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United Nations Industrial Development Organization

General Meeting of the Scientific
Coordinating Committee

Geneva, 19 - 21 December 1973

GUIDANCE FOR BIOLOGICAL PLANTS

by

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11.7-1973

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.



United Nations Industrial Development Organization

Technical Meeting on the Selection
of Working Machinery

Vienna, 19 - 23 November 1977

REPORT OF THE MEETING

Final Report

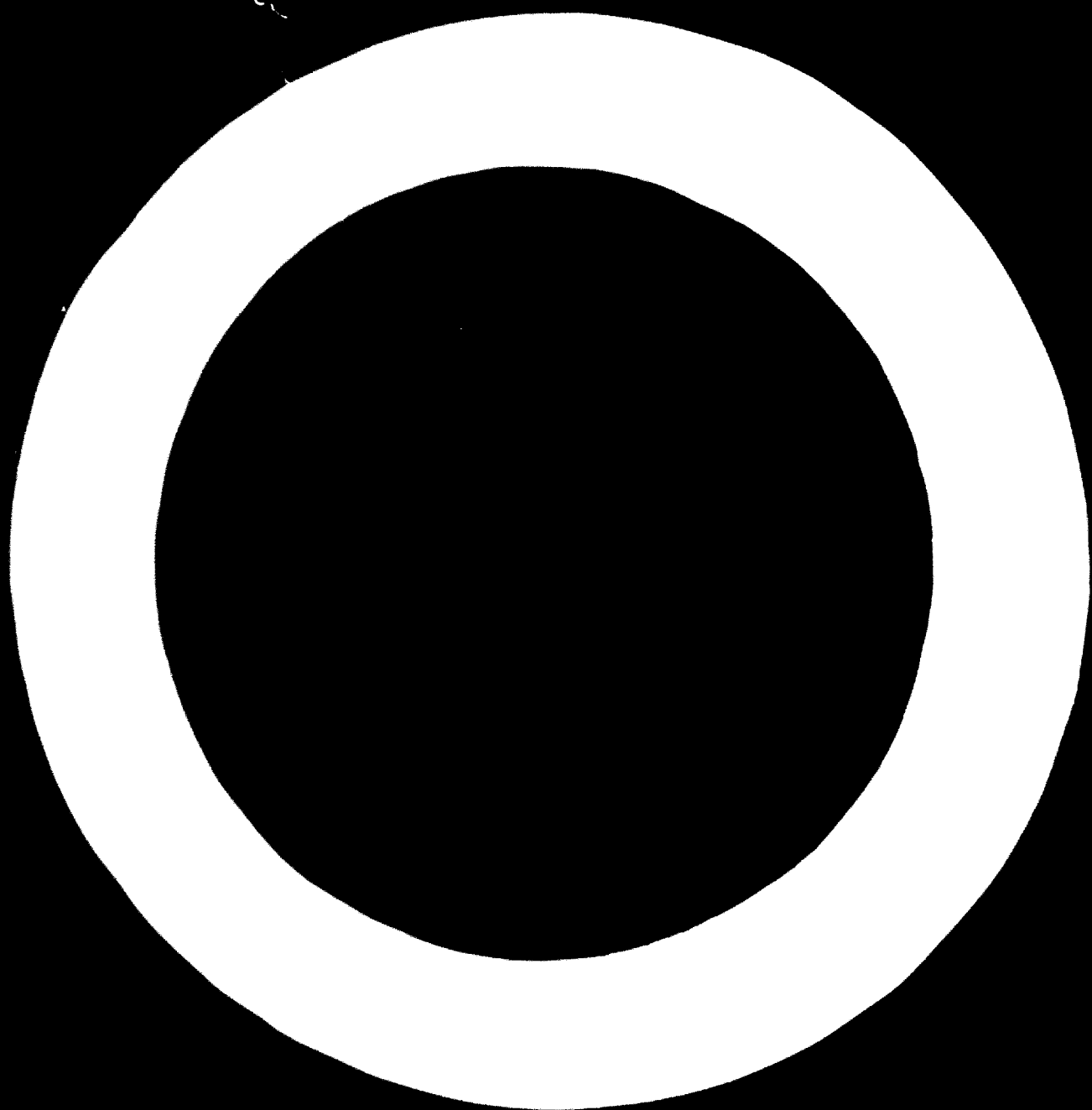
Submitted to the Commission for Economic and Social Development

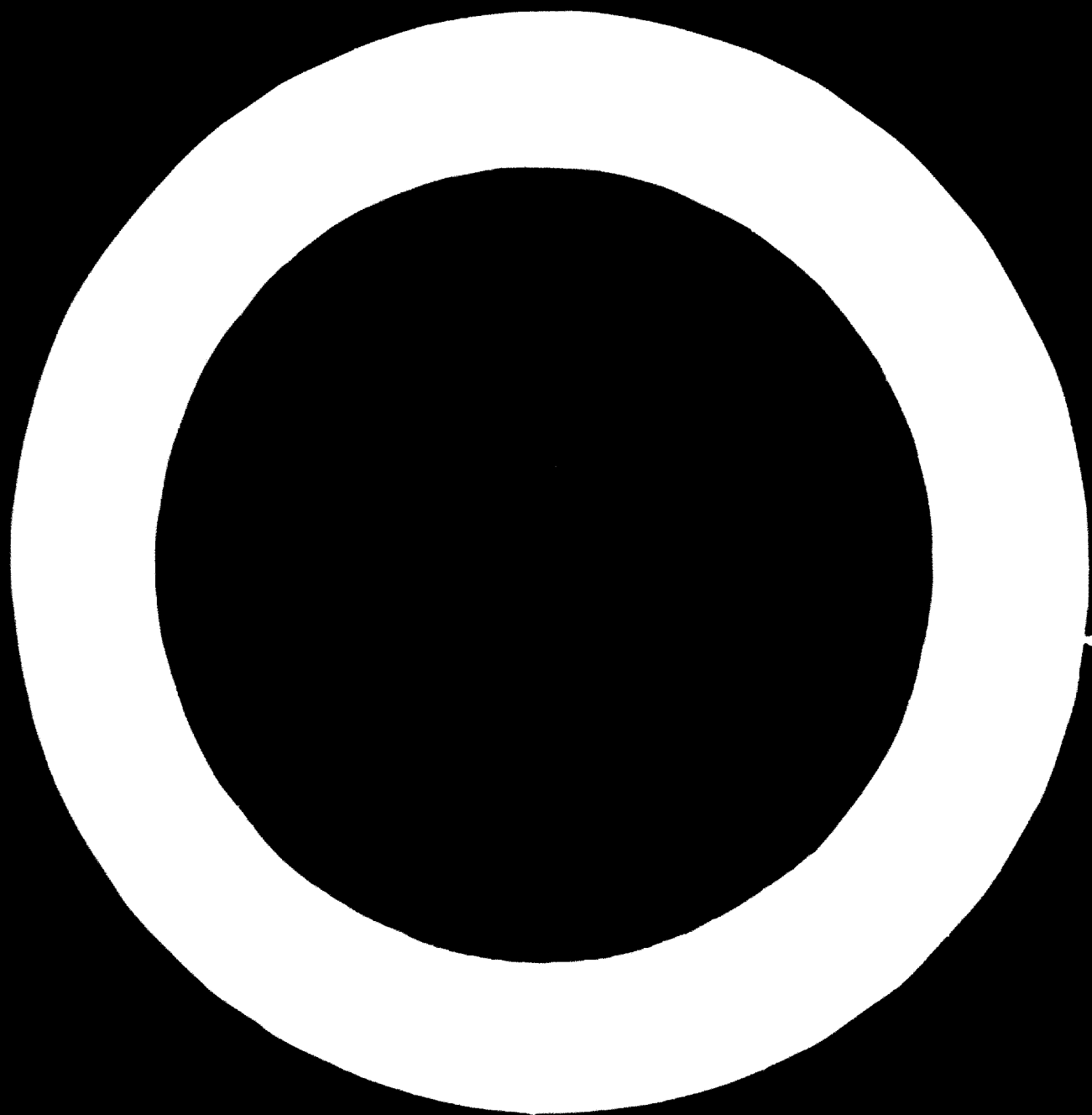
Geneva, 1978

Working machinery will not operate satisfactorily for long without maintenance attention. Delayed repairs and repairs after breakdown are wasteful of the resources of capital and skilled manpower. The cost of breakdown is seen to be more than just repairs.

Although there is not yet international agreement on a definition of maintenance it is widely accepted as including repair or replacement or both of repairs. One useful definition is "any maintenance to bring an machine or plant to an acceptable standard"

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SECTION 1

1. The first part of the document is a general statement of the purpose and scope of the project. It is intended to provide a clear and concise summary of the work to be done and the resources required. The project is to be completed by the end of the year and will involve the participation of several key personnel. The budget for the project is estimated to be \$100,000. The project will be managed by the project manager and will be reported to the board of directors. The project will be completed by the end of the year and will involve the participation of several key personnel. The budget for the project is estimated to be \$100,000. The project will be managed by the project manager and will be reported to the board of directors.

2. The second part of the document is a detailed description of the project's objectives and goals. It is intended to provide a clear and concise summary of the work to be done and the resources required. The project is to be completed by the end of the year and will involve the participation of several key personnel. The budget for the project is estimated to be \$100,000. The project will be managed by the project manager and will be reported to the board of directors. The project will be completed by the end of the year and will involve the participation of several key personnel. The budget for the project is estimated to be \$100,000. The project will be managed by the project manager and will be reported to the board of directors.

II. OBJECTIVES AND GOALS

1. The first objective of the project is to provide a clear and concise summary of the work to be done and the resources required. The project is to be completed by the end of the year and will involve the participation of several key personnel. The budget for the project is estimated to be \$100,000. The project will be managed by the project manager and will be reported to the board of directors. The project will be completed by the end of the year and will involve the participation of several key personnel. The budget for the project is estimated to be \$100,000. The project will be managed by the project manager and will be reported to the board of directors.

1. The first section of the report discusses the general situation of the country and the progress of the work done during the year. It also mentions the various committees and their work.

2. THE WORK OF THE COMMITTEES

The second section of the report discusses the work of the various committees. It mentions the work of the Finance Committee, the Education Committee, and the Health Committee. It also mentions the work of the various sub-committees.

3. THE FINANCE COMMITTEE

The third section of the report discusses the work of the Finance Committee. It mentions the various reports of the Finance Committee and the work done during the year. It also mentions the various sub-committees of the Finance Committee.

4. Although it is difficult to give a complete list of the work done during the year, it is possible to give a general idea of the work done. The Finance Committee has done a great deal of work during the year. It has reported to the Council on the various aspects of the country's financial situation. It has also done a great deal of work in connection with the various sub-committees.

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4. The fourth step in the process of... is to... the... of the... and to... the... of the... in... [197]. The... of the... is to... the... of the... and to... the... of the... in... [197].

to ensure that the equipment is available when it is needed for the operations of the plant and that the equipment is maintained in good working order. The equipment should be replaced when it is worn out or when it is no longer suitable for the work. The equipment should be replaced when it is worn out or when it is no longer suitable for the work.

12. Part of the cost of the equipment should be set aside for a reserve fund. This is still more for the equipment which has been used for a long time. The reserve fund should be used to replace the equipment when it is worn out or when it is no longer suitable for the work. The reserve fund should be used to replace the equipment when it is worn out or when it is no longer suitable for the work.

13. Maintenance of equipment

13. While the objective of having an ample stock of equipment has been made to ensure the maintenance of equipment, the cost of the equipment, even though the equipment may be well preserved, however, it will serve little useful purpose if it is not available when it is required. It is this objective - that of maintaining equipment in good working order - which underlines the importance of regular maintenance. The right amount of maintenance has to be carried out at the right time in the right form of equipment. But all these will demand the same amount of attention and training - planning and scheduling will need most careful attention if the objective is to be achieved. It should be noted that availability is not necessarily being maintained. There is an emphasis laid on the availability of equipment.

14. In the case of equipment which is used for a long time, the equipment may require extensive and careful maintenance attention and so the direct costs of maintenance may be high. The direct costs may include maintenance department labour, materials and overheads. But in addition, such a time there may be substantial maintenance costs if the equipment breaks down in the long period.

and cost of maintenance. The higher the reliability, the lower the cost of the equipment. In the case of equipment which is used only occasionally, the cost of maintenance may be negligible. In the case of equipment which is used frequently, the cost of maintenance will be high. Therefore, the higher the reliability, the lower the cost. In the case of equipment which is used frequently, the higher will be the cost of maintenance. This is because of preventive maintenance and the provision of stand-by equipment or replacement units. Such preventive costs must be put against the increasing value of output from the equipment. It is usually desirable to establish an optimum target of reliability.

2. Standby for use

15. One of the most important objectives of maintenance in some circumstances may be to keep the equipment in a state of readiness for instant and efficient use in case of emergency. Examples include the equipment in a hospital operating theater, fire fighting equipment, rescue vehicles, etc. In such cases the question of economy becomes of considerably less importance. It is common practice to make use of stand-by equipment or auxiliary services in order to ensure instant availability of the emergency facilities.

3. Timing of repairs

16. An essential objective is the wise expenditure of money, time and effort, in other words the wise utilization of resources. The time will come when all equipment when consideration must be given to the relative merits of repair or replacement. Deterioration of certain parts of the equipment may be so advanced that repair would serve a very limited purpose and it might be wiser to invest rather more money in complete or partial replacement. Considerable work on replacement economics has been carried out in the Universities of many of the industrially developed countries. A proper understanding of the subject requires mathematical and statistical knowledge and the application of Operational Research techniques. It is by no means impossible, however, to reach approximately correct economic decisions with a combination of limited mathematical ability and simple common sense.

17. It must be admitted that the decisions are not always based simply on economics. Expediency may play an important role in some circumstances. The situation of limited availability of currency for foreign spending has already been mentioned. Other factors of expediency may be the desirability to provide experience with certain kinds of work within the country, a national desire for

self-sufficiency or the difficulty of obtaining imported parts quickly when required.

18. In considering the advantages which arise from the replacement of a complete item of equipment attention must be paid to the improved output which might result from a newer and more advanced type of equipment. If capital is available it may sometimes be an attractive proposition to replace a piece of equipment even before it strictly requires replacement; higher production rates or better quality products might have considerable influence on the repair-or-replace decision.

g. Reducing production costs

19. Good standards of maintenance will often reduce the cost of operating the equipment. Correct lubrication and adequate cleaning can, for example, make significant reductions in the power consumption. But it is the indirect savings which are of most significance; good maintenance can reduce the amount of sub-standard production. In some industries it has been found possible to link the quality control of the product with the standards of maintenance. With a universal demand for both greater productivity and production quality, the profitability of an enterprise may be substantially influenced by its maintenance standards.

f. Avoiding consequential damage

20. If a piece of equipment breaks down it may cost relatively little to repair but it is not only the cost of repairing it which must be considered. The breakdown of a relatively small component may start a chain reaction the cost of which could be out of all proportion to the original damage. An air receiver in which oil is allowed to accumulate may give rise to explosive conditions and, if adequate inspection and maintenance is neglected there may indeed be an explosion. If that happens the cost of consequential damage to an adjacent air compressor, for example, might be much greater than the cost of replacing the air receiver.

g. Ensuring safety.

21. In human terms, the most important objective of maintenance - and one which must be complementary to any of the others - is that the plant or equipment shall operate safely. There are many ways in which lack of maintenance can lead to accidents, injury and loss of life. No excuse is offered for emphasising safety even though it is dealt with elsewhere.

22. Maintenance and safety are closely related from two distinct points of view. Firstly it must be accepted that the safety of all is often dependent on satisfactory standards of maintenance of equipment, of services, of floors, of stairs, etc. Secondly, maintenance personnel, by reason of their occupation are more often in hazardous situations than anyone else; there is clearly need for careful training of maintenance personnel in safety practices.

23. The International Labour Organization has just completed the revision of its Encyclopaedia of Occupational Health and Safety and one chapter is devoted to the maintenance of machinery and equipment. For the present meeting the subject of safety itself has been dealt with elsewhere but the maintenance/safety relationship is sufficiently important for this reminder to be included. In particular, attention needs to be focussed on the number of accidents in which maintenance men are involved. Some are caused by lack of care by the men when working in hazardous situations. Too often maintenance men take unnecessary risks in the belief that they are saving time by inspecting or adjusting machinery in motion. Although this may sometimes be necessary, the hazards must be recognized. Training in correct practice must be given and appropriate tools and equipment provided.

24. Some of the most serious maintenance personnel accidents - often fatal - are caused by the lack of a safe system of work. Machinery is started with a maintenance man inside because another maintenance man or an operator is not aware of the first man's presence. There is particular danger with large machines and machinery like conveyors which are not wholly in one part of a building.

25. There are two ways of ensuring safety. In the first, a 'permit to work' is issued by the responsible manager or supervisor after he has checked that the machinery is stopped, isolated, cleared of noxious fumes, cool and in all other respects safe to work on. Until the maintenance man returns the 'permit to work' the manager ensures that the machine is not started. As an alternative, or sometimes forming part of the first scheme, the maintenance man has his own padlock with one key. The master switch or control valve has provision for the attachment of the padlock to secure it in the safe position. The maintenance man then keeps the key with him until the task is completed. Where several men are involved, each will have his own lock and key and these will be attached to the switch or valve 'in parallel' so that all locks have to be removed before the machine can operate.

26. The maintenance of a high level of efficiency in machine tools and machinery are difficult to maintain if they are to be used for long periods of machinery in especially the most severe conditions. The maintenance of a high speed router may be particularly difficult, since a wheel of 1/2 inch diameter may be moving at a speed of 4,000 r.p.m. The maintenance of machine tools and machinery is a complex task and must be handled accordingly.

2. Supporting the objectives

27. If an attempt is made to produce a program of maintenance of the maintenance of maintenance it results in the following: The objectives of maintenance will be to keep machinery and equipment in good condition, to insure the highest safety, economically, and at the appropriate performance standards for the extent of use required for production use.

IV. MAINTENANCE OF MACHINERY AND EQUIPMENT

a. Approach

28. In implementing maintenance programs there will be an overall requirement to use of machine capabilities required to give the advantages of the foregoing objectives. The objectives are stated in the following of relative importance of the machine objectives according to period of maintenance, so there will be a need to adjust a number of maintenance objectives to suit these conditions.

29. The IBM (1973) approach provided that maintenance objectives should be solved by maintenance only on technical grounds, such as diagnosis and inspection to determine machine and operator objectives which relate to the maintenance of such matters) to the availability of other resources, (energy, and materials) required when maintenance equipment is a standard, and need to be available and of control and skill. The maintenance program is a continuous and regular consideration of all maintenance, to plan an appropriate maintenance program to insure the operation of maintenance equipment, maintenance objectives and maintenance objectives.

30. Preventive maintenance can be defined as the maintenance program carried out of maintenance objectives on the maintenance objectives and the maintenance objectives to insure the highest level of maintenance for the maintenance to the required standards. The maintenance objectives are to be maintained through the maintenance of maintenance objectives.

work needed to keep the equipment in good order will then be decided on a regular basis. This is generally more satisfactory and less expensive than the maintenance of a rigid schedule of actual work to be done at regular intervals. One of the most important aspects of preventive maintenance is that it can reduce the likelihood of failure which could result in loss of material and which might also result in serious damage to the equipment or loss of production.

2. **Life-cycle maintenance** is a phrase which has become popular over the past few years. It is associated with long-term maintenance planning and it implies the consideration of all factors which can influence future maintenance needs. It calls for an understanding of the way the equipment operates under normal conditions and also of the way it deteriorates through use and through environmental conditions.

3. **Design-out maintenance** is one of the most positive - and yet the least used - of the maintenance management techniques. The idea is that maintenance is a nuisance, adds to the cost of a product but not to its value, and should therefore be eliminated as far as possible. ('Designing out maintenance' is another phrase used to describe the technique). In many cases it will be realised that this means 'as far as is technically possible'. It is often technically possible to design out almost all maintenance by very large additional expenditure of capital at the design and manufacturing stages. In those circumstances the increase in initial cost is much more than the savings in maintenance. A compromise is necessary.

4. It should be recognised that maintenance prevention does not necessarily result in higher initial cost. In many cases the design of the equipment can be modified to reduce unnecessary maintenance with virtually no extra first cost. An example would be the provision of adequate accessibility for cleaning, lubrication or adjustment; this would often require only the more careful arrangement of components in an equipment assembly.

5. **Maintenance prevention** starts at the design, tendering and ordering stages. Future maintenance expenditure can be significantly reduced by more thought at these stages. Maintenance costs occurring throughout the lifetime of equipment normally are often as much as the purchase price of the equipment - and sometimes they exceed it substantially. In spite of this, too many people buy or manufacture, sell or even buy equipment without taking maintenance into consideration. The symposium considered that this was an area of maintenance

concern which had been badly neglected; in its recommendation for action by developing countries, the symposium said "Ensure that maintenance requirements are properly considered when equipment and plant specifications are prepared, tenders evaluated, and contracts finalized. The savings in resources resulting from such a procedure should not be underestimated".

35. Another way in which maintenance costs can be reduced at the specification stage is by appropriate consideration of the future availability of spare parts, maintenance information, after-sales service, etc. Choice of supplier should possibly be influenced by the willingness shown to co-operate in this.

36. Corrective maintenance or repairs should not be the sole approach to maintenance but equally it must not be regarded as altogether wrong. Throughout industry in the developing countries there is a need to reduce the incidence of repairs but this should be done on a rational basis with due attention to the cost factors highlighted in the next chapter.

b. Techniques

37. In any planned approach to maintenance there will be two essentials. There will be a carefully designed and constantly updated schedule of inspections and other preventive maintenance activities; there will be a procedure for the rapid reporting of breakdowns and a procedure for making appropriate repair resources available quickly and effectively. In both these areas there are techniques which can improve performance.

38. In connection with maintenance there have in recent years been useful developments in technology which have opened up a new field of surveillance techniques. Some of these are used with the equipment in use; they are generally grouped under the heading 'on-line condition checking' or 'machine health monitoring'. They range from vibration analysis equipment (useful for monitoring the condition of bearings) to spectrographic analysis of oil. But surveillance systems are not confined to these sophisticated areas and for many years maintenance engineers have made good use of simple monitoring devices indicating or recording pressure, temperature, flow, acidity, etc.

39. Complementary to these monitoring techniques are those techniques used during inspection and these include those grouped under the heading 'non destructive testing'. By the application of X-rays, ultrasonics and other

scientific developments it is necessary to carry out things in a sense which are far more precise than that which is usually understood in the common sense.

40. When a breakdown has occurred it is desirable to carry out an investigation more so - to make use of external forces. Fault diagnosis is a task which has been for many years rather neglected. This is a consequence of a long history and often the case that the actual repair of the fault is done in a very short time than its diagnosis. The new scientific developments in this field are the application of logical thought processes to the field of diagnosis.

41. In some of the diagnostic techniques, particularly as developed in Sweden and under the title 'logical fault finding', emphasis is laid on determining the cause of the failure. This involves the idea of determining what may prove to be a secondary cause and then returning the original primary fault to cause further trouble. It is also to remember that nothing happens without a cause and that finding the cause is the reason for the term 'fault-finders'.

42. In logical fault finding the start out necessarily is with the question, The fault-finder then asks himself "In which order of the system can faults arise which would produce these symptoms?" The possible causes are placed into an order of probability and appropriate tests determined.

V COSTS AND EXPERIMENTATION

43. Before a preventive maintenance program can be instituted a good amount of information is needed on costs. The direct maintenance costs are the costs incurred during maintenance operations, that is the cost of labour, materials and the cost of the running of the maintenance operation. The indirect maintenance costs are the costs of production lost as a result of maintenance inefficiencies. It is important that both these areas of cost should be given equal attention. Too often there is something known about the direct costs, the costs of doing the maintenance, and nothing known about the indirect costs, the costs of not doing the maintenance. Clearly there is little justification for increasing the direct maintenance costs unless there is a greater awareness of the indirect costs.

10. The purpose of this report is to provide a summary of the results of the investigation conducted by the author during the period from January 1, 1964, to December 31, 1964. The investigation was conducted in accordance with the instructions of the Board of Directors of the American Telephone and Telegraph Company, which was established in 1964 to investigate the activities of the American Telephone and Telegraph Company and its subsidiaries and to report to the Board of Directors of the American Telephone and Telegraph Company.

11. During the course of the investigation, the author has conducted a number of interviews with various persons who have been identified as having been involved in the activities of the American Telephone and Telegraph Company and its subsidiaries.

12. It is suggested that the following list of names is included in the report as a result of the fact that as a result of the investigation conducted by the author during the period from January 1, 1964, to December 31, 1964, the author has been unable to identify the persons who have been identified as having been involved in the activities of the American Telephone and Telegraph Company and its subsidiaries. It is suggested that the following list of names be included in the report as a result of the fact that as a result of the investigation conducted by the author during the period from January 1, 1964, to December 31, 1964, the author has been unable to identify the persons who have been identified as having been involved in the activities of the American Telephone and Telegraph Company and its subsidiaries.

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14. Subcontractors

14. Every subcontractor engaged and engaged must... (The text is extremely faint and largely illegible, appearing to be a numbered list item.)

15. It is noted on record of these... (The text is extremely faint and largely illegible, appearing to be a numbered list item.)

16. There are, in fact, many... (The text is extremely faint and largely illegible, appearing to be a numbered list item.)

The first consideration is the cost of the material. It is not possible to estimate the cost of the material until the design is complete. The cost of the material is a function of the quantity required and the price of the material. The quantity required is a function of the design and the size of the project. The price of the material is a function of the market and the location of the project.

50. The second consideration is the cost of the labor. The cost of the labor is a function of the quantity of labor required and the wage rate. The quantity of labor required is a function of the design and the size of the project. The wage rate is a function of the market and the location of the project. It is not possible to estimate the cost of the labor until the design is complete. The cost of the labor is a function of the quantity required and the price of the labor.

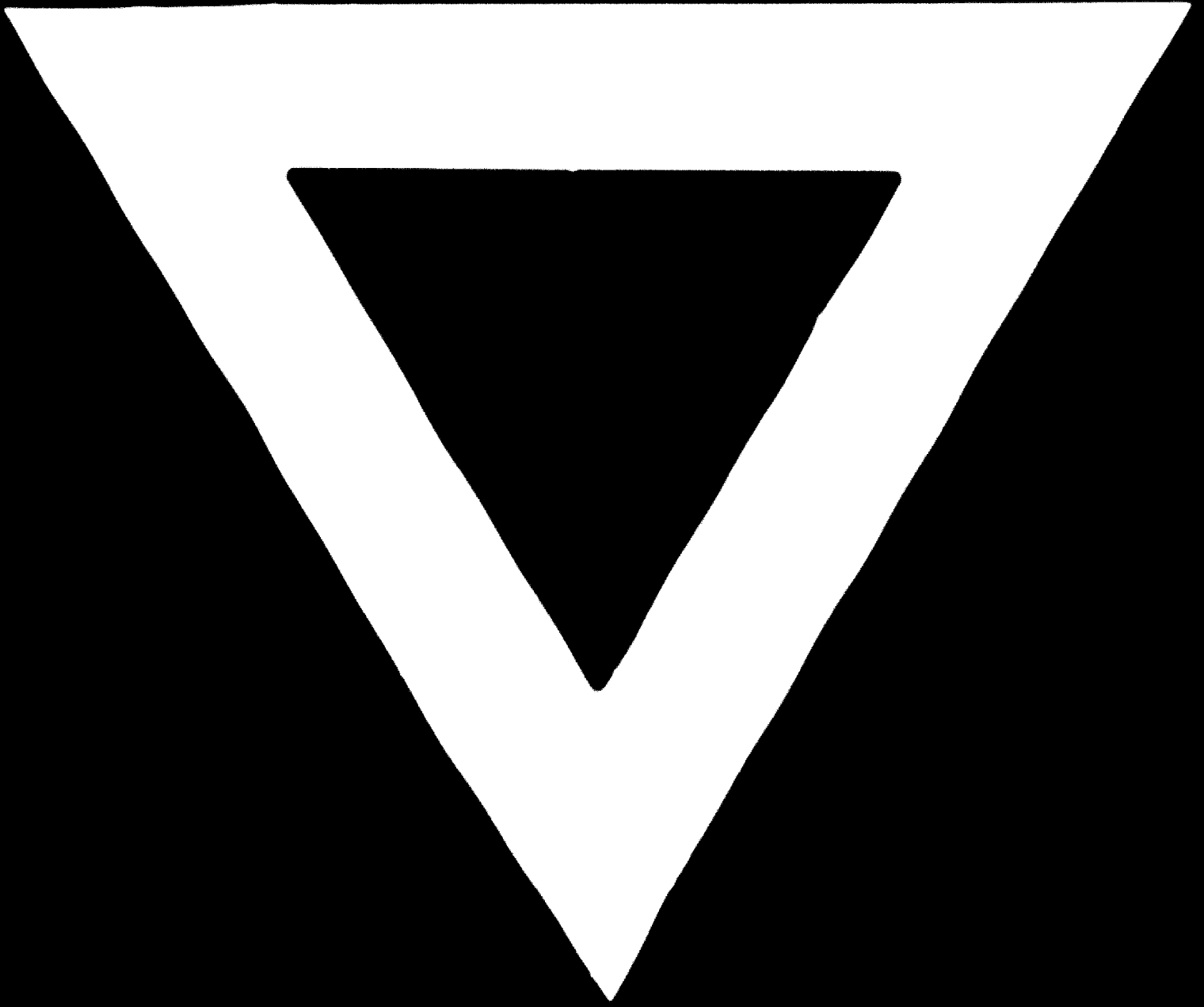
51. It must be admitted that material is not used in a uniform manner. It is used in different quantities in different parts of the structure. It is used in different quantities in different parts of the structure. It is used in different quantities in different parts of the structure. It is used in different quantities in different parts of the structure. It is used in different quantities in different parts of the structure.

52. As with all kinds of construction, the use of subcontractors should be a matter under constant review. It is important to know what kind of work is to be done and to estimate the cost of the work. It is important to know what kind of work is to be done and to estimate the cost of the work. It is important to know what kind of work is to be done and to estimate the cost of the work.

71. SUBMITTING PROPOSALS AND CONTRACT PLANS

53. The future cost of maintenance can be influenced to a substantial extent by care in the selection, specification or design of contracting authority. At these early stages maintenance consideration is essential.





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