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MAN MACHINE INTERFACE
THE EFFECT ON PLANT UTILISATION AND MAINTENANCE

by

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Organised in co-operation with the German Foundation for Developing Countries and the Association of German Machinery Manufacturers (VDMA).

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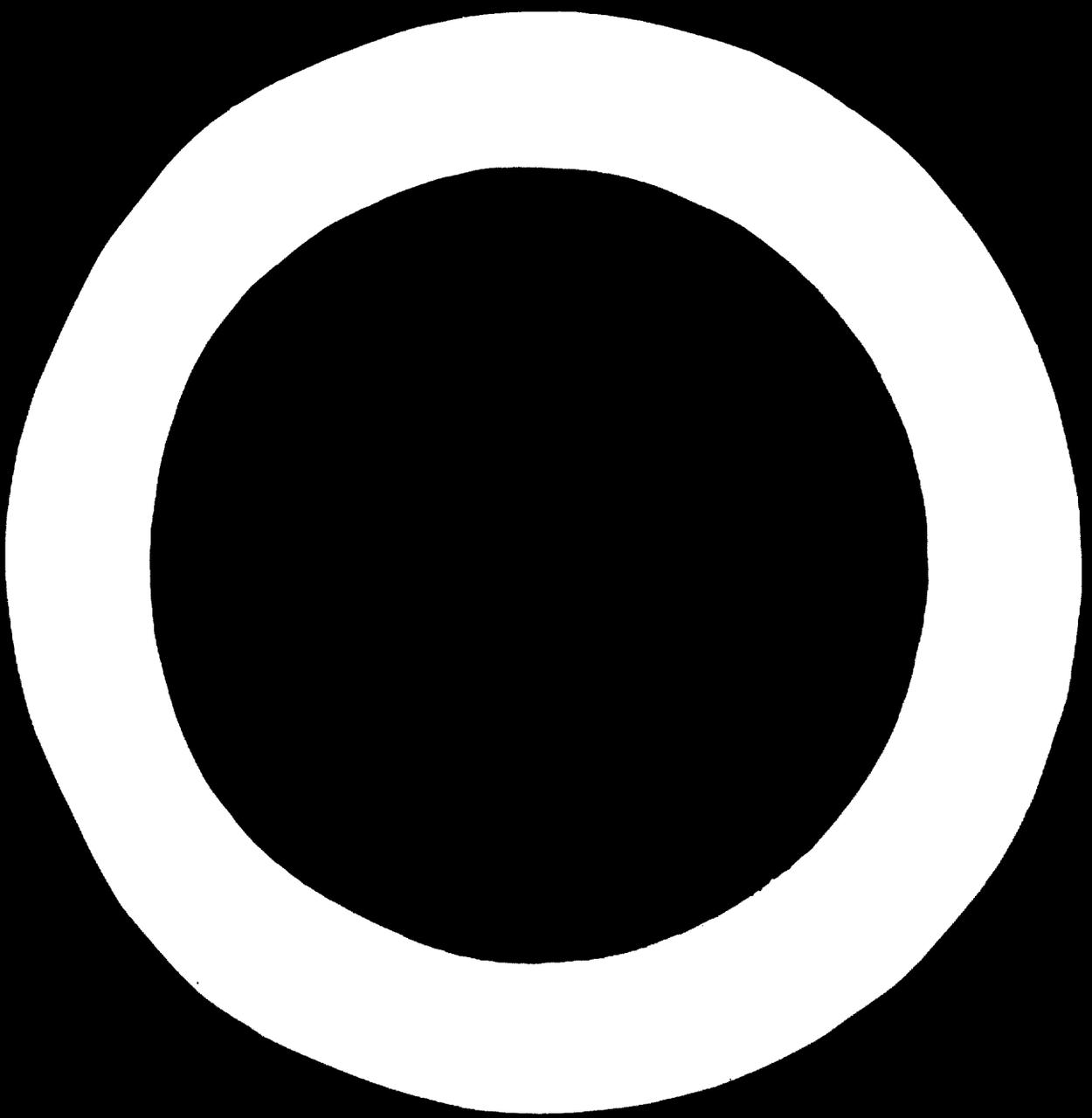

Introduction.

The purchase of the equipment is the first stage in the establishment of an industrial facility and represents a considerable financial committment. Subsequent to the introduction of the plant, the problems of operation and support have to be recognised. These problems are recurring ones, spanning the life of the equipment or installation.

The problems of operation are wholly within the province of the purchaser or user. The manufacturer or supplier's responsibility in this aspect is to design the equipment to minimise the demands on operators in order to meet performance objectives.

The maintenance task is essentially dependant on technical resources represented by the availability of skilled manpower and materials. It is this lack of technical resources which is causing the major problem in achieving a satisfactory rate of industrial progress for the developing nations. A solution to this problem is to introduce information techniques to improve the assimilation of technical knowledge and achieve rapid understanding of the equipment function and operation and is defined as the Man Machine Interface. This will result in improved maintenance techniques and utilisation of plants. Researches have been carried out over the past four years to improve the communication processes involved and the problems, attitudes and results are discussed.

The Problem and Management Motivation.

The difficulties of improving the availability of technical resources are well known, in general, the problems are of technical education and in this respect, the expansion of education facilities must be regarded as a long-term solution. However, industrialisation is the most significant area of development in a country's economy and management must recognise that a solution is required to meet the problems that exist now and will continue to exist for the next decade. Management techniques must be introduced to allow all levels of manpower to operate effectively and ensure the development of skills to the mutual benefit of the employer and employee.

The motivation for the realization of the economic benefits of improved maintenance must be the responsibility of management in the first instance. For example, it is not unusual for an equipment complex to cost in the order of £1million, and assuming a life span of 15 years and allowing financing charges of say, 5%, the capital depreciation will be approximately £100,000 per annum. To this must be added the cost of running the equipment and staffing it. Maintenance, therefore, is essential if one is to achieve maximum utilisation, any loss of operational capability due to faults and failures will result in a loss of income and represents a loss of use of capital investment. Maintenance can, therefore, be viewed as insurance against this loss.

Maintenance expenditure falls into two main categories:

(i) Expenditure on material resources, e.g.:

- Buildings and Workshops
- Test Equipment
- Stocks of Spare Parts and Spare Units
- Technical Support Information

(ii) Expenditure on human resources, e.g.:

- Skilled and Semi-skilled Manpower
- Training Facilities
- Accomodation and Welfare Facilities
- Transportation

Expenditure related to the provision of adequate tools, test equipment and spare parts can represent a relatively large financial committment. The effect is that the availability of such maintenance aids reduces the work load and decreases the "down time" of equipment but does not significantly effect the costs over the equipment life span.

Apart from the initial costs of establishing the maintenance organisation and the running costs related to the spares consumption, the major expense will stem from the number and level of skill of personnel required to staff the organisation. Any reductions in the staff levels will result in small annual savings but will be multiplied over the life span, therefore, careful consideration must be given by management to methods of reducing the maintenance work load or to increasing the productivity of the staff.

It is interesting to consider the costs of maintenance as these can often exceed the capital cost of the equipment. The cost of maintaining any installation depends on its size, complexity and location, therefore, the numbers and qualifications of staff required can only be dealt with by considering the hypothetical case.

For the purposes of illustration, consider a process installation consisting of complex mechanical and electronic equipment costing approximately £1million. To staff such an installation using conventional maintenance techniques would require a staff of four first class engineers at a cost of approximately £5000 per annum, eight first class technicians at a cost of approximately £3750 per annum and twelve second class (junior) technicians at say, £2500 per annum. These costs and numbers may be argued, but experience shows that they are reasonable.

Ignoring the capital and running costs of providing the necessary back up, i.e. Workshops, Tools, Test Equipment, Spares etc., it can be shown that the cost of providing the maintenance knowledge and abilities for the life span of 15 years will be:

$$15 \left[(a_{t_1} \quad n) + (a_{t_2} \quad n) + (a_{t_3} \quad n) \right] + C$$

Where a_{t_1} etc. = annual cost for grade of technician

n = number employed in each grade

C = cost of providing maintenance information

The initial cost of providing normal maintenance manuals for such an installation would be small and would be included ostensibly in the cost of the equipment. The cost in this example in £'000 will therefore be:

$$15 \left[(5 \times 4) + (3.75 \times 8) + (2.5 \times 12) \right] + 5 = £1,205,000$$

That is allowing £5000 for cost of maintenance manuals.

From the above example, it can be seen that maintenance represents a significant cost area and management must view objectively all methods of improving techniques in order to reduce costs.

The hypothetical case described is representative of the problem in most developing nations in that the staff referred to are primarily expatriate personnel, therefore, any improvement in technical communication will alleviate the reliance placed on expatriate personnel and increase the utilisation of local labour.

The Solution and Management Appreciation.

As stated previously, technical manpower for equipment and system maintenance is possibly the most pressing problem facing any developing nation in its industrialisation process. Any maintenance aid that lessens the demand for skill in this area must be investigated and exploited.

The special documentation developed by Planetron International assures a greater understanding of complex systems by selecting the technical content to be applicable to the largest target population. The aims of the communication of instruction process must be stated in performance terms, that is in terms of acts which the operator or technician will be able to perform. Such aims in the past were commonly defined in terms of "knowledge", "attitude" and "appreciation" and represented the approach of a technological society. Experience over the past few years has shown that this is not precise enough. If the aims of the technical process can be restricted to terms such as "do", "operate" and "assemble", then the instructional technologist can be sure of succeeding. In other words there must not be any ambiguity in instructions associated with an operation or maintenance task. Previously it was sufficient to think in terms of equipment being supported by the manufacturer's technical manuals and the expertise of expatriate personnel was usually enough to keep the equipment operational. Today, with the advent of even more sophisticated equipment and the employment of indigenous labour was limited technical experience, it is important to realise that new techniques must be introduced in order to ensure efficient operation and effective maintenance. The performance parameters of the new techniques should be considered as follows:

1) Technical Content.

The object should be to produce operating and maintenance manuals to meet the capabilities and requirements of operators and technicians at the varying levels of performance, that is the content

must be so designed as to ensure complete understanding of the operating or maintenance task and the depth of the technical content will vary in accordance with the logistic policy adopted to support the equipment. Under normal circumstances three levels would be considered adequate. They are Primary, Secondary and Tertiary levels.

2) Access Time.

The object should be to enable an operator or technician to locate information related to a specific situation within a few minutes. Anything in excess of this will probably be unsatisfactory in practice and uneconomic in terms of reducing "down time".

3) Use by Trained but Inexperienced Personnel.

It is imperative that equipment manuals should be produced to enable the appropriate grade operator or technician who has no previous experience of the system or equipment to carry out relatively comprehensive operations or repair tasks.

The techniques described are applied by understanding the environment in which the personnel operate and allows the instructor to have a better intuitive appreciation of the difficulties of the trainee.

An important aspect of the technique is the minimal use of text coupled with a pictorial approach which has been established as the best means of achieving understanding of complex operations, equipment or process activities. The tasks are arranged sequentially in the order in which they are critical to success, thereby reducing extensive diagnosis and the level of decision making. To ease the understanding of complex operations, simple functional diagrams have been developed. In these the operation or theory is explained around a diagram with leaders going direct from the text to the diagram, also the contents of the diagrams and pictures are dictated by their purpose in terms of their level of details and approach.

On systems or equipment with say less than 200 probable fault conditions a logical tree fault-finding guide is produced to the level of the technicians capability (previously established as a parameter of the training policy). Fault-finding is a diagnostic task and, when given the symptoms, the possible causes can be tabulated as questions, with answers "yes" or "no", leading to other questions and subsequent remedial action.

Summing up, therefore, the Planetron technique is based on sound principles of instructional technology and takes into account problems of (a) language, (b) education, (c) ability, (d) social and working environment, (e) specific equipment/apparatus/process, about which information is to be transmitted.

The training and maintenance systems are so designed as to allow for its use by (a) teacher/instructor/ exclusively, (b) the trainee with partial assistance from the teacher/instructor, (c) trainee alone. It is emphasised that the word "trainee" is intended to include trained personnel, who from time to time, must acquire additional skills/knowledge in order to adapt to changes in equipment and processes.

As in every other sphere of operations, training and maintenance costs are steadily rising, due to the nature of the environment. In developing countries the training efficiency, particularly in relation to on-the-job training, is falling. The reasons for this drop in efficiency can largely be accounted for in manpower. The turnover of expatriates, full-time instructors and artisans responsible for on-the-job training is known to be very high and will continue to be so. Replacements, especially of expatriate artisans, are recognised as being of a lower standard of manpower, i.e. men who themselves require to be taught the application of the skills they have acquired to their new environment, men who cannot impart their knowledge and skills, and finally, men who do not want to teach anybody anything.

Costs.

If we now consider providing specialised documentation of the type described, thereby enabling less skilled technicians to perform the maintenance tasks and repair procedures, we are now able to reduce the numbers and skills of the personnel refered to in our hypothetical example. Again based on experience gained in

the field it is reasonable to reduce the maintenance staff by dispensing with two engineers. Also due to the introduction of the more rapid fault diagnosis procedures and easy to follow maintenance schedules, we may further reduce the staff by two first class and three second class technicians. In addition, indigenous personnel would replace expatriates of the technician grades and the salaries used in the formula below are representative of comparative levels between local and expatriate labour. The cost of preparing and providing the specialized maintenance/training documentation would be proportional to the complexity of the equipment. In this case we have assessed the cost at £50,000. Therefore the outlay over the life span would be in £'000's.

$$15 \left[(5 \times 2) + (3 \times 6) + (2 \times 9) \right] + 50 = £740,000$$

The net savings against the previous example of £465,000. In the case cited the operational availability would be the same, the differing manpower levels being compensated by the specialized documentation. In practice, of course, the economies would be greater as no escalation in wage structures has been allowed.

The Justification.

The specialised documentation must be tailored to meet the specific requirements of the user in terms of technical ability, logistic policy, language and training requirements. Even so, considerable savings result from the use of specialised documentation, but even more important is that it provides an aid to assist the development of local skills and brings into being a "springboard" of technology to enable greater assimilation by nationals otherwise constrained to more menial tasks. It provides a solution to the problem of training new staff to familiarise themselves with the equipment in that in place of the intimate knowledge of engineering techniques needed with normal documentation, the new approach allows for the lesser skilled to understand the complexities of the equipment and functional tasks. Of prime importance is the ability to use the documentation initially during the training phase and subsequently in the field of operations. The level of content is so selected to ensure maximum retention of information and improve the comprehension of the importance of maintenance in an industrial environment. It is clear that the problems confronting management and industrial organisations are formidable. The introduction and implementation of the Planetron documentation techniques would make a substantial contribution towards a rapid and successful solution.

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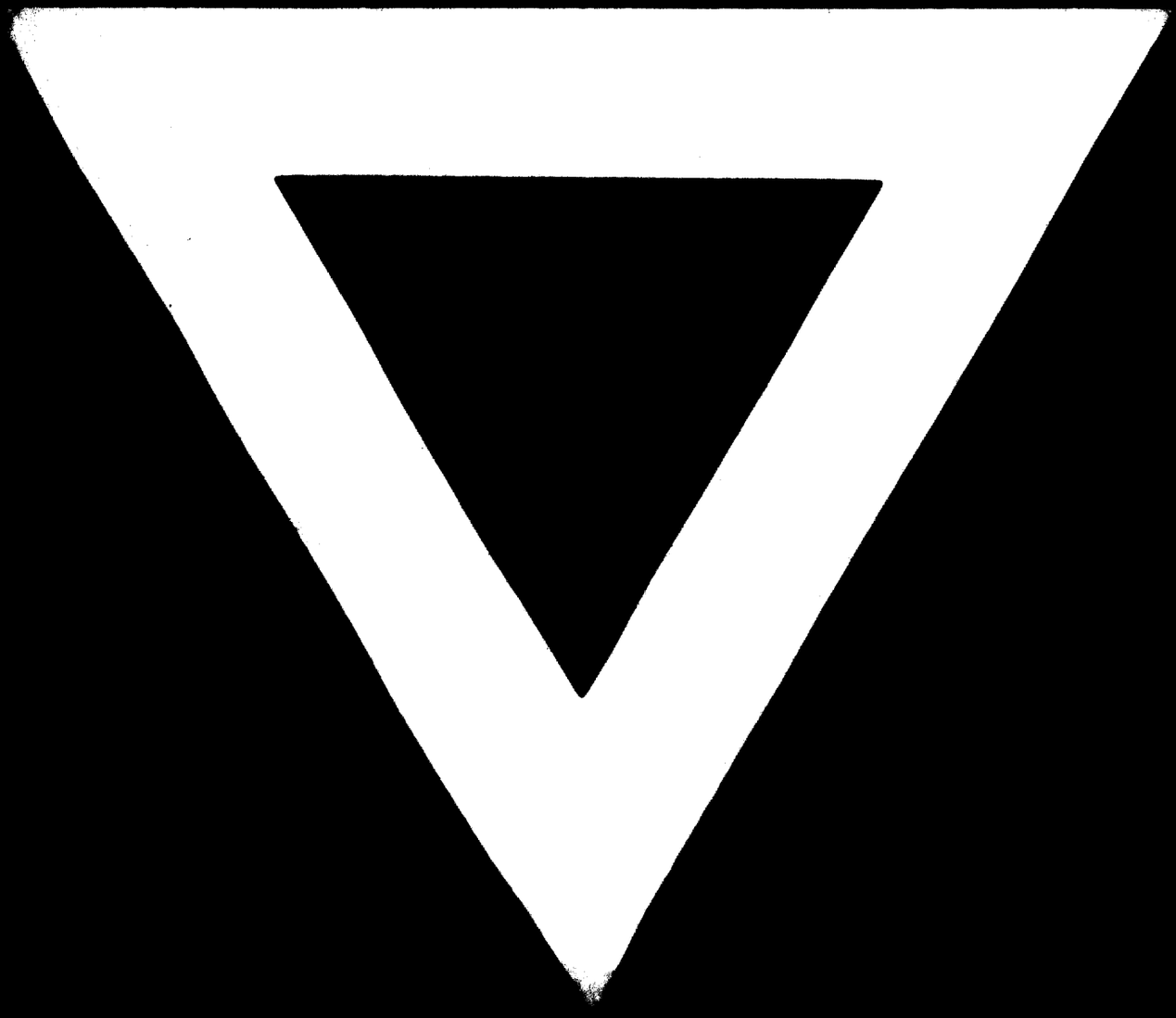

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