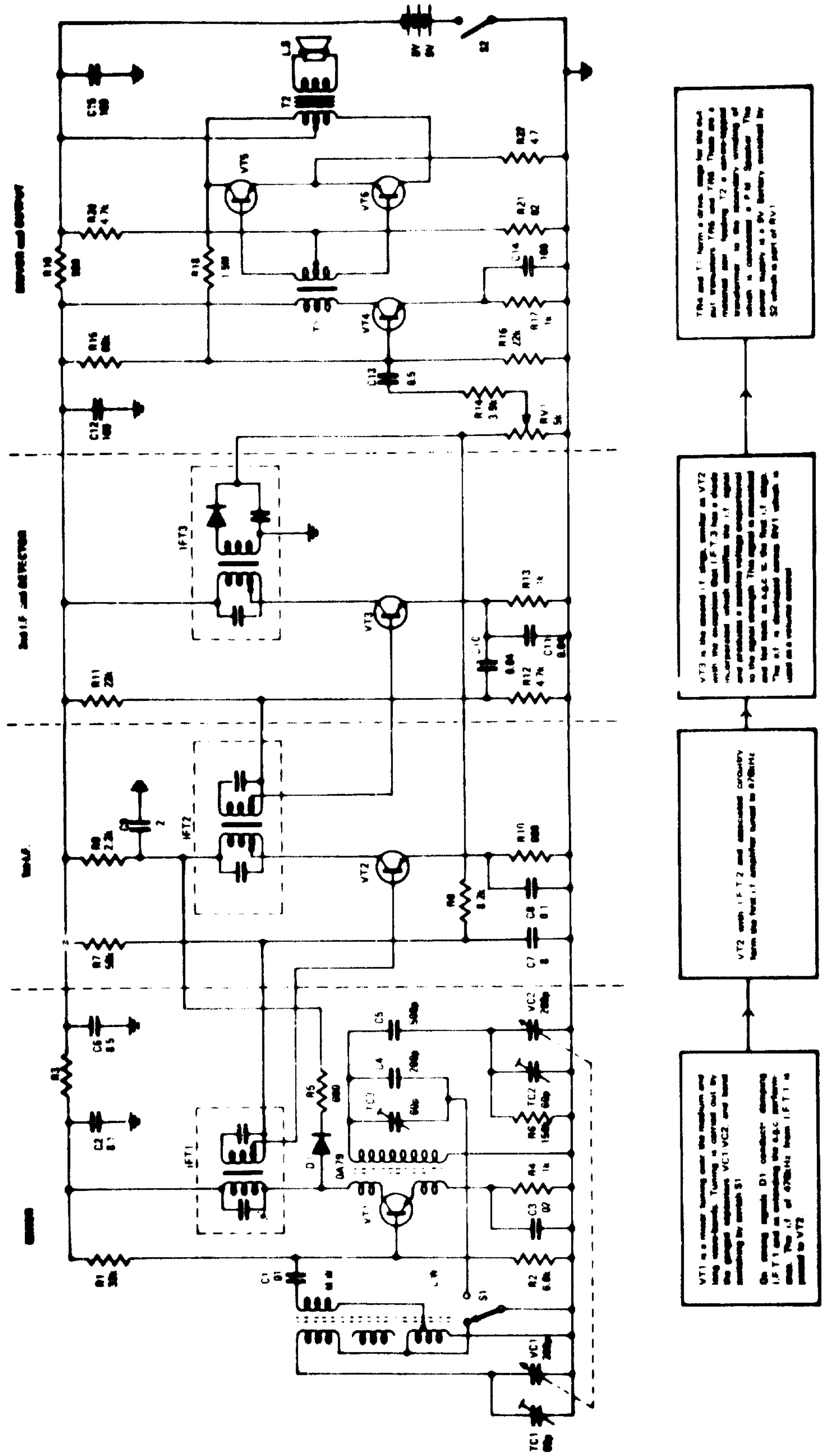


Fig. 12

Circuit Description by Block Text Diagram

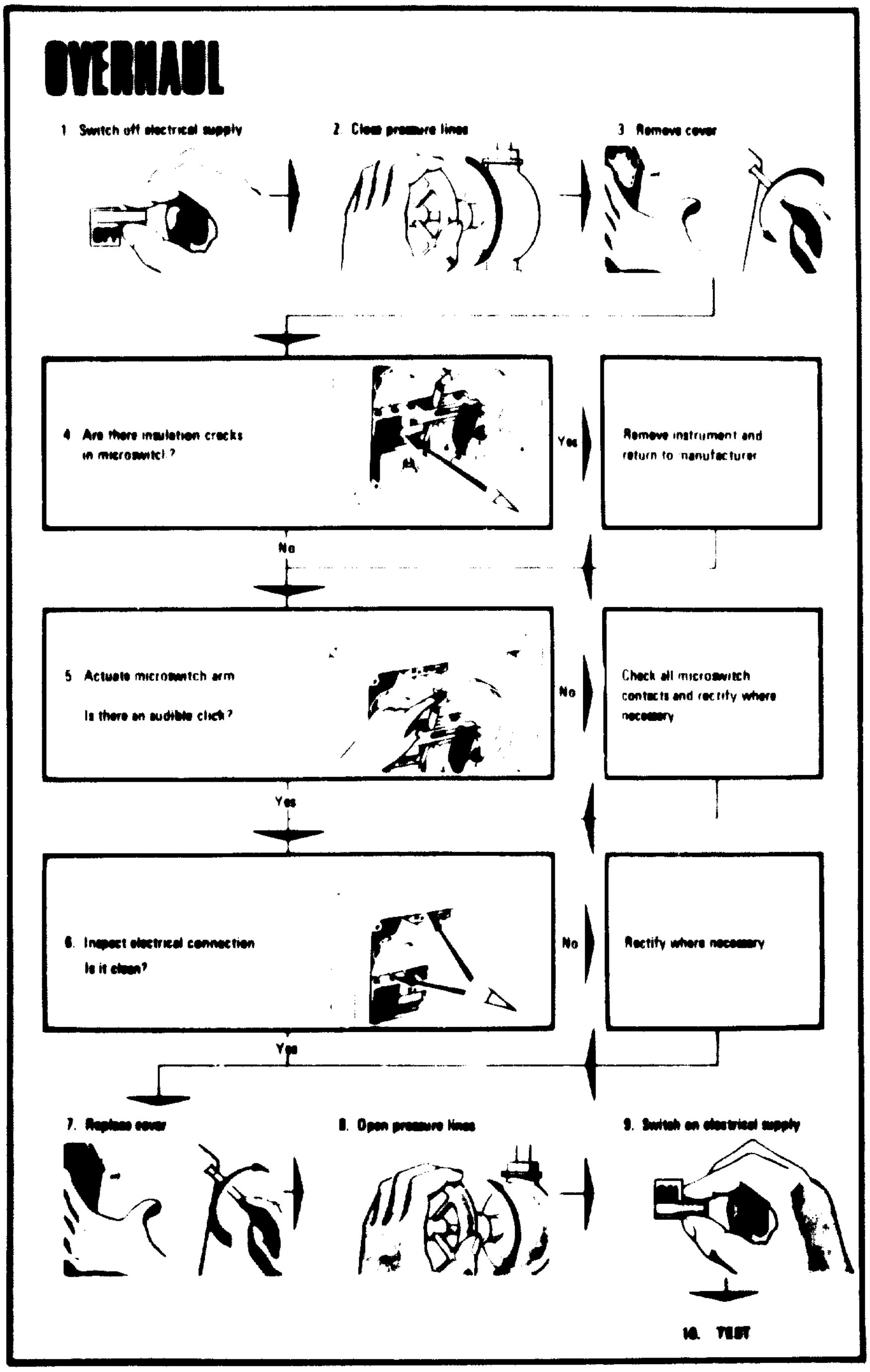


Fig. 13

Pictorial Overhaul Instructions

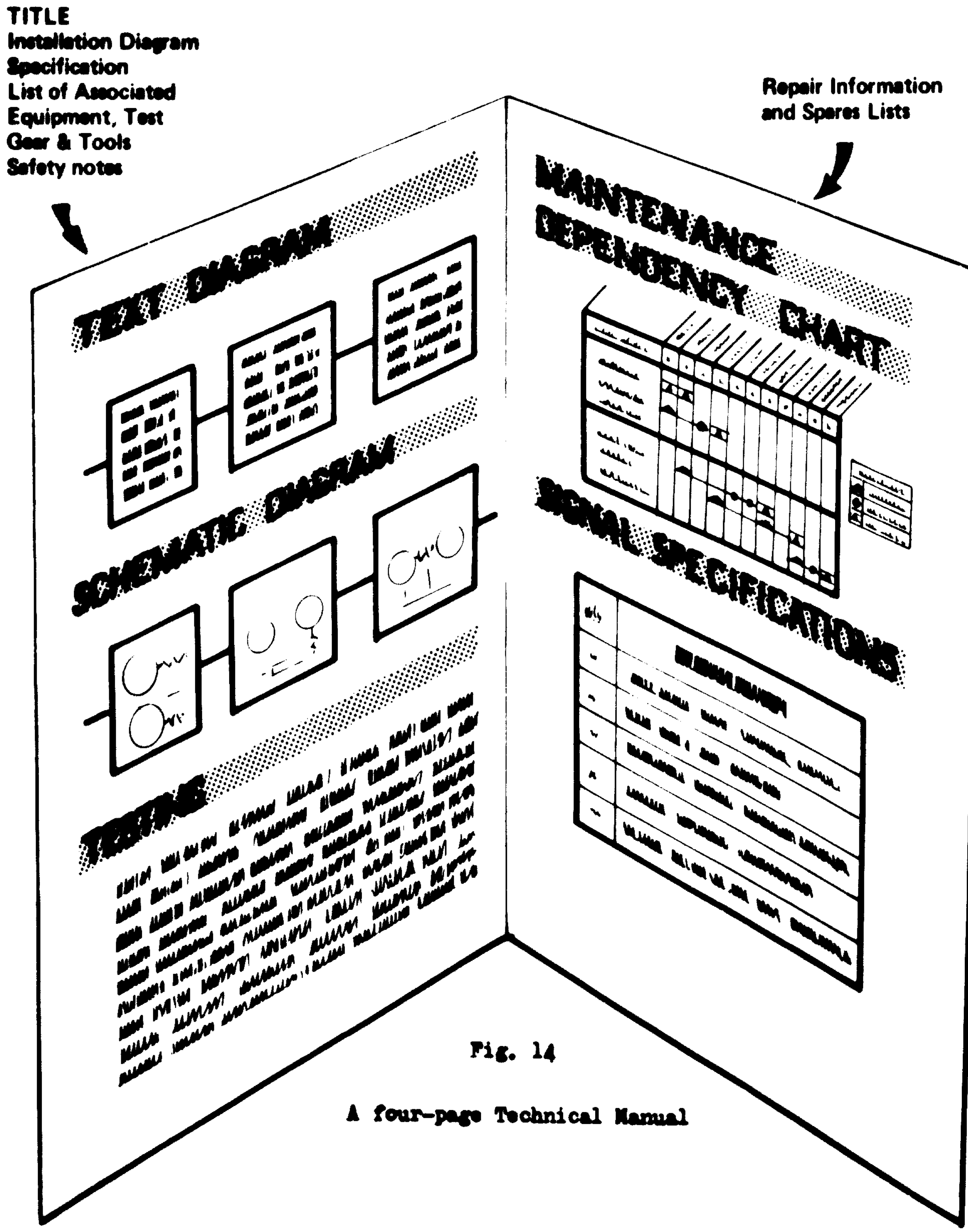


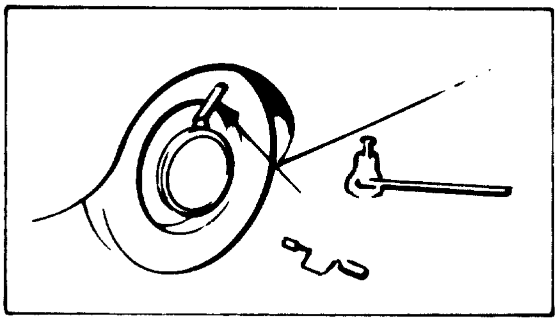
Fig. 14

A four-page Technical Manual

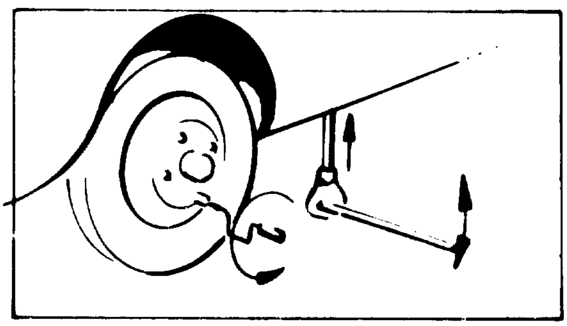
BRAKE SHOE REPLACEMENT
FRONT WHEELS

TOOLS – Vehicle jack, wheel brace, special tool, (spring tensioner) pliers and 1¼" A F open ended spanner.

PARTS – Rag, brake shoes, multipurpose grease and split pins.



1. Set vehicle handbrake on.
2. Remove hub cap.
3. Slacken wheel nuts (not to exceed one complete turn on each).



1. Raise vehicle until wheel is just clear of the ground.
2. Remove wheel nuts.
3. Remove wheel.

Fig. 15

Illustrated Servicing Instructions

5.2 Remove the top coverplate from the recorder and lubricate the following points with silicon grease M.S.44.

(1) Between wheel supports and unit plate.

(2) Upper bearing of primary arm shaft.

(3) Between play bell-crank assembly and take up wheel support carrying take up wheel and play con rod.

(4) Slot in brake lift.

(5) All connecting rod joints

(6) Slot in pinch wheel carrier.

(7) Between right-hand spool rod and unit plate (both sides).

(8) Between right-hand rod and circlip.

(9) Between left-hand spool rod and unit plate (both sides).

(10) Between left-hand spool rod and circlip.

NOTE...........

Remove any excess grease on the drive surfaces of the wheels or Motor Pulley with methylated spirits.

Fig. 16

Part Page From a Typical Preventive Maintenance Specification

drive shaft oil seal (U) in the plate, ensuring that the knife edge of the oil seal (U) faces towards the inside of the mechanism.

22. Refit the bearing seal plate (F) with a new joint, and tighten up the six bolts evenly.

Note

Grease the oil seal surface before installing it over the drive shaft (S)

23. Turn the mechanism right side up and check the drive (S) and driven shaft (H) for end float as follows:-

(1) Push the drive shaft (S) as far as possible in one direction and check the distance from the end of the shaft to the seal plate (F) using a straight edge against the end of the shaft

(2) Push the drive shaft (S) as far as possible in the opposite direction and check the distance.

(3) Measure the end float between the end of the driven shaft (H) and the edge of the mechanism housing, with the shaft in extreme positions. The difference in measurement is the total end float and should be 1/16 in. ± 1/32 in. If the readings are above or below the limits, either thinner or thicker gaskets should be inserted between housing and seal plate and bearing caps as necessary.

24. Refit the bearing caps into their correct positions with new joints and tighten up bolts evenly.

Fig. 17

(8) Replace the cuvette (5) replace the front dowels if they were removed in step (6).

(9) Replace the measuring photocell carrier (9) and tighten up the two knurled screws.

(10) Refit the drain valve coil (7) and tighten the outer clamp knurled screw.

(11) Refit the drain valve (6) outlet pipe and the measuring cuvette overflow pipe (8).

After the cuvette has been cleaned and replaced the zero must be set as follows:-

(1) Set the instrument mains isolator switch to ON and allow the instrument 30 minutes to warm up.

(2) Set the function switch to SET ZERO and wait until the sequence timer stops and the compensation lamp lights.

(3) Set the ZERO CONTROL knob to its mid-position (i.e. when the mark on the knob is at the top position).

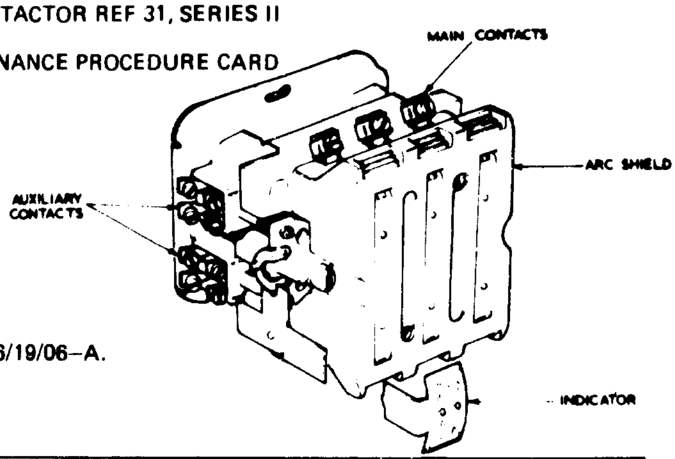
(4) Make a course correction by adjusting the inis diaphragm using the lever (3) on the optical block, until the pointer of the compensation meter is approximately at its centre position.

Fig. 18

Fig. 17 - Part Page From a Typical Specification for Overhaul Work
Fig. 18 - Part Page From a Typical Corrective Maintenance Specification

UNIT TYPE CONTACTOR REF 31, SERIES II

PLANT MAINTENANCE PROCEDURE CARD



1. Location

2. Required Instruments

(1) 500V Megger
(2) Avometer Model 8

3. Associated Publication

Plant Maintenance Procedure Handbook 26/19/06–A.

4. Work List

OPERATION	DETAILS	REMARKS	READINGS NOTED	OPERATION COMPLETE
1	Ensure that the CONTROL selector associated with the cubicle is set to HAND and that the ON/OFF indicators of the cubicle are at OFF.			
2	Open the cubicle and using the 500V Megger check the resistance between each lead to the main moving contacts and earth. Note the readings. Then check the resistance between	Report any instance of low resistance noted. If in doubt as to a particular resistance, consult the		

Fig. 19

Plant Maintenance Procedure Card

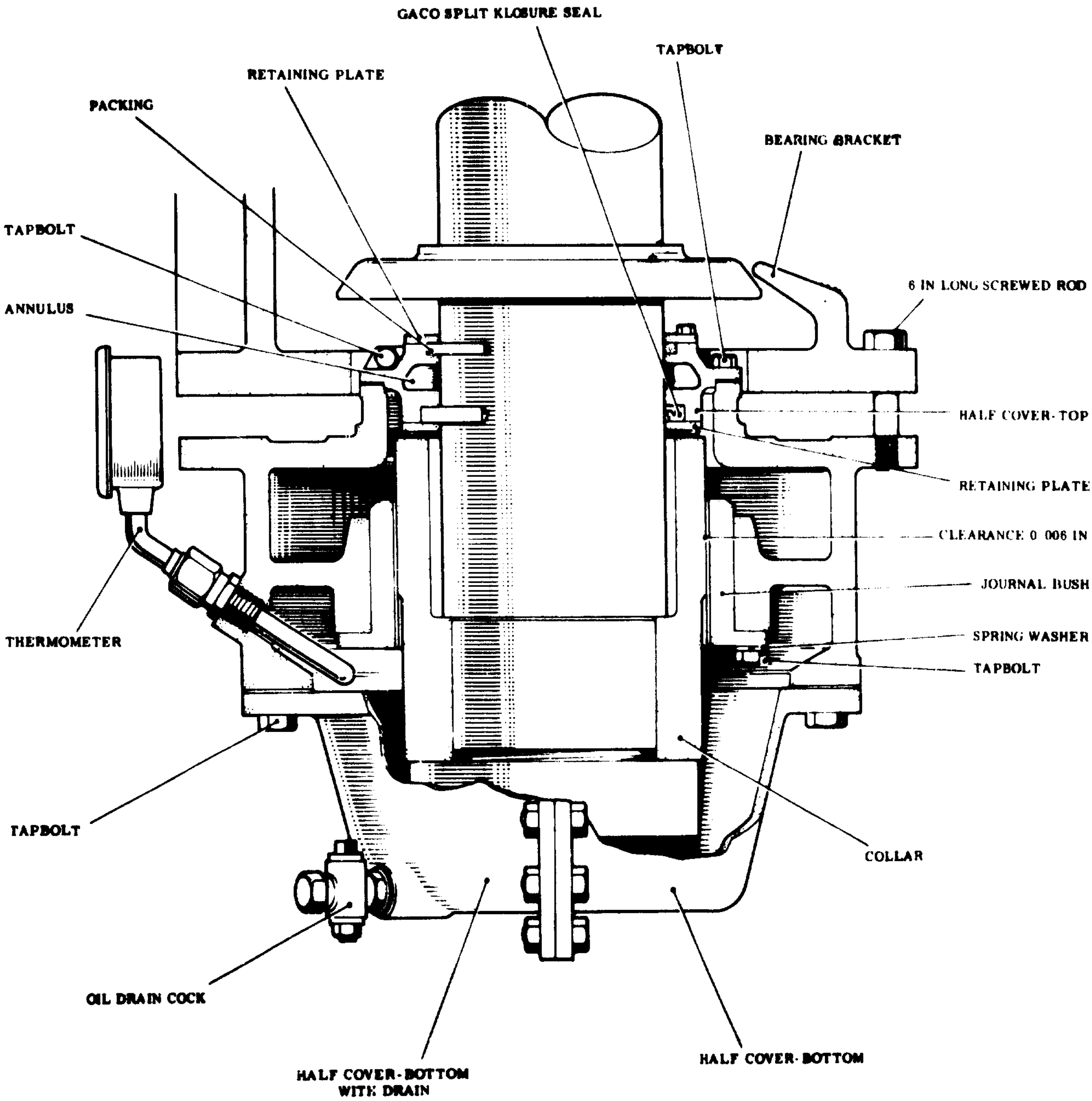


Fig. 20

Typical Illustration for Work Specification

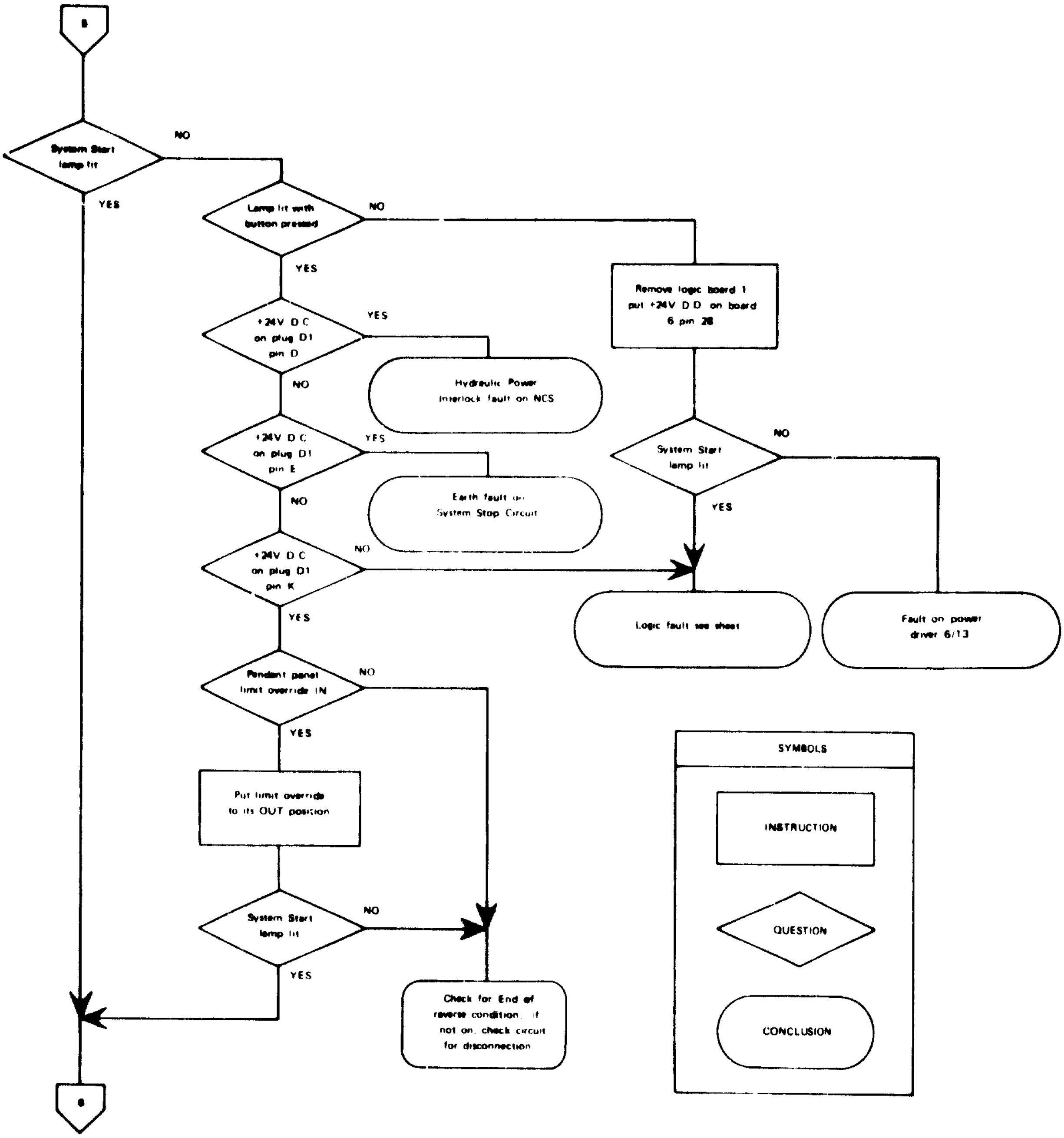


Fig. 21

Algorithm

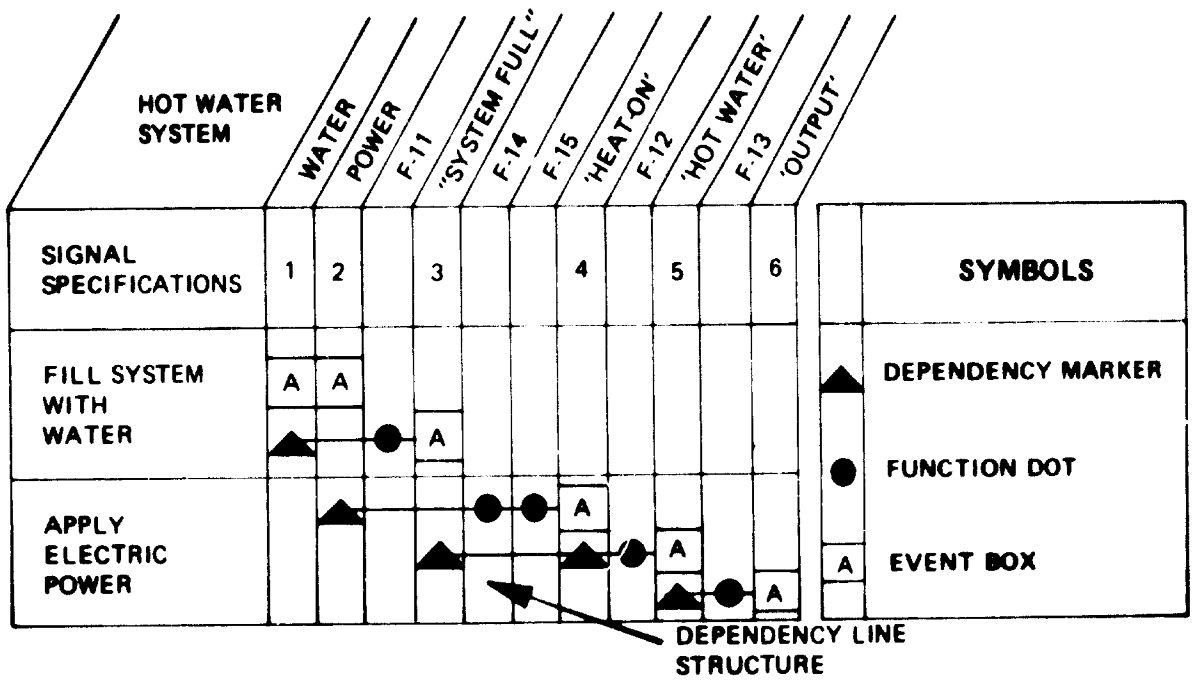


Fig. 22

Maintenance Dependency Chart

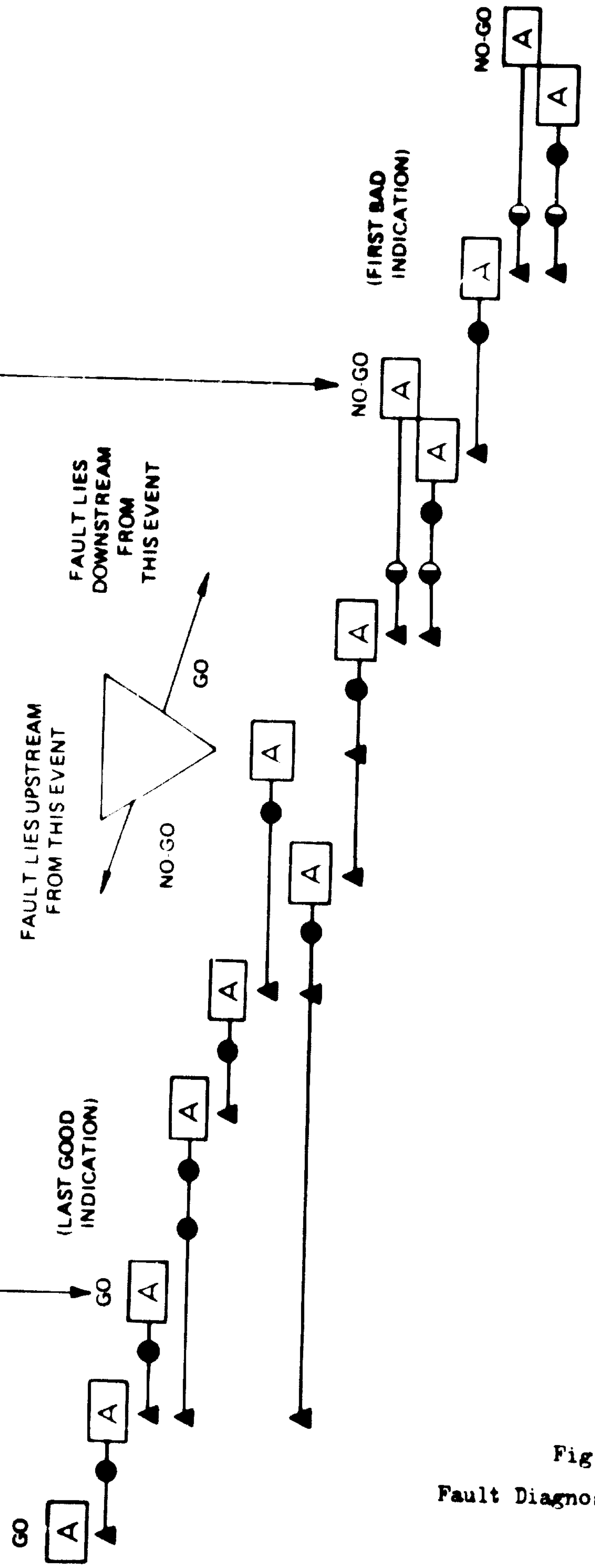


Fig. 23

Fault Diagnosis with Dependency Chart

LOCATION & CODE No NO.1 M/C SHOP G19/24

MACHINE STUBS SURFACE GRINDER AUTO

LUB. CHARTS CHART 1 OF 3 CHARTS

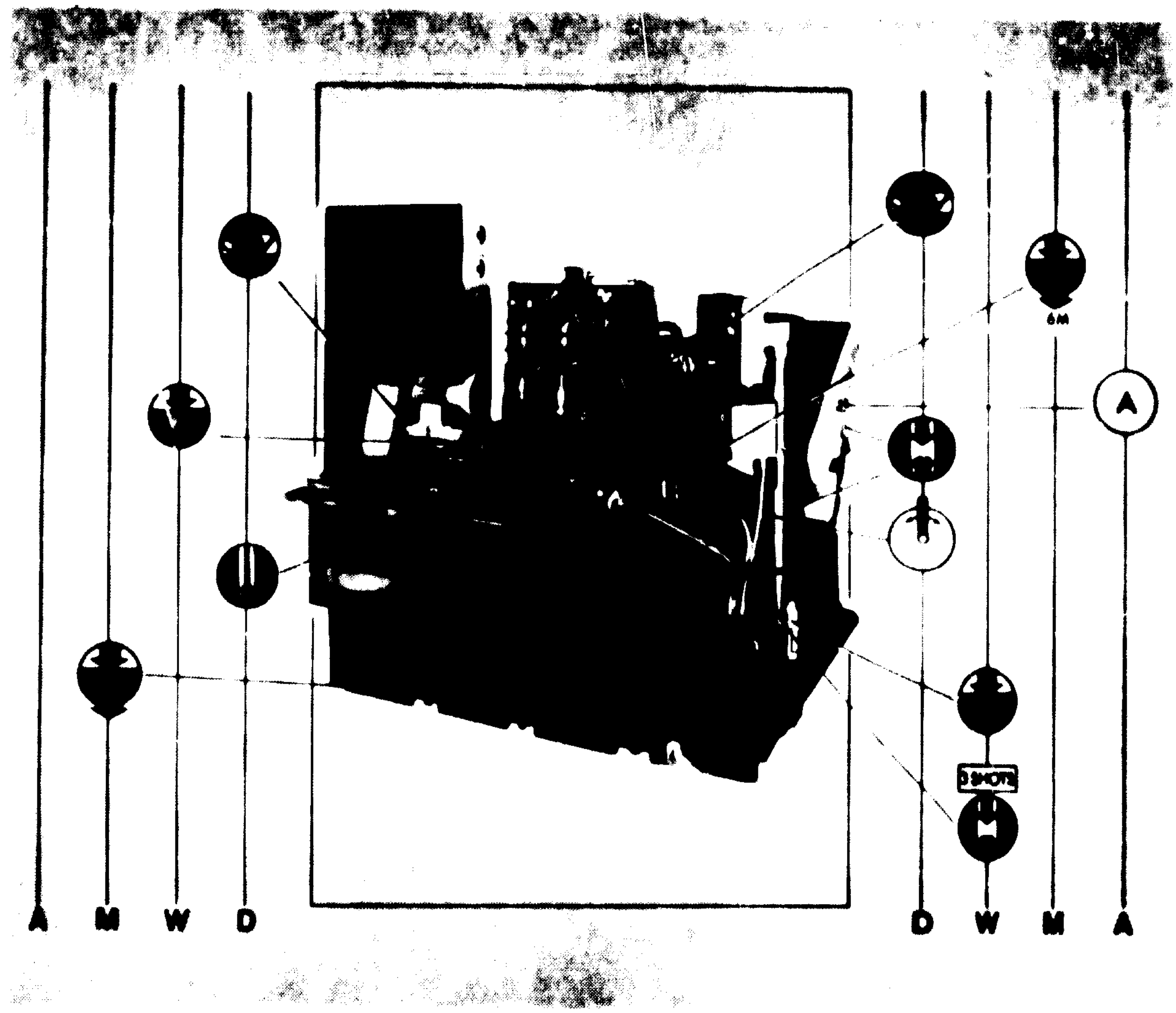
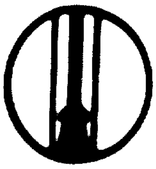


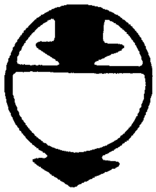
Fig. 24

Symbolic Lubrication Chart

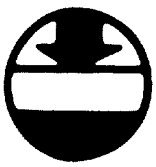
REF.	REMARKS	CODE	LUBRICANT
A	CHECK CHAIN TENSIONER		IBICO L30
			IBICO L10
			IBICO L40
			IBICO L50
			IBICO G140
			IBICO G180
	REFERENCE BELOW SYMBOL [illegible]		



BRUSH OR SMEAR



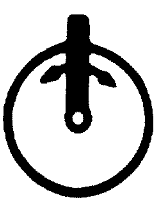
DRAIN & REFILL



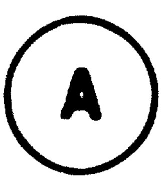
CHECK LEVEL TOP UP

OIL CAN APPLICATION

GREASE GUN APPLICATION



OPERATE AUTO LUB SYSTEM



EXTRA ACTIVITY

Fig. 25
Lubrication Chart Symbols

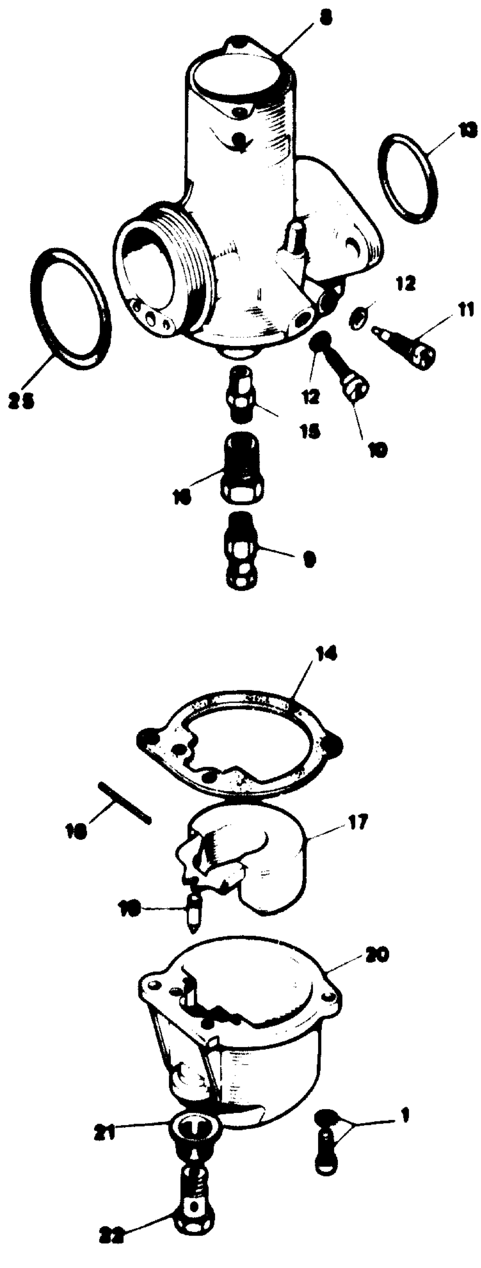


Fig. 26

"Exploded" Illustration for Spare List

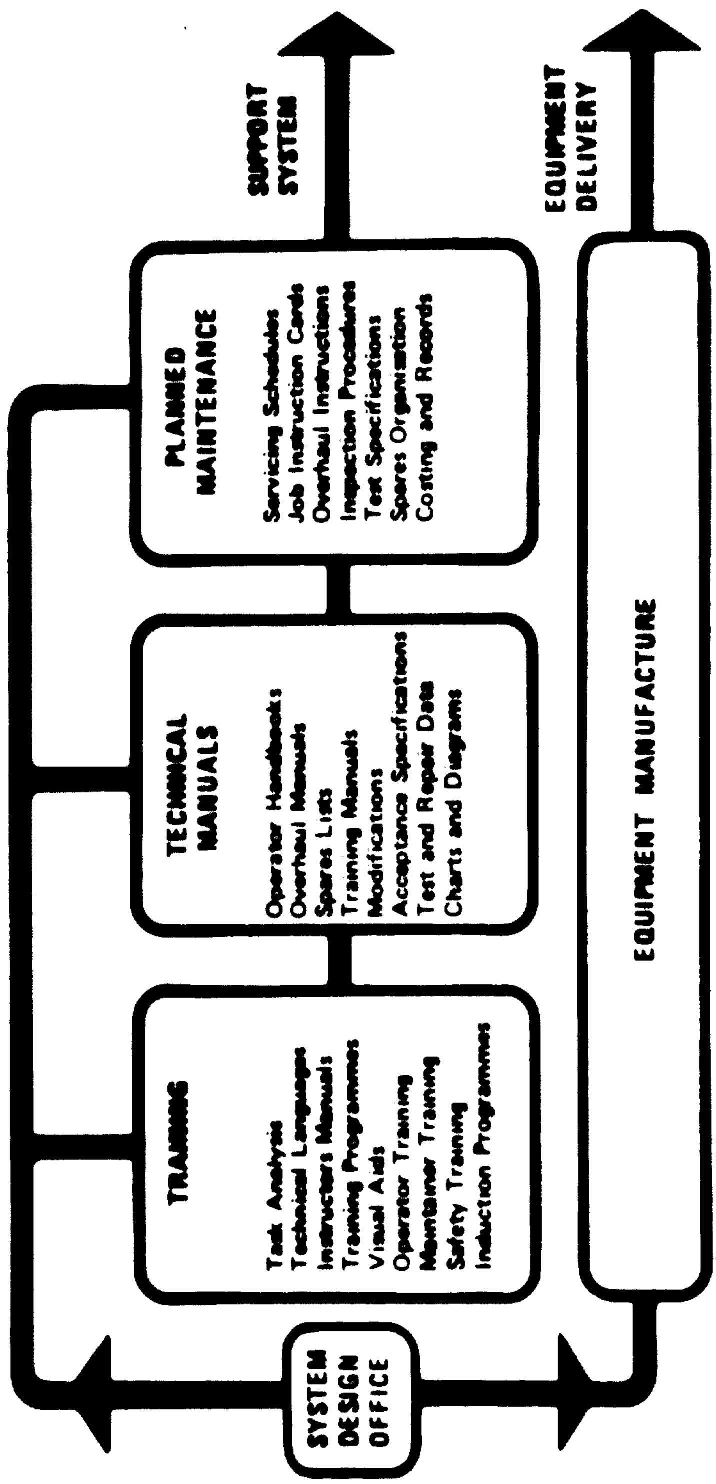


Fig. 27

A Complete Product-Support Package

74.10.16