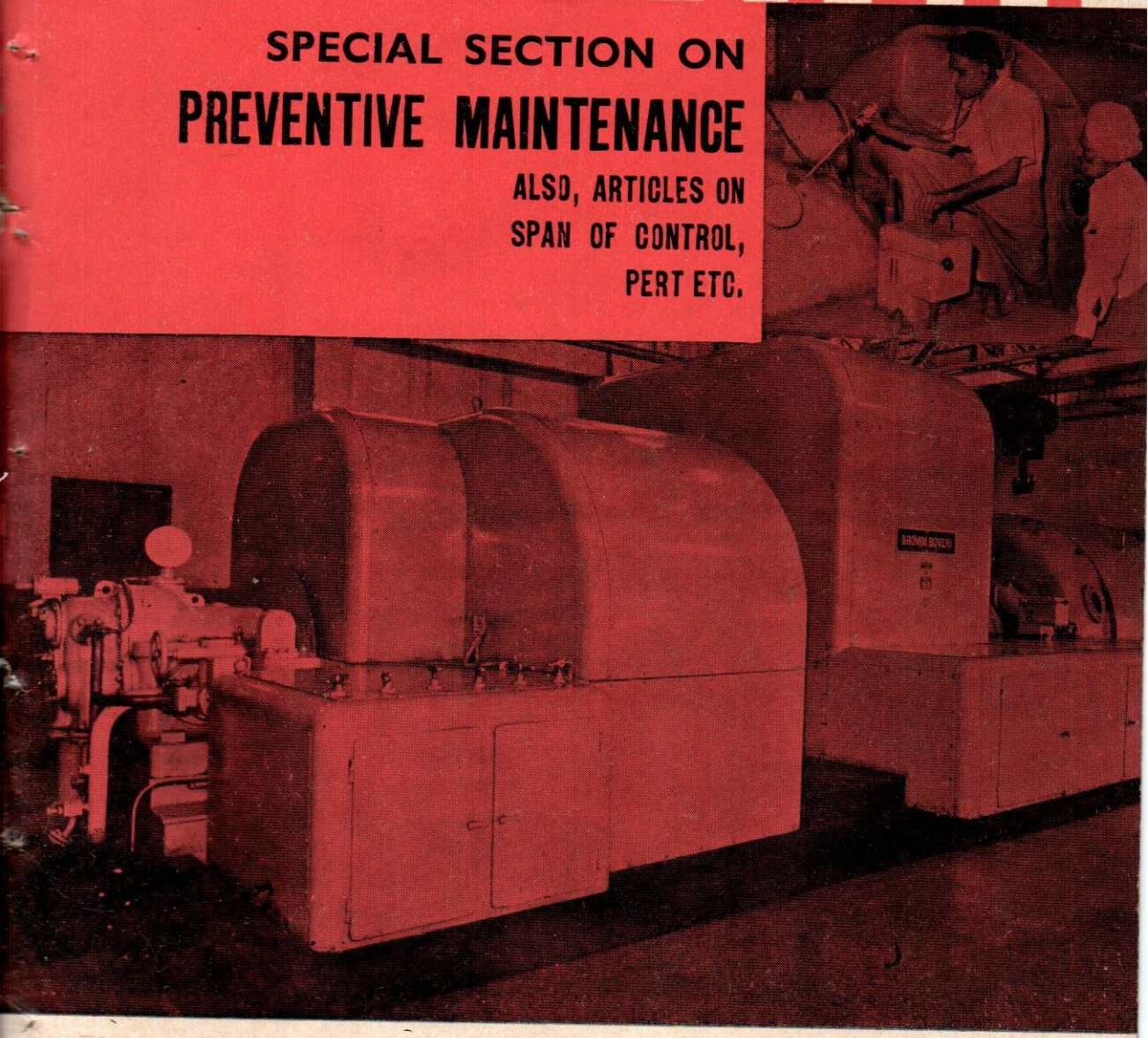
VOL. V NO. 4, WINTER 1964

PRODUCTIVITY

SPECIAL SECTION ON PREVENTIVE MAINTENANCE

ALSO, ARTICLES ON SPAN OF CONTROL, PERT ETC.



NATIONAL PRODUCTIVITY COUNCIL JOURNAL

RUPEES THREE

NATIONAL PRODUCTIVITY COUNCIL

The National Productivity Council is an autonomous organisation registered as a Society. Representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organisations interested in the Productivity Drive. Forty-six Local Productivity Councils have been established all over the country and they work as the spearhead of the productivity movement.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide services with a view to maximising the utilisation of available resources of men, machines, materials and power; to wage war against waste; to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organisations it organises and conducts training programmes for various levels of management in the subjects of productivity. It has also organised an Advisory Service for industries to facilitate the introduction of productivity techniques.

Recognising that for a more intensive productivity effort, the training and other activities of NPC designed to acquaint management with productivity techniques, should be supported by demonstration of their validity and value in application, NPC has decided to offer a PRODUCTIVITY SURVEY & IMPLEMENTATION SERVICE (PSIS) to industry. This Service is intended to assist industry adopt techniques of higher management and operational efficiency consistent with the economic and social aspirations of the community. PSIS is concerned with the investigation of management and operational practices and problems, measures of improvement and their implementation. NPC has also established at Bombay a special Fuel Efficiency Service.

NPC publications include pamphlets, leaflets and Reports of Productivity Teams. NPC utilises audio-visual media of films, radio and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and to create the appropriate climate for increasing national productivity. This Journal is an effort in the same direction.

What is Preventive Maintenance? Why must Indian industry have it? What will its adoption do for industry? How much will it cost? How conditions in India operate with regard to Preventive Maintenance?

To these and a number of allied questions, answers can be found in this issue of *Productivity*, which carries a number of authoritative articles on the subject.

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Sound is one of the indications of soundness.

There is a rhythm in the humming of a generator in a power house, or in the vibrations of a heavy duty hydraulic pump. The moment there is something wrong, the rhythm gets disturbed: an indication to the maintenance engineer that caution is immediately called for, *Something has to be done right* away to prevent damage, and possibly, a breakdown. The industrial stethoscope, an extremely critical sound pick-up, is seen being used (inset) to locate the exact source of abnormal sound in a turbo-alternator set. Besides the main instrument with adjustable control knob on its head, the stethoscope has two earpieces connected to the head of the instrument by rubber tubing, and a probe. Correction may be confirmed after the necessary repairs are made.

Productivity is published quarterly by the National Productivity Council, 38 Golf Links, New Delhi-3.

Editorial & Business Office: 156 Golf Links, New Delhi-3 (Tele: 618773 & 618731).

Subscription: Including postage by Surface Mail,
India : Rs. 12
U.K. : Sh 20
U.S.A.: $ 5

Communications: Change of address notice, correspondence regarding Subscription Service, or Subscription Orders to Information Division, NPC, 156 Golf Links, New Delhi-3. Change of address notices should be sent promptly, indicating old as well as new address.

The Editor invites well-written contributions in the shape of articles and suggestions for improvement of productivity in industry and in all other related fields of activity. The length of the articles, though not restricted, should ordinarily not exceed 2,000 words. Articles should be typed in double spacing, on one side of the paper only, leaving a reasonably wide margin. A brief summary should also be provided.

Photographs and other illustrations are welcome, but should be restricted to a minimum. For each one, the appropriate place of insertion in the text should be indicated.

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PRODUCTIVITY

Wishes Its Readers
A Happy New Year
and
invites suggestions on how to make the Journal still more useful in the coming years

Our Programme for 1965

FIRST QUARTER : Special Sections on

(i) Human Relations in Industry, and

(ii) Measurement of Productivity in Indian Industry

Also, a number of Specialised Studies

SECOND QUARTER: Fuel Efficiency, here and abroad

THIRD QUARTER : Productivity in Agriculture

FOURTH QUARTER: Production Planning and Control

First-rate case studies are invited in all these fields, to reach the Editor two months before the commencement of each quarter, and in case of the first issue of 1965, not later than Feb. 1.

Latest books on technology, economics, social sciences, and on all other subjects having a bearing on productivity will be reviewed in the Journal. Books should be addressed to the Editor, 156 Golf Links, New Delhi-3.

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PRODUCTIVITY *records its grateful thanks to Sri Bharat Ram, Chairman of DCM, and Sri ML Seth, General Manager of the DCM Chemical Works, Delhi, for facilities provided for taking of photographs relating to the feature on Preventive Maintenance (Pages 695-698) and those appearing on the cover.*

Vol. V, No. 4—OCT.-DEC. 1964 Editor: DH Butani

PRODUCTIVITY

NATIONAL PRODUCTIVITY COUNCIL JOURNAL

entive Maintenance, ours is an almost primitive economy. This ety of reasons. The rate of investment in the British period was and, by and large, industry, particularly before the war, was in such a t industrialists were disinclined to incur any costs. During the last 10 nomy, both in its physical magnitude as also in the tempo of change, has extreme. We have made massive investments in a variety of lines: not estments in the traditional industries, railways, and irrigation works, the uring the last 13 years may well be about Rs. 18,000 crores.

pital equipment is, from our point of view, extremely precious, because the resources for new investments. It is as essential to have bought or ipments and facilities as to invest in their maintenance, for counting even depreciation of 10 per cent, we would be losing per year a sum of Rs. 1,800 e halved through the application of preventive maintenance techniques. us costing Rs. 40,000 to Rs. 50,000 becomes a complete wreck within two the London Passenger Transport, the average age of vehicles is 18 to 20 , though vehicles are depreciated on a life-cycle of 10 to 12 years, the h Lines of New York have some buses 22 years old!

ntive maintenance contains within itself the resources for new capital ntly, neither the people nor the authorities are conscious of the new magni- f the productive possibilities of a programme of preventive maintenance. t the new Industrial Revolution, through which we are passing, requires and a new economics. We are bringing into being a network of steel, rmaceutical factories, petro-chemical complexes and the like. Being tantial scale, these complex industries involve sophisticated equipments, huge compressors, turbines, materials handling equipment, etc. We

must make simultaneous investments in their preventive maintenance, if we want to ensure that our investments yield results over as long a period as they possibly can. Also, in respect of continuous process industries, it is necessary to take note of a marked shift in the nature of industrial manufacture in the country—stoppage at any point brings the whole system to a dead-stop. In an aluminium smelter, a stoppage costs Rs. 2,000 per hour, and in a blooming section of a steel mill, Rs. 20,000 per hour!

It is not a question so much of equipment records, check-lists, inspection schedules, and the like, or a question of working a machine or putting it into order when it breaks down; it involves a new attitude to work. It is a matter involving continuous attention, so that the machine does not go out of order. This necessitates the creation of a new employment cadre known, in the jargon of productivity, as the PM gang. *The productivity of a PM gang is really immeasurable.* One of the saddest reflections on industrial management in this country is the failure to realise the contribution of preventive maintenance to industrial productivity.

The basic causes of the low priority of preventive maintenance are (a) under-developed management; (b) untrained labour; and (c) inflation. In an inflationary environment, there is a tendency to run machinery to death. When everything sells, and sells rapidly at the seller's price, why waste time and money on maintenance, for while the machine stops, the owner of industry feels that its money-making potentialities are being cut. Further, if the machine is going to be in any case outdated in a few years' time, *why not run it to scrap?*

In view of India's foreign exchange difficulties, and the general shortage of capital resources, this attitude is not only anti-productivity, but also anti-social.

What then is the way out? The way-out lies in establishing immediately a Central School for Maintenance for all the public sector enterprises, and for small industries. People should be trained wholly in the techniques of preventive maintenance, and, what is more important, brought up on that philosophy, for easily, without any more investment, industry can produce at least 20 per cent more, if only the wheels of machinery run smoothly.

Large private industrial establishments, like TISCO, Hindustan Lever, Indian Aluminium, and Metal Box, have made the necessary investments in preventive maintenance, as a measure of sheer survival. TISCO runs special training courses, and as the TISCO Manual (substantial parts of which have been reprinted in this issue by courtesy of the TISCO management) shows, they have built up a whole code and philosophy in their approach to preventive maintenance. This may as well serve as a model for the public sector enterprises. It appears essential, in the public interest, to make special investments in training facilities for preventive maintenance; and these ought to be made freely available for small industries.

Preventive maintenance personnel have necessarily got to be thoroughly skilled in their craft: they have to be particularly skilled in the development of a fifth sense that smells a breakdown before it occurs. It is not a question only of tools and gauges. Of course, these must be there. But the best tool of the PM gang is the trained mind, trained to hear odd sounds, to watch odd movements, to look out for any odd and out of the way phenomena, for everyone knows that before a breakdown occurs, the trained practitioner can recognise the trouble by its symptoms. It is not so much a question of lubrication and spare-parts, but a continuous watchfulness day in and day out. For the preventive maintenance

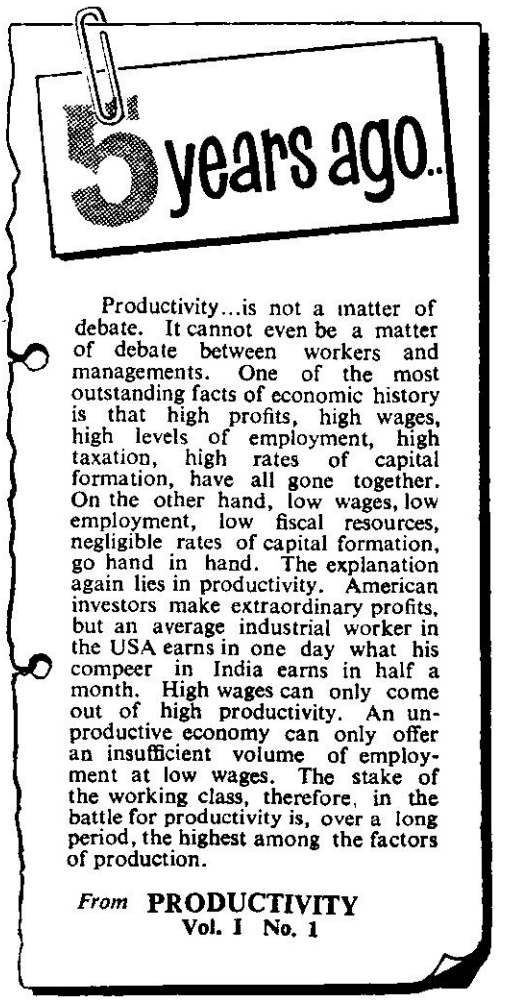
people, there are no holidays, there is no off time—in fact, the night is better than the day.

It is obvious that *the system requires not only training but also incentives*—not only normal incentives, but special incentives. The scales of remuneration for a PM gang have necessarily to be higher than for other production personnel. While their contribution is invisible, it is invaluable. *Without them, the whole economy would be on half time*, and while people would be making money, they would be contributing nothing. The continuity of the contribution of the whole industrial system is due to the existence and functioning of the small group of persons trained to see that the machines run.

In fact, preventive maintenance occupies the same position with regard to industry as preventive medicine does with regard to public health. Just as the public authorities have found that investment in periodical inoculations and check-ups is less costly than epidemics which regularly attack the population: such, too, has been the experience of men in industry in advanced countries in respect of the maintenance of machines. The expenditure on preventive maintenance is an investment that pays off many times.

It is significant how all the productivity techniques hang together. No plant can have good preventive maintenance unless it has good personnel management. Without adequate training again, preventive maintenance would be meaningless. Unless a plant is in good shape, there is no point in launching on a programme of preventive maintenance. This is analogous to the introduction of work study which has no value unless proper methods are adopted for production.

Summing up, the rules of preventive maintenance in Indian industry are more honoured in the breach than in their observance, and something has to be done to safeguard the too rapid depreciation of capital. This problem of preventive maintenance has now acquired a special significance in view of the enormous investments we have been making in road and rail transport, electricity, steel, cement and a number of new industries. National interest requires that we take care of this precious capital equipment, for we have hardly the resources to renew it, and we need all the capital that we can possibly muster for new investments in people's health, education, roads, food, etc. Preventive maintenance is, therefore, the productivity technique par excellence for Indian economy.




MORE OVER TIME PAY...
LABOUR IS COSTLY...
EMERGENCY REPAIRS...
MORE ACCIDENTS...
LESS OUTPUT OF WORK...
MORE PRODUCT REJECTS..
NO PRODUCTION ON SCHEDULE...
MORE POWER CONSUMPTION..
PREVENTIVE MAINTENANCE IN MY LOOM-SHED IS BAD!!
IF ONLY WE HAD BEEN TRAINED..

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Productivity And For
Making Your Enterprise
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Preventive Maintenance: Its Place in Industry

Machine productivity, which plays an important part in reducing production cost, has to depend on preventive maintenance which is yet an under-developed technique in India. A carefully executed maintenance plan is, therefore, essential to any industry, and, in this article, Prabhu V Mehta not only discusses the influence of preventive maintenance on productivity, but also examines why such an important aspect of production is neglected in India, and what should be done to guarantee the continued good working of machines.

Prabhu V Mehta *Chairman, Development Council for Textile Machinery, Bombay*

THE SUBJECT of higher productivity in India's manufacturing industries is being aggressively discussed these days. With every day that passes, this discussion gains momentum because of the activities of the National Productivity Council and the Local Productivity Councils. These productivity activities of NPC are causing quite a ripple of thought even in the seas of the calm and contented industries where profits are guaranteed. It is but natural that competitive industries must concern themselves about higher productivity. I shall discuss here preventive maintenance and its influence on productivity. For the benefit of hardboiled businessmen, three questions have to be answered in the first instance: (a) Why must we have preventive maintenance? (b) What will it do for us? and (c) How much will it cost? *I submit that a well thought-out, scheduled and carefully executed maintenance plan is essential to any industry.* It makes the job of production control and the job of maintaining production schedule easier. For continued production a machine in good working condition is necessary. If this is accepted, it becomes obvious that the preventive maintenance system guarantees the continued good working of a machine.

It cannot be said that breakdowns will not occur when there is a preventive maintenance system in operation. Such a system minimises the costly breakdowns which have to be attended in rush at any cost.

If preventive maintenance is performed at predetermined periods, and co-ordinated with the production schedules, the quantum of production will automatically increase. These predetermined periods are so arranged as to cause the minimum production delays. Increased production within a given period will reduce the unit cost of the product manufactured. A machine in good working order subjected to regular inspection and adjustment will continue to produce quality products for a longer period than otherwise. An efficiently-managed preventive maintenance system improves working conditions and, therefore, leads to better employee relations and, in turn, to fewer stoppages in production.

Maintenance: Its Meaning

I shall now discuss briefly how conditions in Indian industry operate with regard to preventive maintenance. There are certain units in India which religiously adopt a system of preventive maintenance. But they are few in number. On the other hand, *there are many where the word 'maintenance' is misunderstood as repairs.* In Indian industry, generally speaking, maintenance means repairing of machinery when it breaks down. But maintenance really means to keep up or to keep in repair, and not only to repair when it breaks down.

The textile industry is the largest and oldest organised industry in India. In regard to this industry, the ILO Productivity Mission to India stated that much of their time was spent "in trying to rectify the deplorable state of maintenance of the plant." They further commented that even new machines were lying idle because they had broken down for lack of proper machine maintenance schedule. There were also cases of machines clogged with dirt. I suggest that you take a round in your plant and look at the conditions in which the machines are. I dare say you will be dissatisfied.

Let us now try and understand why such an important aspect of production is neglected in India. There could be more than one answer to this question, and it may also be that these answers have a bearing on the problem. However, it is necessary to recognise the fact that the neglect of such an important aspect of production has a direct bearing on the profitability of an industry. In an economy like ours, where one can almost sell whatever one makes, the question of making a product efficiently does not often occur to the producer. To a businessman, the primary object of all manufacturing activities is to make profit. And it should be so; hence, so long as profits are being made, hardly any thought is given to the problem of production with the intensity it requires. When conditions change and loss is in sight, the management sits down to think how it could prevent losses and turn them into profits. Even in this thought process, it does not occur to the manufacturer that along with capital productivity and labour productivity, machine productivity also plays an important part in reducing the cost of production. On the contrary, he plans to run the machines for 24 hours, and to overwork the men and the machines to produce more with a view to reduce the cost. He does not realise that he is increasing the cost along with the production by overworking the men and the machines, because both get fatigued, both require larger maintenance and attention, and both will break down if not attended to.

It is frequently argued that preventive maintenance costs quite a bit, and that it is not profitable to adopt a schedule of maintenance; instead, it is much better to look into the machine whenever a difficulty arises. This is a notion which has its foundation in ignorance. This notion is nourished on the unsatisfactory cost accounting system that exists in most of our industries. On a proper analysis of cost, it would be apparent—and it can be proved beyond doubt—that the cost incurred in preventive maintenance is paid many many times over by increased productivity. This is the experience of all highly industrialised nations. I shall quote from a report of the Anglo-American Productivity Team which states—

> "Maintenance in the USA is very regular and methodical. Machinery is lined and levelled once a year, and when this is done the frame is stripped right down. All the wearing faces are examined and replaced, if necessary. Regular oiling schedules are laid down and scrupulously carried out. Fitters are employed whole-time for regular setting. The emphasis is on preventive maintenance rather than on repairs."

American maintenance is carried out on the principle, 'A stitch in time saves nine'. Machines are overhauled at definite intervals and, though some of the plants are over 20 years old, the condition of the machines is very good.

I had the good fortune to be associated with the Cotton Textiles Productivity Study Team which visited Japan, the USA, France, Germany, and Switzerland. During this visit, we had an opportunity to discuss the preventive maintenance system, and its effect on cost. We were told in Japan that the cost of preventive maintenance, including the repairs and replacement of worn-out parts, comes to nine per cent of the total manufacturing cost excluding the cost of cotton. In the USA, we were told that the preventive maintenance cost varies from two per cent to three per cent depending upon the unit of total manufacturing cost, and less than two per cent of the total sales realisation. Is this too much of a price to pay for the benefits that I enumerated a little while ago?

Modern machines are far from simple. The need for automation, multiple operation, electronic controls, and accuracy in production has necessarily made machines complex. It is no more possible even for a good engineer or foreman or mechanic to carry in his mind always all the details of this complex unit. This is particularly true when he has to attend to many complex units of different types and categories in a large plant. He needs an organisation which has a fine filing system, including a library of catalogues. He also keeps an adequate supply of needed parts in the stores. Because of the complex nature of modern machines, no member of the maintenance team can well know every piece of equipment in the plant. In larger plants, it is advisable to have specialised personnel in the maintenance team to handle delicate and complex pieces of equipment and machinery.

Need for Training

Such a need brings me to the question of the training of maintenance personnel. Let us consider for a moment what time is devoted to the studying of the programme and technique of preventive maintenance in our technical institutes which produce the engineers needed for our industry. I wonder how with this lack of opportunities our men have been able to do a job which, at first assessment, seems to be very satisfactory. It is certainly a credit to their enterprising spirit, inherent genius, and to their ability to find solutions to difficult situations. If we do provide for specialised training for each industry in the maintenance of industrial equipment, it would not be difficult to visualise how effective our maintenance system could become. In the West, each industry has taken upon itself the delegation to train the people in specialised jobs.

Even if we have trained men, they will need an active organisation behind them to enable them to perform their duties efficiently. It would be possible to create, without much effort and capital, an organisation which effectively can function behind the maintenance men. A little thought and study into the past performance of equipment that we have, and a consideration of the need of that particular piece of equipment, will provide a very easy guide to evolve a programme or schedule for inspection, maintenance, overhaul, and repairs or replacements. In many Western countries, the operative on the machine is responsible for keeping the machine clean as well as for making minor adjustments. It is also his duty to report any fault in the performance of the machine to his foreman, immediately he notices it. It is the function of the foreman to see that this defect is immediately attended to. There is abundant proof of attentiveness and cooperation between a man on the machine and the foreman and the maintenance group.

Everyone knows that his livelihood depends on the productivity of the machine.

It is not strange to come across instances in India where a zealous stores purchaser or management tries to economise and save on lubricating oils, stores, and other necessary maintenance equipment, little realising that this saving is costing him enormously in quicker wear and tear of the machine. From my two-decade long association with various industries, it is possible for me to quote many examples of this penny-wise and pound-foolish policy. I refrain from doing so because at this very moment you may be thinking of some incident that did happen in your plant, in your organisation, or in the place where you work, which is a parallel to what I have in mind.

The need for preventive maintenance, and for scheduling such a programme, will definitely differ from plant to plant, but its aim is to devise a system of regular inspection and maintenance in order to have the maximum machine productivity. I shall quote one example that I came across in a mill in West Germany. In that mill, which I must say was a very well-maintained unit, each department had, on a wall near the entrance, a neatly typed big chart detailing the schedule of maintenance. The chart specified what would be done to which machine every day, who would do it, how it would be done, and what tools and implements were to be used in doing the job. Similar instructions in the chart were available for the jobs that were to be done every week, every fortnight, every month, and every six months. There was no programme for every 12 months, the reason being that every machine in the plant was so scheduled by a phased programme of overhaul that it would be attended to atleast once in six months. The plant had machines manufactured in 1908 and also those manufactured in 1959. We were informed by the plant manager that the machines manufactured in 1908 were producing quite as satisfactorily as those made in 1959.

I would like to mention along with the subject of preventive maintenance the subject of good house-keeping. Good house-keeping in Indian industry has received very little attention. Good house-keeping in itself means keeping the work place and plant clean, creating good environment for the workmen to perform their jobs, and giving freedom of movement to men and material. Good house-keeping will in itself reduce stoppages and maintenance costs.

Productivity of a Spare Wheel

Few people know that the spare wheel of a motor vehicle makes an excellent life-buoy. In an experiment carried out by the Avon Rubber Company Ltd., a spare wheel from an ordinary family saloon supported five people. They were able to keep their heads and shoulders above the water with ease, and could have stayed on in the water safely for as long as it took a rescue boat to reach them.

Planning of Maintenance Management

LN Misra, a member of the NPC Study Team on Preventive Maintenance, discusses here types of maintenance, value of equipment records for maintenance, men and materials required for maintenance, etc., and gives us glimpses of some of the team's experiences. Modern machinery poses a challenging demand for a more progressive maintenance management and programme. The success of maintenance also depends upon how it is organised, and the author pinpoints attention on the importance of the maintenance force. Should industry have centralised maintenance, or, should maintenance be attached to departments? How much should be the strength of the maintenance force?

LN Misra *Chief Superintendent (Engineering Services), Bhilai Steel Plant, Bhila*

NEGLECT of maintenance of equipment seems to be in the nature of man. It becomes glaring only when he switches on from ordinary economy to mechanisation. As Indian industry is in a transitional stage, preventive maintenance yet remains an under-developed technique.

Probably, the very first type of maintenance was *capital replacement*. In this method, an equipment, say a farmer's implement, was changed only when it broke down or completely got worn out. The nearest solution to this was to have a stand-by equipment. When one broke down, the spare one was used. This method is still not uncommon in some places. As industry grew, the bigger size of stand-by plants and machines became uneconomical as they involved capital being locked up. Here maintenance took a definite shape, and *breakdown maintenance* carried out by operatives themselves caught in.

Industry slowly became bigger and more complex. Most of the continuously operating plants, more so in iron and steel, use a number of heavy machines involving large capital investment and continuous processes. Here, every minute of downtime of any single equipment, not only renders this equipment out of operation, but affects operation of the rest of the plant. Breakdown maintenance on such occasions became inadequate, and

steps had to be taken to adopt methods which ensured continuous planned operations of the plant. This led to new maintenance procedures and techniques now given various names as *scheduled maintenance, planned maintenance, preventive maintenance,* and now *productive maintenance.*

Best Suited

Scheduled maintenance is best suited to service plants such as small boiler houses and compressed air stations where the plant is subject to being idle due to change of load, product, or completion of orders, and does not run continuously. The plant is inspected during nights or weekends, when it is not in operation, and all maintenance is scheduled to synchronise with the natural gaps resulting from intermittent production programmes.

In the case of plants operating continuously, at high rates of output, regular natural down-periods are not sufficient to do all maintenance work. Machines have to be specially shut down for the purpose. This has to be specially planned, and is hence called *planned maintenance.* Scheduled maintenance goes on side by side. A regular planned method of inspection of equipments and history sheets decide the interval of inspection, frequency of maintenance, and the time to be taken to carry out maintenance work. Records of actual performance form the basis for estimates in making a forecast for long-range planning of details of the actual volume of work, enabling tentative estimates to be made for labour and material required.

With the growing use of more automatic machines in continuously operating plants, scheduled maintenance and even planned maintenance are not enough. For this, the American industries have developed properly scheduled and planned schemes to prevent instances of breakdowns, and reducing the quantity of maintenance calling it the *preventive maintenance* system. This system is directed not merely towards planned maintenance, but towards upkeep, replacement and modification. Planned maintenance forms the basis for preventive maintenance. Items which really need more frequent maintenance and attention are looked out for design, material, and technology, and, by some method, the volume of maintenance work is reduced.

More important is the idea of doing maintenance for preventive maintenance. Very often suppliers of equipments and their designers, in an effort to sell their machines and methods, and to be able to meet competition, are apt to forget the maintenance aspect of the machines. What may have been an achievement from the design point of view, may turn out to be a great disadvantage from the maintenance point of view. Under preventive maintenance will fall the procedures which may spot out places requiring more frequent maintenance, and methods introduced, if necessary, by even changing the design of the equipment to reduce such quantity of maintenance. Preventive maintenance, therefore, is really reducing the quantity of maintenance, and even designing out maintenance. Bearings of motors lubricated for a life-time, and permanent lifting tackles in places where maintenance is done very often, rightly fall within this.

Productive Maintenance

In India, most of the industries only follow breakdown or scheduled maintenance. New industries are thinking in terms of planned maintenance. The Bhilai steel plant is following scheduled and planned maintenance, and preparing the ground for preventive maintenance.

Over-maintaining a plant is not necessary. It should be maintained only to the extent that it is integrally economical. Therefore, the tendency is now developing to divert the maximum effort, time and money on that part of machine and equipment which holds up maximum production. This is termed as *productive maintenance.* Preventive maintenance takes time to show up results and may be costlier, but productive maintenance is immediately effective and it is becoming popular in America.

The success of preventive maintenance depends upon proper integral planning.

Nothing succeeds more than the fundamental idea that in planning, "*take away the job of thinking from the doers.*" Mr WA Irvine, Manager of Production Engineering, Maytag Company, Newton, Iowa, says:

> "Formerly maintenance planning, scheduling, procurement of materials, and co-ordination between crafts were handled by the maintenance supervisor. Now, we have a planner for each craft foreman. The planners are supervised by a chief planner, who reports to the Superintendent of Maintenance. Thus the planners work with, but are not subject to the control of, the craft foreman."

There are plants of some size where, although a good work order system exists, no attempt is made to estimate the time requirements of jobs, or to line up the jobs to be done a day in advance. The maintenance foreman takes about an hour each morning to wade through his order file, and assign the day's work to the 50 men in the force. Thus 50 valuable man-hours are first lost each morning before the men could get started. Then, the men cannot start or finish some of the jobs assigned, as they lack materials or spare-parts, for which advance planning had not been made.

In the organisation of the maintenance department of a steel plant, of which the author has special experience, particular mention may be made of the practice that obtains in India regarding division of services between mechanical and electrical engineers. The Russian practice, which is better, merges all power services—electricity, steam, gas, water, oxygen, air and fuel—under one Power Engineer who is responsible for all electrical and mechanical work. This way the workload also gets balanced. Otherwise, the mechanical organisation becomes too big, and the needed power services are not well-balanced for optimisation of productivity. In the case of the Bhilai steel plant, the plant itself has been designed in such a way that the working of any other method is difficult. The Oxygen and the Water Works have 6,600 V motors, and function better under the Electrical Head only.

The operating departments have their own men and equipment engineers under their administrative control. There is, however, effective co-ordination at all places and at all times. Every morning the departments report to the Deputy Chief Mechanical Engineer (Maintenance) the condition of the mechanical equipment in the plant. He is available daily at a fixed place and time for consultation by the departmental mechanical chiefs. He holds periodic meetings with officers of the spares manufacturing shops. The Central Planning Department holds regular meetings with the planning group of all repair shops for better co-ordination of the spares programme. The Chief Mechanical Engineer also holds plant mechanical co-ordination meetings regularly, and periodically with departmental mechanical chiefs. The Chief Electrical Engineer and the Chief Mechanical Engineer make joint inspection

This is really an Age of Productivity

An English farmer, says **Industrial Times,** *has patented an automatic remote control device with which one driver can operate two tractors simultaneously during ploughing or other operations on an arable farm. The two tractors can be of different makes. There are no modifications to the leading tractor, which is driven, and the only extra fitting required for this part of the set-up is an offset hitch of the type used for tandem discs. A telescopic control bar to couple up to the second or "slave" driverless tractor is attached to the hitch on the leading tractor's implement.*

of all equipment at least two to three times a year. Constant check is kept by standard proforma on the manufacturing of spares being done in the departments, and also in the centre. The efficiency of men on jobs being carried out at both the levels is also checked.

Men for Maintenance

The author was a member of the NPC Team on Preventive Maintenance. At Halskesiemens Karlsrhu, Germany, the team was told that in that factory in the past, for every six men on operation work, they had half a man for maintenance. Operation was then mechanised. It reduced operation men, but maintenance men increased. The position now is that for every one man in operation there are two men in maintenance. In some industries today, as many as 30 per cent to 50 per cent of their total personnel are for services, and, by and large, most of these are on maintenance alone. Probably, this would remind the readers of the woman who wanted to mechanise her kitchen to avoid the whims of a cook. After mechanisation, she found, to her horror, that she had to deal with the whims of maintenance men, and that too a mechanic and an electrician.

It was further found that men working on the production lines need not be technical men, and can be trained from people who have had no technical education. They have to develop only the ability to do repetitive work. Maintenance men, however, have to be trained persons, have to develop skill, and have to do new types of work independently every day. Therefore, they are also paid higher than production-line men. In the Hoest Chemical Plant, an unskilled man can become an operation man on the production line, but never a maintenance man.

Generally, there is a marked tendency for management to resist the employment of adequate maintenance staff until the pressure of emergency work forces them to do so. At this late point, the emphasis becomes—"Fix everything at any cost." Men are hired in large numbers without any knowledge of the actual work-load. Often this drive for maintenance leads to staff additions beyond the bounds of reason. That is not the end of it. Having solved the problem by hiring, management forgets all about increased labour costs until business slacks off. One can understand the reluctance of the maintenance foreman to agree to any reduction of staff, even if the work-load decreases. They argue within themselves that it is only a temporary lull. So they "spread over the work," while management "waits and sees." This practice results in higher costs than necessary. By the time management comes into grips with the situation, money has been wasted. It uses pressure methods, and steps far below the point for good maintenance, because it has no factual data regarding work-loads.

...In Western countries, the operating man...sets right his equipment for small defects. In India, the tendency is different. Operators do not take enough pride even to clean their equipments; lubrication is left to be done by small men. As soon as the equipment breaks down or shows signs of trouble, the operating man washes his hands and stands aside...

In some plants, the strength of the maintenance force is based on the rule that the expenditure required for maintenance is directly proportional to the volume of business being done, and an arbitrary lump sum for maintenance for the year is allowed. This budget is set without regard to the existing maintenance load, and is unrealistic. The maintenance requirements are, to some extent, related to the gross volume, but are certainly

not directly proportional. In other plants, the maintenance budget is a percentage of the factory payroll. The percentage figure can be the average experience of several similar industries. Since items thrown into maintenance vary widely, there is no correlation. From place to place spares and contractor facilities are different, and work is organised on different lines. Obviously, it is trying to fit a square peg into a round hole.

In a running organisation, a way to size the work force is to exp ess all work in terms of orders, and estimate these orders in craft man-hours. For each work these are charted so that the exact conditions are graphically apparent. This results in—1. Properly sized total work force, balanced in craft skills; 2. Ability to "switch" or interchange work to meet the fluctuating demand; 3. Ability to give promised dates for the completion of maintenance jobs, and to fulfil the promises; 4. Good supervisory morale, because logic and objective analysis is used to size the work force, assign overtime, and shift of work. These are no arbitrary decisions, or erratic correlation; and 5. Good worker morale, because work-load charts, completed sufficiently in advance, allow supervision to plan and "even out" the peaks and valleys in manpower needs with steadier work, and time for training and upgrading. All these lead to more contented employees. More often than not men leave maintenance because of demoralised conditions prevalent in maintenance leading to pressure tactics.

All these obviously need proper office men for maintenance. Yet, management would not give the maintenance executive one clerk to handle paper work. Actually the maintenance foreman has more supervisory work to do than the production foreman, because of fewer repetitive jobs. He needs just as much if not more staff help.

To arrive at a proper maintenance force, it is essential to study even the operating force and the conditions in the plant. In Western countries, the operating man looks after house-keeping, and even sets right his equipment for small defects. In India, the tendency is different. Operators do not take enough pride even to clean their equipments; lubrication is left to be done by small men. As soon as equipment breaks down or shows any sign of trouble, the operating man washes off his hands and stands aside.

No amount of maintenance force can help such operation, and that is the Indian trouble. Not only have maintenance men to do house-keeping to save their equipment, but they also need a large number of men working without any help in operation departments to do even small jobs. To that extent we have to divorce maintenance from house-keeping, and operatives should be able to do small adjustments themselves, and call for skilled maintenance men only to do the skilled work and to participate in the maintenance work being done. Then alone can any plan be made.

Reduction in the number of men on the job is one of the constant practices, because it has been realised that putting more men itself causes complication. With more men employed, the idea that the other man will take care of the work takes greater root and is unhealthy. This, however, should not mean increase of physical work for men. Inspection records and job study should simultaneously combine to find methods for mechanical gadgets and machines to work under a man's control, and reduce his drudgery.

Supervision of Work

A big difference in supervision of work in this country and the West is that, unfortunately, a supervisor here is most of the time busy in seeing that men do their work. In industrialised countries, a workman fixed for a certain job has to do it during duty hours, and has to work all the time on the job or has to clear out. He will be appointed only if he can deliver the goods. The work of supervision is to make constant improvement in machines, equipments, and, more important, improvement in working conditions, so that machinery under man's control does the work. This important feature is missing in our supervision here. The

common man in India has still not developed independent industrial habits, and needs more and more guidance, check, and follow-up. The supervisor also carries his own weaknesses. All this calls for a fundamental reorganisation of the factory system with each one taking care of his part of the job. Then alone can preventive or planned maintenance be successful.

After men, materials are the next important item required for maintenance. Among materials, spares are the most important. In an economy where machines are all imported, spares have also to be bought in distant countries. Naturally, we think in terms of storing spares for a certain period. But it is not unlikely that very often there are no elaborate arrangements for proper storing of spares, and when the spares stored are required they are found mostly not usable. Also, at times we know that a certain part is there, but cannot lay hands on it when required. Then it is not uncommon that the stores have items, but the users do not know whether they are there or not. Efficient and even costly storing services should be at hand for efficient storing and handling of spare-parts, all under the maintenance man. As a prominent American engineer put it: "Even this day of rising labour and material costs, maintenance stores are still neglected. I find stock rooms being supervised by pensioners long past their point of usefulness."

Availability of Spares

In industrialised countries spare-parts are available, on telephone, round-the-clock. Still in places where spare-parts of machines bought from other countries do become a problem, the worn-out parts are repaired. In advanced countries, however, the building up of such worn-out parts has already become a good technique. It is felt, however, that built-up worn-out parts are uncertain in their behaviour. Therefore, unless any emergency really exists, such parts should not be used very much.

Firms supplying machines generally give the estimates of life of machines, and the likely requirement of spares for a certain time. Such estimates are based on general conditions rather than on particular conditions existing in a certain plant. A cold, dry place may need one kind of preventive maintenance and spares, but a humid and hot place may need entirely different spares and maintenance. If the place is dusty, it may have more maintenance requirements. Dust nuisance alone puts us at a comparative disadvantage. The manufacturers may have in view factories which have no dust problem, and where the temperature is not high. Therefore, the recommended life and period of change should be studied in every factory, and each factory should develop a basis for its own use.

In industrialised countries, labour is costlier than materials and spare-parts which are obtainable without difficulty. Parts are, therefore, changed in time, or even before time, to save costly labour and unwarranted failure. We have to decide our problems on the basis of our conditions.

Tools form a very important item in maintenance. Our hand tool industry has not developed much. Thus tools still pose a problem. Also, whatever tools industries can procure with difficulty soon get lost. Factories in the USA have a very nice way of controlling this. There, the man brings his own trade tools and owns them. When a fitter is employed, he is employed with his own tool-box. Loss of tools is unknown, because every fitter recognises his tool anywhere. Also, as a mechanic gets known by the type of tools he keeps, every mechanic tries to keep his tools in a better condition than others.

In an American factory, one of the mechanics indicated that his tool-box cost him about $ 500 (about Rs. 2,375), and he was proud to own it. We, on the other hand, just have no habits of keeping tools. Right from the technical institutes, people selecting a trade should keep their own trade tools. This will give them the pride of their profession, make them more suitable in their jobs, and help industrialisation.

The transport of hand tools is no less costly. Lot of time is wasted in maintenance men running about from the stores to the work site for tools in their pockets; otherwise tools should be carried in a special carriage.

Three Pre-requisites

Communication is another bottleneck. For efficient maintenance, the maintenance man must have the fastest means of communication. Mechanised transport, telephone, and radio communication are the pre-requisites for efficient maintenance. In the Bhilai plant, wireless telephones on locos are used. Maintenance men can profitably carry small transistor sets in their pockets to keep in touch with the head office wherever they are. If we want maintenance, we should have these facilities for our maintenance men.

Equipment records that accumulate maintenance costs against each piece of equipment provide management with a strong tool to tell when repair costs are excessive. An American maintenance man says:

> "Why does not management do something about some of our equipment? We keep repairing the same machines over and over again. Why, I bet we have done enough to some of the machines in the last year to pay for the new ones, or to pay for a real repair job several times over. It sure does seem foolish to spend any more on some of this equipment."

The answer is that management just does not know about these maintenance costs, or it would do something about them. In Western countries, they have developed an elaborate system of cost control in regard to maintenance. They consider

$$\frac{\text{Cost of insurance} + \text{cost of maintenance} + \text{cost of downtime}}{\text{Operation cost}}$$

as a very good yardstick to know whether or not maintenance is doing fine.

In breaking down maintenance work in smaller basic units, it is seen that 30 per cent of the men are all the time busy opening bolts and nuts for inspection only. It is for

... The more highly mechanised an industry gets, the more it needs the advantages of preventive maintenance...

such things that job methods and job study should form a continuous programme to eliminate extra maintenance. It is also found that 48 per cent of the breakdowns in an industry are associated with lubrication. This lubrication alone, if taken care of, can save half the unwarranted downtime. Therefore, the tendency should not be to leave lubrication to unskilled men any more, but to put suitable skilled workers on the job.

General experience shows that every equipment has some teething trouble for a year or two in the beginning. From then on is the normal working life—about 25 years—of most of the machines. If at the end of this period, the machine is not thoroughly repaired, it may start showing failures and give troubles. If at the proper time, the machine is thoroughly overhauled and renovated, its life can be made longer.

Position in UK

The British Institute of Management indicated that only 15 years back scheduled or planned maintenance was not thought a factor deserving consideration in British industry. Production 'somehow' was the only criterion. As production increased in other countries, and competition set in, England also had to find its own methods to increase productivity. Now besides regular inspection, proper records, and study of job

methods, constant improvements are being made to keep the wheels of industry running better and economically.

India is possibly passing through the stage of infancy where production, not productivity, is aimed at. In general, Indian industries feel the same as the British felt 15 years back. In its report dated Nov. 15, 1956, Ramsey Miller & Co., consultants on steel plant maintenance to the Government of India, indicated that "repairs and maintenance" were already a problem in the existing steel plants in India in the private sector, and that if the Government steel plants did not plan in advance, repairs and maintenance might soon become a problem in the public sector too. Time alone will show whether we have learnt by this timely suggestion.

"Not a Cure-all"

The maintenance function really starts at the plant ordering stage. Designers and manufacturers of equipment look to general mass conditions, and such equipments may not fit a particular requirement. Also, they may not have taken care of maintenance matters at all for any particular local condition. This may become a serious situation. Therefore, all design, specifications for equipment ordered for the first time, expansion and extension, if any, modifications, alterations, additions, or deletions all eventually pass through the maintenance department, so that all the problems are thrashed out with it.

The more highly mechanised an industry gets, the more it needs the advantages of preventive maintenance. Costs of maintenance of modern equipment are higher. And cost of downtime too. One automobile plant estimates a penalty of $ 3,000 (about Rs. 14,250) for every minute the main assembly line is down. In any plant, where downtime is important, preventive maintenance will reduce it. To what extent, depends of course on what you aim for. It should also be noted that preventive maintenance is not a cure-all for excessive downtime or high maintenance cost. If a preventive maintenance programme is to succeed, the administrator must learn to let economic considerations guide, and even over-rule, his engineering dictates. Any good engineer can set up an air-tight preventive maintenance programme aimed solely at conserving plant and equipment. He might do this at minimum maintenance cost. But he has got to learn right from the start to examine the effect of all facts of the preventive maintenance programme on manufacturing costs. It might be an engineering folly to let a $ 500 (about Rs. 2,375) motor go to ruin to keep a whole production line going. But if balanced against a loss of $ 2,000 (about Rs. 9,500) in work-in-process because of shutdown, it makes commonsense. This emphasis on economics may seem a strange approach to what appears to be strictly an engineering problem. But as we get into the mechanics of the preventive maintenance programme, we will be faced at every turn with economic decisions on where to draw the line.

As a young construction engineer, I was told by my officer, who had spent years in America, that on any job, services should be erected first. This should include pipelines, electricity, accesses and approaches, and workshop facilities. This not only helps operation to come up fast when started, but it also reduces cost in construction. In our country, the operating units get ready, but the services are not touched. Repair facilities which should have been completed first are not finished even though the main machines are in operation. These facilities are only given second priority. What is the result? For the first few months, there is no trouble. When simultaneously construction goes on along with operation, the operation surroundings are left dusty, and machines deteriorate fast. Then the resources of spares do not remain sufficient to meet the challenge of the industry to keep its wheels running. Like the new car, the damage done may not be repairable in the life-time of the equipment, and, in any case, the life of the plant is affected.

A Matter of "Right Attitude"

It is the absence of the "right attitude" to preventive maintenance that is responsible for many difficulties and handicaps in any industry, according to G Y Mangrulker who points out that such an attitude can be built up through a training programme which is related to conditions on the shopfloor. The best way to ensure the cooperation of those at the lower level of the maintenance staff is to assure them that flaws reported would be used for improving maintenance, rather than to fix blame. Another way is to tell them, and to show them, where possible, the harmful effects of negligence.

GY Mangrulker *Staff Training Officer, Tata Iron & Steel Co. Ltd., Jamshedpur*

PRODUCTION is the result of a team-work between the operation and the maintenance staff, and depends as much on the technical competence of the men as on their attitude to work. The maintenance engineers have to keep the equipment in running order to ensure uninterrupted production. The technical people engaged in maintenance work acquire their knowledge and skill at technical institutions. Yet, experience shows that while one shop is maintained in tip-top condition, another is constantly suffering from breakdowns and hold-ups on account of machinery failure. Thus, *it is not always the lack of technical skill, but the absence of the right attitude that is responsible for indifferent results.*

All maintenance is preventive. But the term 'preventive maintenance' has been deliberately coined in order to focus attention on the fact that something has to be done *before* the machinery comes to a standstill due to some fault which could have been detected earlier. No maintenance engineer likes to sit back and wait until a bearing burns down or the coupling bolts shear off. Yet, there are plenty of instances where these things happen, and everyone rushes to the scene to rectify the defect and restore production.

There are cases where similar defects occur time and again. It is not the technical incompetence, but a lack of the right attitude that is responsible for such cases. The right attitude can be built up, to some extent, through a properly devised training programme which is not theoretical, but is related to conditions on the shopfloor.

It is not, however, suggested that breakdowns can be entirely eliminated. In shops, which employ heavy or fast-running machinery, a few mishaps are bound to occur. But the question, by and large, is whether the system of maintenance is such that premature failure of parts does not take place, or the defect does not go unnoticed by the maintenance staff, while there is still time and opportunity to rectify it and prevent an interruption of production. This, in substance, is the preventive aspect of maintenance work.

Vigilance is the keynote of preventive maintenance. It is different from a planned inspection which follows a set schedule. Vigilance is a constant alertness which makes it possible for the maintenance man to spot things that are not quite all right. A vigilant maintenance engineer will not fail to notice anything that is out of rhythm on the shopfloor. Take for instance the sound of machinery. The humming of a generator in a power house or the vibrations of a heavy duty hydraulic pump have a rhythm about it. The moment there is something wrong with it, the rhythm gets destroyed, and gives a sort of a caution to the engineer. Something has to be done right away, or soon enough, to prevent further damage, and an eventual breakdown.

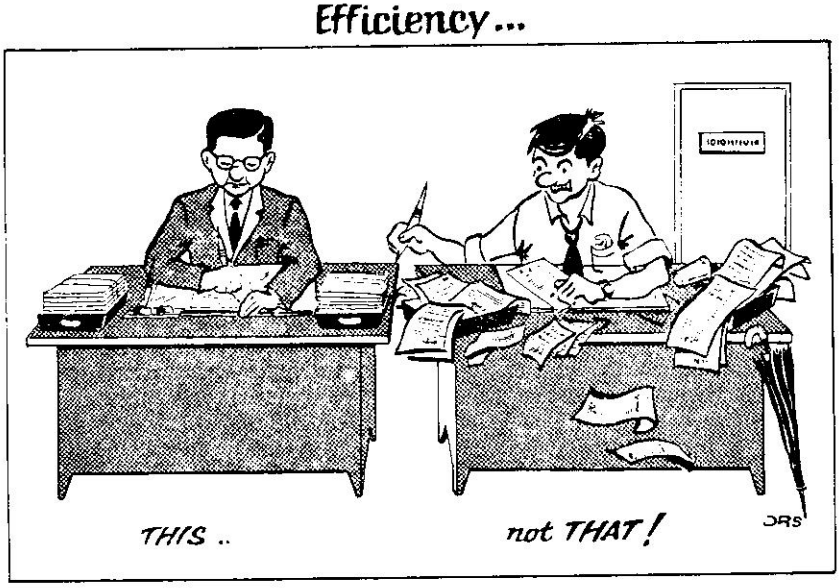
Safety Factor

Nothing really breaks down all of a sudden. Every equipment has a sufficient factor of safety allowed in its design. The fault develops over a period of time, and the engineer, in most cases, gets a fair chance to do something about it. For example, a tilting table in a mill used to operate erratically. The engineer got suspicious about it and, on investigation, found that the liner on one side was missing. The defect was rectified as soon as he could get the equipment down for a few hours. A reversing shaft jerked very badly. The jerking gradually increased. The fault was located in the coupling. The bolts had worn out, and the holes elongated. A long shaft caused knocking at a bearing, and the bracket on which the bearing was supported had started shaking. A close inspection revealed that the white metal in the bearing had worn down to such an extent that the buckling of the shaft under its own weight and loss of alignment had resulted in violent knocking. These faults were rectified because the engineer was vigilant and located the root cause of the trouble. Otherwise, each of these cases had the potential of a total breakdown which would cause a loss of working time and valuable production. Heat, smoke, discolouration, non-uniform wear, etc., are some of the indications of impending trouble. Looking out for symptoms and doing something about them is a matter of attitude which every maintenance man has to develop.

Inspection is important for proper maintenance. Entrusting it to persons other than those responsible for the maintenance of equipment can only lead to bickerings, and the development of a tendency to pass the buck. The maintenance man's argument that he is so busy, that he has no time for inspection, is futile, because, inspection is an integral part of maintenance; and who gets the blame anyway if something goes wrong for lack of inspection? Inspection reveals undue wear and tear, cracks, gaps between matching parts, faulty alignments, abuse of equipment, etc., and makes it possible to take corrective action before a major breakdown occurs. The time and energy spent on inspection is, therefore, well-rewarded. All maintenance men from the engineer down to the fitter have to be inspection-conscious, so that each does his part, reports are checked, and action lined up according to priorities. People, especially at the lower levels, are reluctant to inspect and report. The absence of a ladder, insufficient light, lack of a small tool or gauge is regarded as a sufficient excuse for ignoring to do what may later result in

much running about and downtime of plant. The best way to ensure their cooperation is to provide these small conveniences, and to assure them that flaws reported would be used for improving maintenance, rather than to fix blame.

Another way to enlist the cooperation of the junior-levels of the maintenance staff is to tell them, and show them, where possible, the harmful effects of small negligence. Even an important thing like lubrication is taken lightly, and they seem to think that the foreman is fussy when he insists on a proper grade or quantity of the lubricant. Quite a few of them are ignorant of the long-range significance of small acts of commission and omission. Many of them have never been told what it means in terms of production or money, if a certain equipment remained idle for so much time because of a breakdown. The habit of watchfulness, inspection of equipment, and detection of snags as a continuous process should be built into one's attitude. If men are asked to fill a number of forms and printed reports, the whole thing may soon get reduced to a drill which is followed mechanically. The form-filling may become an end in itself rather than an instrument for initiating action. Of course, in some cases, forms and written reports are essential, and should be insisted on. But they must be limited to the bare minimum. Maintenance supervisors, and for that matter any supervisor on the shopfloor, abhor filling in of forms or writing of reports. Many forms become superfluous anyway, once the maintenance staff develop the right attitude of looking at their job.



All office designers agree that a clean desk suggests efficiency, and they outdo themselves to preserve the uncluttered look.—ELAINE KENDALL in *The New York Times Magazine*

Right Standard of Maintenance

The only way to keep costs of maintenance under control is to make an effort for better maintenance of equipment, and thereby to reduce machine failures and plant stoppages. GS Sanders, who emphasises here the need for the right standard of maintenance of a manufacturing plant, suggests two approaches if analysis of costs and other evidence reveal a standard of maintenance that is too low.

GS Sanders *Senior Partner, Urwick, Orr & Partners Ltd., London*

THE STANDARD of maintenance of a manufacturing plant can only be defined indirectly, and yet it is important to appreciate how vital it is to establish the "right" standard —not too high—or it will cost too much, and not too low, or production losses will exceed the savings in maintenance costs.

To define the *standard of living* of the population of a country to a stranger, it is necessary to quote a lot of facts such as average income per head, nature of economy, and indigenous products. Even then, to make such facts meaningful, the listener must know many other background facts such as climatic conditions and standard of education. Much the same is true of the *standard of maintenance*. A large number of relevant facts—production loss due to breakdowns, inherent reliability in plant concerned, age of plant, working conditions, running hours, amount of stand-by equipment, etc.—must be known in order to define the standard of maintenance. As this is not easy to assemble in the mind into a coherent whole, an alternative approach is suggested below.

In most plants there is some kind of prime document recording all the tasks undertaken

by the Maintenance Department. This may be a job ticket, an instruction sheet, or a requisition. Whatever it is—and assuming it records the man-hours expended on execution—collect all these documents over a fair period, say three months, and analyse them as follows:

1. Extract all those that refer to alterations, additions, and new construction, besides those that cover plant removal and installation. None of these, however, truly represents *maintenance* costs.

2. Next extract all those that refer to buildings, land and site, as these are not directly productive assets.

3. Classify the remainder into four categories:

a. Preventive maintenance;
b. Plant overhaul;
c. Plant repairs; and
d. Attending to breakdowns.

The ratios which these four categories bear to each other can be very revealing indeed. If there is a preponderance of "attending to breakdowns," it is probable that the standard of maintenance is low, and that more money should be spent on preventive maintenance and overhauls. If, on the other hand, attention to breakdowns costs very little, the standard of maintenance is high, but may be too costly. Though it is difficult to prescribe a yardstick of what the ratios should be, because conditions and plants vary so much, I would expect these ratios to be reasonable:

a. Preventive maintenance	10—20%
b. Overhauls	30—50%
c. Repairs	30—50%
d. Attending to breakdowns	2— 8%

Two Approaches

In stating the foregoing thesis, it is assumed that preventive maintenance covers (a) oiling and greasing, (b) routine cleaning and adjusting, and (c) routine examination and testing. "Overhauls" cover the stripping, reconditioning and assembly of productive plant at predetermined intervals. "Repairs" refer to the repairs of damaged or worn-out parts revealed as a result of a routine examination or test. "Attending to breakdowns" refers to the time spent on repairing an unexpected failure.

It is sometimes difficult to distinguish between repairs and breakdowns. "Repairs" occur when the remedial work can be undertaken at production convenience, and "attending to breakdowns" when the work almost inevitably must take place at production inconvenience.

If the analysis and other evidence reveal a standard of maintenance that is too low, what can one do about it? An attempt can be made to foresee trouble and put it right at a convenient time, preferably before it causes more trouble or loss. There are two ways of going about this:

1. List every part or sub-assembly of the plant item concerned, and estimate its effective 'life'. Then proceed to establish procedures that ensure that the part or sub-assembly is replaced by a reconditioned unit *before* its life gets expired; and
2. Establish examination procedures under which every plant item is critically examined at regular intervals and action to replace or repair is only taken when such examination reveals a need.

In general, the first approach is essential when safety is concerned, such as for lifting

... Establishment of examination routines has many practical advantages to commend it under normal factory conditions ... It is less costly in labour. Materials and spare-parts need not be acquired unnecessarily ...

tackle in the factory or transport outside (e.g., aircraft). It tends, however, to be expensive where there is no such consideration as inevitably the values of "life must be underestimated until a lot of experience has permitted some accuracy in the assessment.

The second approach, viz., establishment of examination routines, has many practical advantages to commend it under normal factory conditions. It is less costly in labour. Materials and spare-parts need not be acquired unnecessarily, and skilled examiners can forecast the work needed at the next regular overhaul with considerable accuracy.

In the normal manufacturing plant, it is usual to employ three kinds of examiners, viz., mechanical, electrical, and civil. For each major item of plant, examination specifications must be written. An example is shown in the Appendix. Although examiners are only intended to examine and report, it would be ridiculous to carry this to the extreme; hence it is usual to include the instruction—"Repair any minor defects that would take 15 minutes or less and require no material."

Each examiner should be given a weekly list of examinations due, and he must be able to refer to the relevant specifications. His reports should be simple and comprehensive. Often just ticks or crosses against a list of checkpoints will suffice.

Each examination specification should be given an availability code, according to the nature of the work. For example:

A = Can be done at any time without stopping production.

B = Requires a brief stoppage that can be arranged at shopfloor level.

C = Requires a long stoppage that must be prearranged between maintenance and production.

When writing specifications, the more that can be categorised A, the better. Also, examiners can use their time effectively by filling in with category A work between the prearranged B's and C's.

Unless the plant concerned is already at a high standard of maintenance, the effect of introducing examination routines will be to bring to notice a large amount of overdue repair work. The immediate effect of this will be to increase maintenance costs until such time as the standard of maintenance is brought up to the level implied by the examination specifications. This abnormal maintenance cost must be foreseen, and plans made to deal with it. If all goes well, however, the maintenance costs should eventually fall to as low or a lower level than they were before whilst maintaining a higher standard of maintenance.

APPENDIX

Examination Specification

Equipment: Soaking Presses Job Grade: Mechanical Examiner

Spec. No. and frequency	Operations	Availability code
M82/1B Monthly	When soaking bath is empty, clean encrustation and surplus grease from vicinity of glands and from control gear. Inspect the following: 1. Main ram gland for leakage. 2. Return ram gland for leakage. 3. All parts of ram cylinders and hydraulic system for leakage. 4. Control valve plungers to ensure they are free. 5. Press plates for broken or damaged plates. 6. Chute and back plate for damage. Repair any minor defects that would take 15 minutes or less and require no material. Report all defects found. Operate ram and apply ram dressing to surface of ram between the two glands. See that both rams operate freely without chatter. Report if chatter is present even after applying dressing. Leave press with ram retracted.	B

Purpose and Economics of Maintenance

Machines form the most important wheels of industry, and their better maintenance will certainly lead to their better utilisation and longer life. The author of this article makes a vigorous plea that industrial managements in India should recognise the vital role of preventive maintenance, and recommends to them a number of ways by which such a programme could be implemented.

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TILL the 'forties of this century, the equipment and machines in many industrial establishments in India were of slow speed, sturdily built, older design, with fewer sophisticated controls. To begin with, these equipments were installed by foreign or company's commissioning engineers, and operation and maintenance personnel actually got trained on the equipment itself. Sometimes when the equipment could not stand the operation or maintenance, it would stop and then undergo breakdown or emergency repairs.

The equipment and machines imported these days are designed to work at much higher speeds, and have more precise design, lesser safety factor, greater mechanisation, and sophisticated electric, electronic, and hydraulic controls. If these machines are operated and maintained in the same old way, they break down sooner and remain idle for a longer time. This would result in the locking up of scarce capital resources, and hold up production and subsequent operations, increase consumption of spare-parts, and require more maintenance personnel working without a thought-out plan at hectic speed and pressure. These factors tend to reduce the volume of production due to decreased utilisation of costly

machinery and using of more spare-parts, etc., thus pushing up unit costs.

Cost-conscious managements, therefore, thought about preventing such mishaps by gearing up for preventive maintenance or planned maintenance (terms recommended by the British Standards Institution). Anyone can appreciate the significance of preventive repairing, because production and services are disturbed when equipments go wrong. Preventive repairing seems to have been practised since olden days. However, it was only recently that preventive maintenance was introduced in industrial enterprises as a systematic and economical concept. The idea was first put forward in the USA, as a plant management method, around 1925. Since then it has been greatly popularised, accepted, and implemented in the industrially advanced countries. The concept of preventive maintenance is gaining acceptance in bigger plants, like steel, and is being applied in continuous process industries, like oil refineries and engineering industries. But the concept is yet to be sold to and accepted by a majority of industries, if the cost of production is to be brought down and prices reduced.

Scheduled and preventive maintenance can stabilise production, cut maintenance costs, and drastically reduce emergency repairs as shown in Fig. 1. But this cannot be achieved without a systematic procedure. Just as with method study—an improved method can be used to produce more units, with lesser effect—so also with systematic preventive maintenance more machines can be made available and kept running at an acceptable standard, with lesser maintenance effort. In such cases,

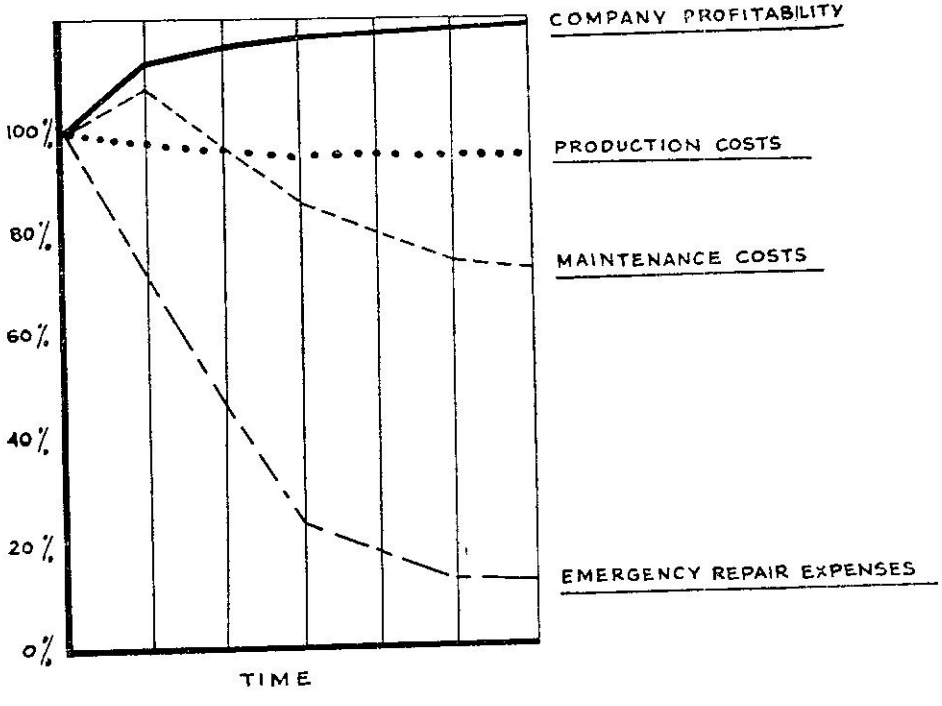


FIG. 1

maintenance and operation staff keep the machines under their control rather than have machines control the maintenance and operation personnel. This requires periodical inspection of machinery and equipment to discover conditions which may lead to breakdown and interruption of production. Also it requires adjustment of equipment and repair of defects even when they are of a minor nature.

In many cases, this may require a planned shutdown of the machine or equipment for some hours or days, to make the machine fit for an anticipated period of running. This is regularly done for aircraft or railway engines, and is also made obligatory as passenger safety is involved. But some managers or production personnel do not permit planned shutdown of machines or equipment for inspections or minor repairs, on the plea that "production will suffer," and ultimately the "production does suffer"—for a much greater length of time and with no warning—when the bearings seize or some components fail or break or the quality deteriorates.

Maintenance Costs

Preventive maintenance is thus an exemplification of the saying, "A stitch in time saves nine." It is like preventive medicine for equipment under which periodical medical examination (inspection and examination) and early medical treatment (early upkeep) are done. Naturally, preventive maintenance involves expenditure and the more advanced prevention is given, the higher the maintenance costs. Hence, if 'preventive' is too much emphasised, all kinds of equipments will be repaired before they break down, and with maintenance cost mounting to a large sum, there is a fear of over-maintenance. Maintenance is not an end in itself, but a means to advance the economic merit of the equipment. So it requires categorisation of equipment, and it is economical to do preventive maintenance to that equipment, where the loss resulting from lowering of equipment performance or deterioration of equipment resulting from breakdown or interruption is larger than the expenditure on preventive maintenance. On the contrary, if the loss is smaller, preventive maintenance is uneconomical, and breakdown maintenance will be more economical.

This should remove the common misconception in many minds that all the equipment has to be covered by preventive maintenance procedure, and that this task is never attempted as it is naturally assumed to be improbable and uneconomical. The examination of each equipment for its

A novel technique of productivity

So far scientists have been thinking that productivity is limited by the receptivity of the human mind in respect of stimuli from the external world. In this analysis, however, the sub-conscious mind has been left out of account.

According to a Moscow Radio broadcast, eight Russians, considered incapable of learning a foreign language, have mastered a year's course of English within 19 nights, while actually sleeping! All this time gently whispering loudspeakers were pouring into their subconscious minds the intricacies of the English language.

The man-in-charge of the experiment says that the chief aim was to explore the limit to which one can charge the human memory: "These limits proved to be wider than could be expected," he said. If so, infinity is the limit of productivity.

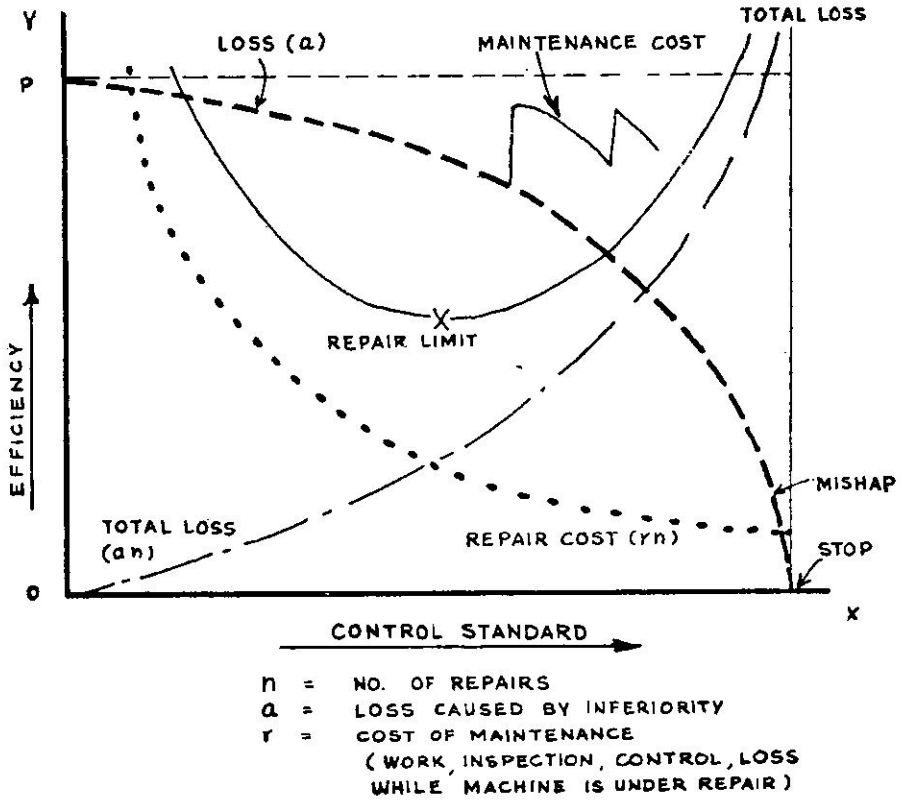


FIG. 2

performance, effect on subsequent operations, effect on quality, effect on delivery schedule, effect on safety and morale of employees—all these factors are to be evaluated to categorise equipments in categories like critical, semi-critical, and non-critical. Accordingly, an appropriate degree of preventive maintenance with equipment standard, operations standard, inspection standard, lubrication standard, and spare-parts consumption standard, can be applied.

The repair limit is determined by considering the balance between the decrease of profit-making ability of the equipment and the cost needed for its rehabilitation (Fig. 2), as the equipment efficiency is just the same as the profit-making ability. When the equipment becomes so inferior that no repair of it can effectively be made, then that condition is referred to as a mishap. Preventive maintenance is the activity to eliminate such mishaps. In one company, such a mishap did occur in an important equipment, and while the Board of Directors had decided to scrap it, the maintenance department asked for a planned shutdown of 10 days which was finally agreed to. In this shutdown, with previous planning, the whole equipment was reconditioned, repaired, and brought to a much higher and stable level of efficiency. The equipment thus

earned for the company profit in place of the regular loss for years.

13 Steps Suggested

Our industries can be geared to implement preventive maintenance, if steps are taken to do the following in a systematic manner:

(1) Arousing consciousness of top management towards preventive maintenance for giving adequate support to maintenance organisation.

(2) Familiarising the production personnel with the concept of preventive maintenance, and giving them responsibility of routine maintenance.

(3) Training of operating staff in proper methods of use of equipment, controls, and behaviour of equipment.

(4) Training of maintenance staff in proper maintenance methods for mechanical, electrical, electronic, hydraulic and instrument maintenance.

(5) Categorisation of equipment for application of various grades of preventive maintenance.

(6) Formulation of inspection check-lists, recording of performance of machines and formulation of performance index or productivity index, where possible.

(7) Co-ordinated and timely lubrication schedule with responsibility of lubrication allocated to designated personnel.

(8) Measurement and quality control over spare-parts—made in own works or purchased from outside—and supplies.

(9) Classification and standardisation of spare-parts—spare-parts inventory control.

(10) Analysis of delays by causes and rectifications, improvements devised so that such delays are prevented or reduced in future.

(11) Maintenance planning to be done before a maintenance job is undertaken to co-ordinate availability of equipment, components, spare-parts, supplies, proper methods, tools and tackles, instruments, safety appliances, and maintenance personnel of various trades. For costly jobs, the Project Evaluation and Review Technique (PERT) can be gainfully employed.

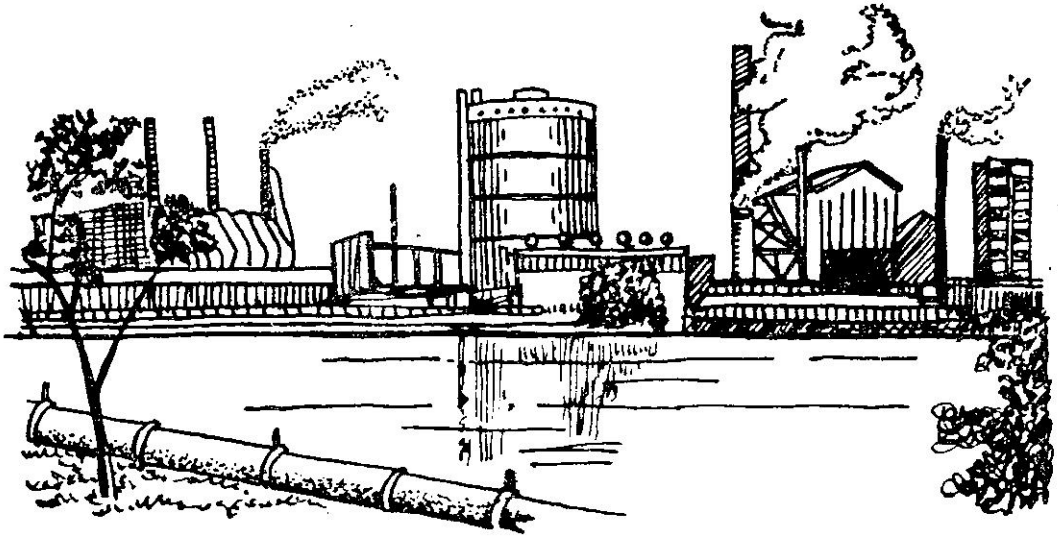
(12) Consulting the maintenance department when purchasing new equipment.

(13) Keeping proper records and control to show real maintenance costs—thus evolving "equipment replacement policy" also.

The National Productivity Council has been running courses on preventive maintenance for the benefit of management, operation and maintenance personnel, with the conviction that better maintenance of machines will lead to their better utilisation and longer life. This will lead to higher productivity from the existing equipment, and help in bringing down prices.

Operational Research

Studies on the trend of productivity in different industries are important from the point of view of forward planning. A Ghosal, writing on "Operational Research on Economic and Social Problems" in the *Economic Times*, says: "From my exploratory studies in various industries, it appears that during the period 1951-59, a substantial improvement in labour productivity, as measured by man-hours spent for producing one unit of production in industries like cotton textiles, iron and steel, general engineering, chemicals, cement, ceramics, vegetables, oils, glass, and sugar, has been experienced—in some of the order of 100 per cent or over during the period under review. If we define capital productivity as the ratio of value added by manufacturer to the productive capital employed, we do not find an improvement in most of the industries, especially because there is an appreciable lack between investment and production in any industry. Nevertheless, the study of productivity from the operational research standpoint provides a great scope for research.



Maintenance Personnel & Their Training

PREVENTIVE maintenance is only a systematic approach based upon the commonsense principle of taking care of equipment in such a way as to prevent premature breakdowns or failures. If the scheme is to succeed and produce results, the proper ground has to be prepared to ensure its full implementation. Maintenance is always a team-work. The essential pre-requisites for the success of any preventive maintenance scheme are:

1. *Proper personnel policy*—men with good know-how and facilities for improving their knowledge are essential since much of the work in preventive maintenance has to be shared even by the lower ranks;
2. *Proper equipment policy*—proper purchases, standardisation, procurement of spare-parts, etc.;
3. *Proper ancillary services*—like spare-parts from shops, storage space, lubricants, transport facilities, etc.;
4. *Proper management attitude*—delegation of power to supervisors on the shopfloor to take suitable action, correct appreciation of the need for proper maintenance *vis-a-vis* good production, need for proper replacement programme, etc.; and
5. *Proper training policy*—to ensure that the supervisors are fully equipped for the introduction of the preventive maintenance scheme.

To ensure that all the above pre-requisites are created, the following procedure may

Vigilance is the keynote of preventive maintenance. This calls for a properly devised training programme as in the Tata Iron and Steel Company, Jamshedpur, which consists of 11 sessions during which the philosophy of preventive maintenance is rubbed in at every point. In Session I, the management representative introduces the subject; the trainer then takes over, puts the group at ease, and discusses every problem threadbare against actual experience, and in the context of what is laid down in TISCO's *Manual on Preventive Maintenance*. Session II is devoted to examining the problem, and how to make plant workers and supervisors inspection-conscious. The Inspection Report Form is discussed in detail, step by step, at the next session. The subsequent sessions go over the Questionnaire on Lubrication, Equipment Records, Job Planning Sheet, the Delay Analysis Report, etc., and, in between, the trainees are also taken out on plant visits. Here is a complete resume of the invaluable *TISCO* experience in the field of preventive maintenance as embodied in the *Manual.**

be adopted in launching a preventive maintenance project:

1. *Management seminar* (one session): This should be attended by top management officers and heads of the production, maintenance, and service sections. The idea is to give them a correct appreciation of what preventive maintenance means, and what help they could render towards its success by adopting a correct and consistent policy. The Chief Maintenance Engineer may give a short talk covering the main aspects of preventive maintenance, and the facilities needed for implementing it. A discussion may follow the talk to promote better understanding.

2. *Appreciation course* (three sessions): This course is to be given to the departmental heads and senior production supervisors of each department. The objective is to pave the way for proper atmosphere in each department for the introduction of preventive maintenance.

Session 1—Evolve the four-step method.

Session 2—Discuss card thoroughly.

Session 3—Discussion on the implementation of preventive maintenance.

3. *Detailed training for maintenance supervisors of each department* (one week's duration): The detailed training covered by the TISCO Manual is to be given then to the departmental maintenance supervisors covering all levels. Have plenty of examples ready, drawn from the industry or departments concerned, so as to bring conviction to the group members.

As production techniques are improving with the introduction of automatic and labour-saving devices, the maintenance of equipment has assumed great importance. The equipments of today require more skilled attention and planned maintenance to ensure their efficiency. Inevitably, the cost of maintenance and its proportion in the cost of a finished product is going up owing to higher costs of replacements and wages of highly-skilled personnel. The only way to keep costs under control is to make a concerted effort for better maintenance of equipment, and thereby to minimise equipment failures and plant stoppages.

In recent years, our concept of maintenance has undergone a thorough change from one of attending to breakdowns to one of preventing them altogether. This is the principle on which the programme of preventive maintenance has been based. The programme seeks to cut down plant stoppages and delays thus making the equipment available for production in a trim, well-maintained, and trouble-free condition. This,

*For reasons of space, however, *Productivity* had to telescope through several passages of routine instructions, etc., contained in the *Manual*, though an attempt has been made to run together the material, and reduce the inconsecutiveness to the minimum.

in turn, helps to cut down costs in the long run. Let us examine the facts:

In the blooming mill an hour's delay will cost 100 tons of semi-finished steel, i.e., about Rs. 20,000. In coke ovens, one hour of hold-up may affect one battery or more. Fourteen ovens-hour may not be pushed. This affects the units consuming coke oven gas. It affects the schedule of heating in coke ovens itself, and the quality and quantity of coke produced. In blast furnaces, one hour of delay may again mean a serious loss—amounting to 35 tons per furnace. This, in turn, affects the blast furnace gas-consuming units.

The cost of breakdowns in an integrated plant like TISCO's can be very serious, since a breakdown in one unit sets a chain of hold-ups elsewhere. Apart from the loss to the company, let us look at the effect on the maintenance people. Your experience would tell you that in all cases of breakdown, every minute counts, and you are standing as if on the razor's edge, working under duress, forced by circumstances to finish a job quickly *somehow*, about which you are not perfectly happy. At times you are not fully sure that a similar breakdown may not recur. It is true that proper preventive maintenance will result in *more production at less cost, and of better quality.* All breakdowns do not occur suddenly. Often, they give sufficient warning in the form of noise (knocking), heat (bearings), improper sections (bearings being loose), erratic operation (no liner), etc. Could they have been taken notice of by some one?

Creaking Sound

It is true that there are so many difficulties and handicaps. That is why preventive maintenance requires a proper *build-up of attitude* towards the maintenance of all equipment. The very word 'maintenance' means *proper* maintenance of the equipment without allowing it to break down.

Some creaking sound was heard one day in a transfer car which was hauled by a wire rope attached to its ends. The rope passed over two pulleys fixed on brackets at the extreme ends of travel. The transfer car could be moved in both directions by reversing the motor. Thinking that the sound must be due to lack of lubrication, the Mistry had asked the oiler to put some extra grease in the axle-box.

In a week's time the transfer car got derailed, and, on inspection, it was found that the flanges of a pair of diagonally opposite wheels had worn out badly and had caused the derailment. The foreman found that the uneven wearing of the flange was due to the pull on the car being oblique and not straight. He examined the pulley at one end of the travel, and saw that the pulley was fitted with the hub on the wrong side!

When this equipment was newly installed, one of the brackets for the pulley was not properly grouted, having been shifted off the centre in order to suit some change made in the power rail system by the electrical people. Since there was no time to dig out the foundation, it was decided to make some modification in the pulley. A hub was welded on one side to bring the pulley in alignment. Though this change was later incorporated in the drawing, it was known to the foreman only. During the years of operation, the pulley was changed twice. The last change took place when the foreman was away, and a Mistry had supervised the job.

Inspection of the job just when it was completed could have revealed the wrong fitting of the pulley. This would have helped in taking action in good time. Also, had the foreman explained to the men concerned, they would have kept a record either in the logbook or in their minds as to what special points were involved in this particular job.

This leads us to a general plan of work which can be summarised in these following four steps:

1. Plan,
2. Inspect,

3. Take action, and
4. Maintain.

Planning: Planning is the keynote of any effective preventive maintenance scheme. The card relating to planning suggests: *Plan overall scheme for men, materials and machinery.*

What do we understand by overall planning for men? Proper men with technical know-how are essential for the success of preventive maintenance. In most cases, on-the-job training helps a good deal to achieve this. Each man should know what he has to do and how.

What do we understand by planning for materials? Requisite material like spare-parts, tools, cupboards, tool-boxes, inspection forms, etc., should be procured by planning well ahead.

...Each man should know what he has to do and how...

What do we understand by planning of machinery? *Right from ordering an equipment to installing it should be well-planned.* In addition, knowledge about machinery, through drawings and other information, should be made available to all concerned and kept in order.

Planning must start at an early stage, and continue at all stages. By planning one can visualise every item in the overall picture and be prepared for any eventuality. In addition, work goes on according to schedule, costs less, and reduces the rushing about.

Inspection: Inspection seeks to bring out defects, maladjustments, undue wear and tear, cracks, etc., *before* they cause breakdowns. Inspection is a vital function of any organised programme of preventive maintenance. It has to be *exhaustive, properly planned and diligently carried out.* The success or failure of preventive maintenance will depend on how effectively and accurately inspection was carried out. In order to make *inspection* effective, the obvious questions to be considered are: What?, How?, How Often?, When?, and By Whom?

Let us see which are the items that can be inspected by *visual or external inspection* (while the machinery is running).

Can you point out some of the items? (Vibrations, abnormal sounds, wear and tear, slackness, heat, smoke, colour, too much gap, etc.) Let us see how we can distinguish some of these faults. (Use tape recorder and play each noise or sound due to crack, loose nut, loose mesh, etc., and ask group members to diagnose the trouble.) Sound is one of the indications of soundness. A break in the rhythmic sound might mean something significant...A clean equipment and surroundings enable a maintenance man to do a better job. The question "How?" includes all this. He can *improve* the facilities in order to make the inspection easy and, therefore, *more effective.*

There may be many difficulties in getting a shutdown agreed to. Production supervisors may require the crane at the same time. Here is a small situation:

You require the equipment to be shut down for half an hour. Production men are not willing. Have you any

views on the approach to be made in such a case? *Let us have some role-play.* Who will play the role of maintenance supervisor? It will be the production supervisor.

The next question is "By Whom?" *Who should do the inspection?*—the maintenance man or an outsider? It is always better that men on the job inspect their equipment, because they know it better. They are also in a better position to do something about the faults detected, viz., lubrication, tightening up, etc. An outsider may not be equipped for all this.

But will our men do the inspection objectively and critically? Will one criticise one's own job? (It is human nature not to be too self-critical. Hence no. This should be discussed.) Then how to bring about that awareness? How can you bring about the conviction necessary for diligent inspection?... It helps if the foreman sets an example of deliberately inspecting things regularly and bringing to the notice of men in the section any lapse in their inspection.

The next point is *"Make note of all findings. Do not rely on memory."* In other words, there should be an "Inspection Report." Is it necessary? Inspection reports are necessary as a guidance for future action or reference. Will our men be able to fill in such reports? Initially our men may have difficulties in noting down things. But they should be helped and encouraged. Symbols, etc., may be used to avoid lengthy writing.

Planning of Job

What do you mean by planning the job itself? The sequence of operations of a job is to be analysed, time schedules fixed for each phase of the job, and arrangement of tools, tackles, spare-parts and different services made. Some preliminary arrangements may be made, viz., easing out rusty bolts, cutting out concrete to cut down time of repair, preparing and erecting a scaffold, etc. Proper planning of a job enables one to be prepared for all eventualities.

If inspection reveals some bad workmanship, lack of attention, etc., then action includes correctly instructing the men concerned to prevent recurrence of the fault.

You will all agree that *a stitch in time saves nine.* This point is illustrated in the case narrated below:

A particular shaft had a CI pedestal bearing of $1\frac{1}{4}$" thick shell, with a white metal lining of 5/8" thickness. The bearing ring was lubricated with oil. The pedestal bearing was at a height, and covered with dust. Visual inspection was difficult because of inaccessibility and poor lighting.

One day the lubrication Mistry reported to the General Foreman that the bearing was quite hot. Since the General Foreman had no spare ready, but had ordered for one in the shops, he asked his chaser to get the material soon, so that the bearing could be changed. Meantime, he asked the Mistry to put the compressed air hose over the bearing. But within the next 24 hours the breakdown occurred when the bearing suddenly fell down in two pieces. Luckily no one was hurt.

Investigation showed that the white metal was all worn out, and the oil ring had broken into pieces inside, and even the $1\frac{1}{4}$" thick casting shell had been reduced to $\frac{1}{2}$" at the bottom where it rubbed with the shaft and finally broke. The shaft was also so much worn out that it had to be changed. Since a new shaft had to be forged and a new bearing made ready, the equipment was down for nearly 36 hours resulting in a considerable loss of production.

How was this breakdown caused? Could this have been avoided?

In earlier sessions we discussed the first three steps. Now we shall discuss the fourth step. A simple case is narrated below:

In a particular equipment, grease to a ball-bearing was fed through one end with the grease gun. There was a plug on the other side and against its pressure, the grease went to the bearing. Though the grease was fed in regularly, the bearing failed once. On inspection, it was seen that there was no grease in the bearing. The foreman felt that the lubrication Mistry was slack. The Mistry was quite sincere, and felt sore about the foreman's attitude. Since there was no spare bearing, the equipment had to be shut down for quite some time. As it affected production considerably, quite a hue and cry was raised. On further investigation it was found that the plug on the other side of the bearing was missing, having fallen off due to jerks.

...Lubricants are the blood stream that maintain the life of moving mechanisms. With the right type of lubricants, and dependable men and methods of lubrication, and feeding correct quantities at regular intervals... half of the maintenance failures can be prevented...

Thus all the grease used to get wasted. Whenever the men complained that the equipment was running heavy, the Mistry used to pump in extra grease. The old plug was found out. It had worn-out threads. That was why it had gone loose. A new plug was fitted. Since then there was no further trouble with that bearing.

Have you any comments to make on this? How was the breakdown caused? Now let us look into the card. The card suggests: *Watch performance*; Is that necessary?

Correction of Faults

Initial check-up on performance will enable one to correct small faults which, if left to a later date, may prove too costly. The next suggestion is: *Check frequently*. This means continuous follow-up and correction of small faults. *Routine maintenance is always complementary to any effective scheme of preventive maintenance.*

The next suggestion is: *Follow the lubrication schedule*. Is that important?

Lubrication is the most *important* aspect, though *least cared for*, in any maintenance system. Lubricants are the blood stream that maintain the life of moving mechanisms. With the right type of lubricants, and dependable men and methods of lubrication, and feeding correct quantities at regular intervals, it is estimated that half of the maintenance failures can be prevented. We consume quite a large quantity of lubricants, costing nearly Rs. two lakhs every month. But high consumption is no proof of proper lubrication of equipments.

Too much of lubrication may result in clogging in addition to being wasteful. Too little is, of course, dangerous. Here again much work has to be done to make our workers lubrication-conscious.

In spite of all care, some breakdowns will still occur. When a breakdown occurs, the primary aim of any maintenance supervisor should be to restore the plant to normal operating condition as quickly as possible. The job is not over unless a recurrence of the breakdown is prevented. An

...With Whale Oil

In primitive days, prior to the discovery of petroleum, people in India used to lubricate their machines, tools, and accessories with whale oil and other oil substances. Today, lubricating oils extracted from crude oil have replaced all such diverse products, and their use is confined not only to widespread industrial and automotive application, but has become an integral part of the household affairs of human beings.

example where a breakdown used to occur repeatedly is cited below:

In a reheating furnace, the top roof bricks as well as side-walls used to fall down quite often apparently due to the charging crane damaging them. Many a time the crane driver was charge-sheeted, but there was no improvement. Due to the frequent breakdowns of the furnace the production of the shop was hampered. When the problem was scrutinised thoroughly, it was found that the crane driver had perforce to charge and draw from the furnace with the full gas on, and hence he could not see the side-walls or roof while doing his job.

Originally, there were controls at the furnace pulpit to cut off the gas, but since the control wires got corroded, the system went out of use. The main gas valves were later shifted to the back of the furnace far away from the pulpit. Since then, the furnace operator would not cut off the gas, as he was reluctant to go behind the hot furnace every now and then.

The problem was thoroughly studied and some pneumatic cylinders, which were lying idle elsewhere, were fitted on the gas valves so that they could be remotely operated from the pulpit. In addition, the control pipelines were amply protected and the crane driver was instructed not to damage them by dropping any heavy material on them.

Since then the gas in the furnace could be easily controlled and the crane driver could do his job more accurately without damaging the furnace walls or roof. The furnace life increased considerably as also its efficiency, and consequently the shop production went up.

Hence analysis of any breakdown alone will bring out the hidden causes. Superficial remedies will not solve problems altogether. Breakdowns should not be taken for granted, and replacement of parts should not be considered as the only remedy. No material when put in operation is supposed to fail without reason. If it fails, we should ask, Why? So the card suggests: Was it due to faulty maintenance, defective design, defective material, or poor workmanship?

Lubricants in India

In India, the consumption of lubricating oils has risen rapidly from 180,000 metric tonnes in 1951 to 266,000 metric tonnes in 1961, and has increased to 328,000 M.T. last year. By 1966, the demand is expected to increase to about 500,000 M. T., and by 1971 to 900,000 M. T.

India's future requirements of lubricating oils are strongly linked with the pace of industrial development in the country and the rapid industrialisation called for in the various Plans have already enhanced the need for good quality lubricating oils.

Till the end of 1963, the Digboi refinery was the only refinery in India producing lubricating oils to the extent of about 25,000 tonnes per year, which was hardly seven per cent of the total demand in the country. The balance of about 300,000 tonnes was met by imports. Every year India spends around Rs. 12 crores to Rs. 15 crores by way of foreign exchange for the import of essential lubricating oils.

A motor which works all right in Sheffield may get over-heated under the same load here. Can something be done in such cases?

Preventive maintenance should be a creed with every maintenance supervisor, so that the spirit will permeate down the line to change the outlook of every maintenance man from the attitude of "just keep it going" to one of "keep it going the right way."

GLIMPSES OF Maintenance Set-up in South India

A team of expert engineers, sponsored by the Asansol Productivity Council in 1963, visited a number of industrial establishments in South India which had implemented 'modern, well-planned, tailormade' preventive maintenance programmes. The report of the Council, extracts from which are presented in the following pages, deliberates upon the theoretical aspects of preventive maintenance, and helps to clear our ideas and concepts in order to equip us to compare and to judge the merits and demerits of various preventive maintenance programmes. The case studies of the plants visited by the team are also incorporated here.

MANY persons think of preventive maintenance only in terms of periodic inspections of plant and equipment to prevent breakdowns before they occur. To this limited view, some add repetitive servicing, upkeep, and overhaul. However, progressing on these lines, we come to a stage when *by preventive maintenance we mean any activity that will not only prevent breakdowns, but will also improve the output and quality of the products.* Any preventive maintenance programme should then consist of (i) periodic inspections to *uncover conditions leading to production breakdowns*, and (ii) upkeep of plant to overcome such conditions, or to adjust or repair such conditions while they are still in a minor stage.

Any well-planned preventive maintenance programme would have the following basic aspects:

I. *Inspections*—What to inspect? and How to inspect?;

II. *How often to inspect?*—Frequencies;

III. *When to inspect?*—Schedules;

IV. *Who inspects?*—Organisation, Personnel, Training; and

V. *Records and Reports*—Paper work.

We shall now try to elaborate on each of these aspects and try to make it as clear as possible.

I. **Inspections**: The entire preventive maintenance programme rests on inspections and their related duties of adjustment and

repairs. But inspections are costly in labour and in equipment downtime. "What to inspect?" is a question which should be decided on the basis of the answers to the following: (1) Is this a critical item? Will failure cause major shutdown or costly damage or harm to workers? (2) Is stand-by equipment available in case of failure? (3) Will cost of preventive maintenance exceed downtime cost? and (4) Will the normal life of equipment without preventive maintenance exceed manufacturing needs?

After deciding on whether to inspect an equipment or not, it has to be determined what physical parts of each equipment should be inspected. This should be decided on the basis of (i) service or maintenance manuals provided by the makers; (ii) actual running experience; and (iii) advice of experienced operators familiar with the equipment. After consulting all these sources, check-lists would be prepared for each equipment. These check-lists list all items to be inspected, so that inspections are uniform and impersonalised. Besides listing items of inspection, *check-lists also sometimes tell the sequence of inspection, and how to inspect.*

II. **How often to inspect?—Frequencies:** The decision of how often to inspect has the greatest bearing on costs and savings of a preventive maintenance programme. *Over-inspections would be costly*, and involve needless productive downtime.

Frequency is the period or interval which is determined from an engineering and economic viewpoint as most desirable. Age of the plant, kind of equipment, working conditions, process of manufacture, and so many other factors are to be considered. Though technical and engineering factors override any other considerations in determining frequencies of inspection, usually a compromise has to be made between technical requirements and practical aspects.

III. **When to inspect?—Schedules** Frequency and schedule are terms which are commonly used vaguely and improperly. A schedule should give a calendar time or date chosen for inspection. A frequency is the period or interval between consecutive inspections. 'Scheduling' is thus the next logical step after deciding upon what to inspect, and how often to inspect. It involves fixing of calendar inspection dates that would fulfil frequency requirements.

...In a good, preventive maintenance programme, everybody gets inoculated with the preventive maintenance spirit...

It is not always possible to translate frequencies into schedules by 100 per cent—particularly in the case of production machinery and equipment. That is where the snags lie, unless there is full co-ordination between production and maintenance forces. The common problems that confront 'scheduling' are—(a) Should every item of inspection be scheduled? (b) What should be done when a schedule is not completed on time? (c) What if the level of plant activity chan (d) How to schedule a continuous proce equipment? and (e) How to schedule a productive equipment? Who is responsible? Who has the final say? How to get production men to release equipment for inspection? There are some other factors which 'guide' scheduling. Difficulties in 'scheduling' are overcome—

(a) *By flexible scheduling*—Giving a leeway of a few days on preventive maintenance assignments. Preventi maintenance men fit in their p ventive maintenance whenever machine is down; and

(b) *By higher management dictum*—Giving the maintenance executive the deciding vote.

Naturally the best way out would be to encourage close cooperation between maintenance and production.

IV. **Who inspects?—Organisation, Personnel, Training:**

Organisation: Whatever the actual form of 'organisation' for preventive maintenance, it should be seen that—

(a) Preventive maintenance work is not interrupted by other maintenance work. If this point is insisted upon, eventual decrease in breakdowns will release enough men from repairs to preventive maintenance;

(b) Routine work required for preventive maintenance, and by preventive maintenance men, should be handled in the same way as that handled for regular maintenance; and

(c) The function of preventive maintenance should come under the same executive who directs all other plant maintenance.

Some plants like to handle preventive maintenance by a separate division of inspectors, fitters and supervisors. That should protect preventive maintenance against encroachment from other maintenance functions. Others prefer preventive maintenance to be done by the same force.

Personnel: A good preventive maintenance inspector is a craftsman with top skill who has the ability to test, adjust and repair the unit he inspects. It helps if he is a trained trouble shooter. *Preventive maintenance is more a philosophy of operation than a method.* All you therefore need to do is to train a competent craftsman in the philosophy of preventive maintenance.

Assignment of Work

There are two methods of using men for preventive maintenance. One method assigns the same jobs to the same men every time. Thus men get specialised in the equipment they inspect. In the other method, men are rotated round the depots so that they become conversant with all types of equipment. Of course, both systems have their merits and demerits, and the choice would depend on the plant set-up. It would be wrong to create the impression that preventive maintenance men alone are responsible for detecting trouble. In a good preventive maintenance programme, everybody gets inoculated with the preventive maintenance spirit.

Training: The first requisite of course is that the man can read and write, and make a reliable report. Secondly, he is to be baptised with the philosophy of preventive maintenance. Then there is the necessity of explaining the details of the new jobs to him—the report he has to write and submit. He is also to be trained in *inspection methods.* To train a man, it would be advantageous to prepare *inspection manuals* giving written instructions on procedures and practices of maintaining any particular equipment. Specialised training is of course required in specialised complex equipment.

Checking inspections: What evidence has the preventive maintenance executive that his men are doing a thorough job? There is a practice of 'spot checking'—to ascertain that the laid-down procedures are being followed. The best criterion is of course the 'results'. If the plant covered by inspection schedule does not show signs of reduction in the number of breakdowns, the quality of preventive maintenance may be questionable.

V. **Records and Reports—Paper work:** Excessive load of paper work seems to be the biggest single factor in delaying adoption of preventive maintenance. Paper work need not be top heavy or burdensome, but its usefulness has to be acknowledged. *No good preventive maintenance programme can succeed without facts to tell you where you are and where you are going.* To keep down and simplify paper work:

1. Minimise the number of forms and entries.
2. Integrate the preventive maintenance system with other maintenance paper work.
3. Arrange for a periodic control report to check a preventive maintenance performance.

Any preventive maintenance programme should add a maximum of five basic forms

to conventional maintenance paper work. They are—

1. equipment record,
2. check-list,
3. inspection schedule,
4. inspection report, and
5. equipment and maintenance cost record.

As for the 'systems' of records, there are a number of such systems in use. In general, there is a choice between the manual system and the business machine operated.

Any well-designed preventive maintenance programme would yield benefits far in excess of its cost. The benefits derived cannot be equal in every plant: the product, the process, the method of manufacture, existing maintenance practices, etc., are factors which would determine the amount and scope of results.

The more highly mechanised an industry gets, the more it needs the advantages of preventive maintenance: Costs of maintenance of modern equipment are high, and so also are costs of downtime. Specialised and complex machinery cannot be duplicated just to serve as 'stand-by' equipment. In any plant where downtime is important, preventive maintenance will reduce it. To what extent it would be reduced depends on the aims set before.

Below are recorded the team's observations of preventive maintenance practices in a number of factories in South India*:

*The plants visited by the Asansol Productivity Council Team in South India are: Industrial Estate, Guindy (Madras); Binny's Engineering Works, Meenambakkam (Madras); Dunlop Rubber Factory, Ambattur (Madras); Integral Coach Factory, Perambur (Madras); Indian Telephone Industries, Doorawaninagar (Mysore); Kolar Gold Fields, Kolar (Mysore); and Hindustan Machine Tools, Jalahalli (Mysore). The team was led by Mr JB Dustoor of the Indian Iron and Steel Co. Ltd., Burnpur, and consisted of Messrs SV Suri, Hind Refractories, Durgapur; DP Biyani, Ratibati Collieries, Asansol; S Sanyal, the Indian Iron and Steel Co. Ltd., Kulti; SP Ganguli, Hindustan Cables, Rupnarainpur: A Ganguli, the Indian Iron and Steel Co. Ltd., Burnpur; A Das Gupta, Hindustan Steel Ltd., Durgapur; S Bharatiya, Ashoka Mills & Transport Co., Raniganj; JC Kalra, Chittaranjan Locomotive Works, Chittaranjan; and SP Deolalkar (Secretary), Burn & Company, Raniganj. (See also Appendices I and II.)

New chemical for tanning

A material called tannin produced from cashew skins is claimed to be a good substitute for wattle bark used by Kerala's tanning industries. Tests conducted by the Central Leather Research Institute at Adyar (Madras) are stated to have shown that it should be a good substitute for wattle bark, 10,000 tons of which India imports annually from foreign countries.

(a) Organisation for preventive maintenance differed widely—but here and there we found a separate, autonomous preventive maintenance organisation. Generally, however, it was part and parcel of the main maintenance organisation. The head of the maintenance organisation was also the head of the preventive maintenance organisation.

(b) Levels at which the preventive maintenance set-up differed from the maintenance set-up within the maintenance organisation varied. In one case, they demarcated at a high level, and had independent supervisors of high rank answering to the common head. In many factories, however, the separation was at the levels of Mistries or charge-hands, who controlled the preventive maintenance and maintenance gangs.

(c) In many factories preventive maintenance men were grouped into small squads and distributed over various sections of departments. One such squad would consist of 'millwright or mechanic, electrician, oilman, and Khalasi'.

(d) In one case we came across 'Patrolmen' who kept round-the-clock vigil over the machines and did trouble-shooting as well.

(e) There were of course cases where preventive maintenance and maintenance

'set-ups' were not well-defined at any level, and, therefore, overlapped. During week-ends, one factory claimed, 75 per cent of its maintenance men were preventive maintenance men.

Below are given some statistics (not claimed to be too accurate) as regards the strength of preventive maintenance organisations—relative strengths of maintenance men, production men, and their proportions to the overall strength of various factories. These figures tell their own story.

Factories Visited

(*All figures are approximate*)

Factories	1	2	3	4	5	6
1. Preventive maintenance force	100	50	50	—	150	30
2. Maintenance force	130	150	—	380	450	180
3. Productive force	400	700	7,000	5,000	—	3,600
4. Total strength	1,200	900	9,000	8,000	4,500	4,700
Expressed as per cent—a better way of grouping						
1. Preventive maintenance as % of maintenance	75	30	—	—	30	16
2. Preventive maintenance as % of production	12	7	—	—	—	61
3. Preventive maintenance as % of total	8	5	—	—	3	61

How much should be the strength of the preventive maintenance force? Does it depend on

(a) *Total number of employees?*—Apparently not, as would be seen from the figures.

(b) *Number of machines to be looked after?*—The difference in number of machines is, however, not proportionately reflected in the strength of either the preventive maintenance or maintenance men.

(c) *Number of working hours?*—Partly, but not wholly, most of the concerns were doing a minimum of two shifts, and had a weekly off. Many were doing three shifts in some sections, or even in all their sections. However, none of the concerns visited had a continuous manufacturing process.

In the case of small units, preventive maintenance and maintenance set-ups were not defined, but merged into each other. Maintenance and service manuals were the principal sources of information, and instructions on maintenance repairs and/or overhaul of machines, and instructions given therein were being followed.

Other big firms first decided upon what to inspect. All had taken 'inventory' of their equipment in one form or other, and had kept either registers or 'case history cards' which gave detailed specifications of each machine or piece of equipment. As a next step, they had prepared 'check-lists' for each piece of equipment to be inspected under the preventive maintenance programme. Check-lists were either cyclostyled or printed. They were distributed to the inspecting personnel at the time of inspection. Later, they were filed or put in cabinets. The findings were, if need be, transferred to machine registers, or case history cards, as the case may be.

We have reproduced here one type of check-list. This gives us an idea as to how important check-lists are, and how they standardise inspection and help collect all relevant data and record it in a standard manner. It would be noticed that a lot of information is packed into the check-list.

Frequencies of inspection: We noticed the following common frequencies of inspection. Each factory selected its frequencies of inspection to suit its engineering and production requirements.

(a) *Daily* for vital and critical items, and for items of machinery and equipment coming under the purview of mines' rules.

(b) *Weekly* for enclosed lubrication systems, forced lubrication systems, coolant systems, etc.

(c) *Monthly* for such equipments as compressors, airconditioning machines, filters, ore-processing equipment for equipment which has to be serviced after a certain number of hours' run. Inspections coming under this frequency would take more time and would be more thorough.

(d) *Six-weekly:* This was found to be used in one case only, and it suited their 'replacement' of wearing parts of crushers, ball mills, stamping mills, etc.

(e) *Quarterly:* This was found in only one place.

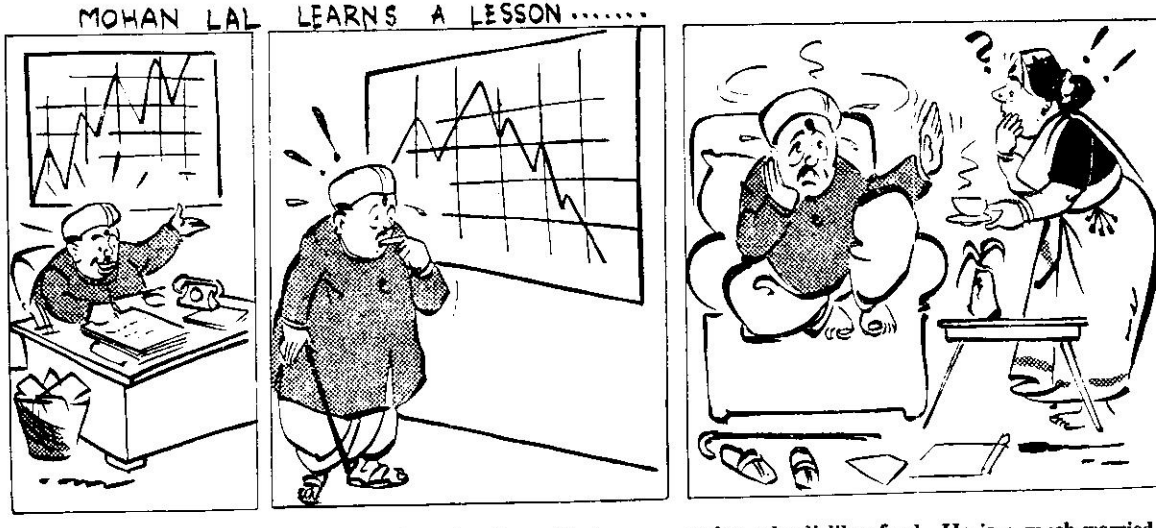
(f) *Four-monthly:* This is an interesting case. One concern had divided its complete equipment into two categories—one which required check-up every four months, and another which required it every six months. This frequency was adopted for such machine-tools as lathes, milling machines, and drilling machines. The machine would be checked once in four months, but quite thoroughly. Inspection at this time included alignment and accuracy tests as well, and the results would be recorded.

(g) *Six-monthly:* The same concern adopted this frequency for such machine-tools as grinding machines. This type of inspection would be as explained above.

(h) *Yearly:* This was a salient feature of the preventive maintenance programme in quite a few concerns. The whole plant would be stopped for a certain period taking advantage of festivals, holidays, power-cuts, shortage of raw materials, major breakdowns, etc. All major equipment would be subjected to 'tear-down' inspection.

Schedules: The term 'schedule' was used ambiguously to mean 'frequencies' of inspection, check-lists, etc. Therefore, it is necessary to distinguish between frequencies and schedules:

(i) *Frequency* indicates how often to inspect; it is a period between successive inspections.



Mohan Lal is the proprietor of a manufacturing firm...He is happy because he has imported new machinery, and production has increased...Six months later...He is depressed... Production has fallen...

At home he dislikes food...He is a much-worried man...

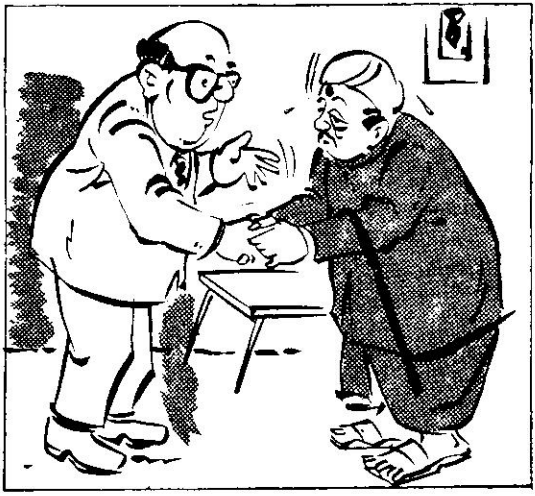
(ii) *Schedule* indicates when to inspect—it is a time—a date set aside on the calendar to carry out actual inspection: "Scheduling" would, therefore, mean fixing times and dates for physical inspections of equipment in a section.

(a) *Daily schedules:* In the case of mines we visited, half an hour of each shift was set aside for checking equipment, winding gear, etc. This was required to be done under mines' rules. In other factories, which worked in three shifts, the change-over period was utilised for quick checking of vital and critical points of equipments.

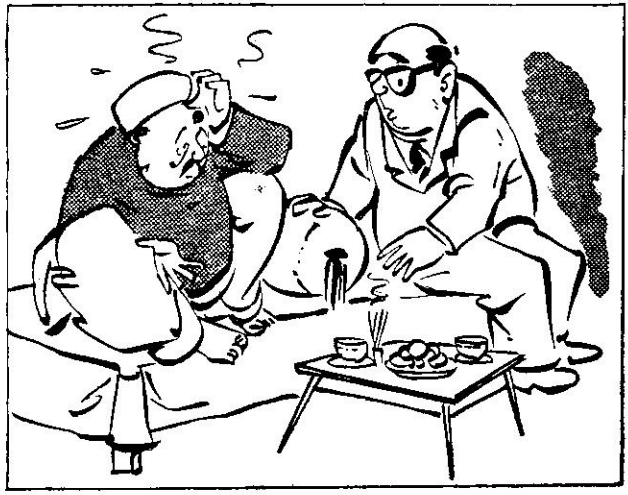
(b) *Weekly or rather weekend schedules:* These were fixed for weekends which were off-days for most of the factories we visited. Hence machines were generally easily available for inspection. However, the 'schedule' for a particular section of the plant was circulated to its Head well in advance, so that production men took necessary steps to make available the machines on scheduled dates.

(c) *Monthly and quarterly schedules:* These were also fixed for weekends, and included all items that had to be inspected weekly. Only these would take longer time, and inspections would be more thorough.

(d) *Four-monthly and six-monthly schedules:* The plant was divided into convenient sections, and maintenance gangs visited these sections at intervals of four months and six months for checking machines coming under four-monthly and six-monthly cycles. On each occasion, the preventive maintenance gang would be visiting a particular section for a certain period of time, say, one week or two weeks, depending on the number of machines in that section. During the appointed period allocated to each section, the preventive maintenance gang would inspect all the machines in that section. But actual allocation or sparing of each individual machine was left to the discretion of the production men. It was known how much time each machine would take for inspection under these cycles. Accordingly a time-table for the work of preventive maintenance gangs was prepared. Production men made available accordingly two or three machines per day for inspection to the preventive maintenance gang.



An industrialist friend visits him...inquires why he is morose.



"...Only six months ago I had imported the latest type of machinery involving considerable amount of foreign exchange ...The fine, new machines have started giving trouble .. dislocating production, upsetting schedules, and throwing everything out of gear...and hundreds of workers are idle..."

Please turn to pp. 718-719

(e) *Annual schedules:* This was not an affair for only preventive maintenance or for only maintenance men. It involved all spheres of activity in the plant. The time for actual stoppage had to be fixed. It depended on such factors as major breakdowns, holidays, shortage of power, and raw materials. Once that had been fixed, the whole factory organisation made detailed plans for conducting activities such as check-ups, overhauls, repairs, and clean-up. Each section put up its own plan of activities—repairs to be carried out, and so on. These would be centrally scrutinised and finalised. All details such as manning, tools and tackles, stores and spares, would be worked out well in advance of the actual date of stoppage. The aim would be to compress as much inspection, repairs and overhaul work into this period as possible.

For many factories 'schedules' were prepared in consultation with the production department concerned. 'Schedules', frequencies, and check-lists were continually reviewed and revised to make them more and more practical. 'Calendar chart' types of schedules were circulated in advance to production departments so that they were aware of the programme, and got time to adjust themselves to meet the requirements of preventive maintenance gangs.

'Banks' of Machine-tools

In many of the factories we visited, there were *'banks' of similar machine-tools like lathes, milling machines, drilling machines, grinding machines, screw-cutting machines, and so on, turning out similar products.* There was, therefore, a certain amount of 'spare capacity' available in such cases. Hence implementation of preventive maintenance schedules did not pose so much of a problem. In one case one 'spare' machine of each category would be kept idle, and would be available for production in case of emergencies, or to meet the requests of preventive maintenance programmes.

If the preventive maintenance programme is to succeed, its quality should be dependable and of a high standard. It should, however, be noted that it should not include actual maintenance or repair work. Hence the 'quality' of work referred to above does not apply to such routine maintenance jobs. *Preventive maintenance programme should consist of only inspections,* and minor routine adjustments or checks. It should, however, be thorough enough to bring out all serious defects which could be attended to during the course of normal maintenance.

Matter of Attitudes

Does preventive maintenance require any special type of personnel as distinct from maintenance personnel? Apparently not—but if we go deep into the matter, we find that there is a basic difference in the philosophies of preventive maintenance and routine maintenance. This difference is evident in the outlooks of preventive maintenance personnel and maintenance personnel. All maintenance men could not be good preventive maintenance men. A maintenance man has to be trained in the philosophy of preventive maintenance. It is not so much a question of skills as that of *attitudes.* Of course preventive maintenance men should be thoroughly skilled. Normally the best maintenance men are selected for preventive maintenance jobs. They should be thoroughly familiar with the machines entrusted to them. Another requisite is *vigilance.* A third one is a sense of *responsibility.* All these qualities would develop if the men would accept the concept and philosophy of preventive maintenance.

Preventive maintenance personnel are to be trained to carry out the inspections in an orderly manner: *missing nothing, and noting everything* within the stipulated time, they should be able to select what is relevant and reject trivialities. They should also be trained to submit *a precise and yet concise report.*

Training is undoubtedly desirable. It will pay dividends. But it will be more of a practical nature than anything else. We did not come across any special training scheme conceived and conducted for preventive maintenance alone. However, everywhere we found emphasis being laid on selecting the 'best' maintenance workers for preventive maintenance jobs. In many

...If we are to have the best men in maintenance or preventive maintenance, there should be enough attraction for men to take up such jobs. The attraction could be in the shape of better or higher grades, incentives, production bonuses, etc.

places there were technical training centres attached to the main factories. Maintenance men coming out of training schools would also be trained to operate the machines. Then they would be sent and circulated around various sections of the works, so that they became familiar with all types of machines and their maintenance. When they had picked up adequate skill and gained enough experience, they would be taken into the central maintenance gang. Here, if they proved their dependability, they would be selected for preventive maintenance.

Obviously, if we are to have the best men in maintenance or preventive maintenance, there should be enough attraction for men to take up such jobs. The attraction could be in the shape of better/higher grades, incentives, production bonuses, etc. It is now an accepted theory that maintenance men have legitimate share in the production incentive schemes, such as production bonus. They do not share incentive benefits cent per cent always, but share a certain percentage of it. If this is not so, the alternative incentive for maintenance men happened to be overtime, which is not compatible with increased production or productivity. We also found that grades of maintenance workers were higher than those of production workers.

One form of incentive scheme gave double increments or promotion to those workers who had displayed great skill, and shown a sense of responsibility and devotion to their duties. Another incentive scheme for maintenance men consisted in recommending a special rate by the hour or by the day over and above their normal basic rates of earning. This 'special' rate had to be earned by dint of hard work, and was attractive enough to tempt the men to try to get it. Some firms were anxious to introduce some sort of 'incentive scheme' for their maintenance men, and were working out the details of plans to introduce such schemes in their works.

Biggest Obstacle

As mentioned earlier, paper work is the single biggest obstacle in implementing preventive maintenance. The paper work can be divided into the following categories:

(a) *Records* for the use of the maintenance department itself and which are of a nature of faithful noting down of the findings of inspection. The facts thus collected can be put to any number of uses.

(b) *Reports:* The finding of preventive maintenance inspections are reported to departmental or production heads, chief engineers, and others for any of the following reasons:

  (i) acquainting them of the progress of the preventive maintenance programme,

  (ii) bringing out mal-alignments or impending repairs,

  (iii) pointing out abuse—neglect by the operators, and so on, and

  (iv) pointing out probable causes of certain defects noticed.

Again, 'records' could be of two types—written and visual. In the 'written' category would of course come such items as case history cards, check-lists, etc. In visual category would come (a) 'graphdex' system, (b) graphs and charts, (c) boards fixed at prominent places to give machine downtime, etc., (d) calendar schedules, and so on, and (e) colour codes of lubrication schedules, etc. The records could then again be distinguished by the 'system' used. Under the old 'manual' system, involving much of avoidable clerical and writing effort, plain registers are converted into

records for preventive maintenance by ruling carefully each page. Check-lists and all other types of records are also similarly prepared. Though this system certainly avoids 'capital expenditure' at the start—it is more costly and wasteful in the long run—it has its psychological disadvantages also.

Filing Systems

Modern 'filing' systems—consisting of the Kardex system—for storing and using cards while they are stored and the records are safe, secure and do not have to be shifted for entering the facts. A number of 'printed' forms are devised to suit each type of job, e.g., (a) case history cards, (b) inspection and maintenance and repair cards, (c) spares consumption cards, etc. The actual writing work is minimum and is more impersonal, and saves time, paper, etc., in the long run.

As to the volume of actual paper work involved, it depended on the size of the concern itself, and the total types of records accepted and maintained by each firm.

We had said earlier that preventive maintenance adds five (maximum) different 'types' of forms to the paper work. This was found true. Actually, very few firms had adopted all the five basic types of forms.

Undoubtedly periodic attention to lubrication is a vital aspect of any preventive maintenance programme. It would, therefore, be interesting to see how 'lubrication' was attended to under the maintenance organisation, or whether it was part and parcel of the preventive maintenance programme, and whether it had any organisation of its own to carry out this function efficiently. *Invariably we found that all the factories we visited took this subject seriously*, and wanted to go about it in a systematic, planned, and scientific way.

As a first step towards scientific and systematic, yet economical, lubrication, all firms had invited reputed oil companies to do a 'survey' of their plant, and advise them on various aspects of lubrication.

(1) *Selecting suitable grades of oils and greases:* All the firms had 'standardised' the grades of lubricants based on recommendations of makers and surveys conducted by oil companies. This had resulted in striking reductions in the number of grades to be stocked and handled.

In most of the factories we visited, machines and machine-tools had built in forced lubrication system, and hence required little external lubrication.

(2) *Organisation for carrying out lubrication:* Here we found two systems in operation—(a) Day-to-day lubrication of machines carried out by operators, and weekend lubrication attended by maintenance gangs; and (b) All lubrication attended by maintenance personnel only, relieving operators of all responsibility of lubrication.

The different forms of organisation were: (i) Operators who were also maintenance men did all lubrication in small units of the Industrial Estate; and (ii) Day-to-day lubrication done by operators and weekend lubrication done by the preventive maintenance gang—in this instance 75 per cent of the maintenance gang did preventive maintenance jobs. They incorporated schedules in check-lists.

(3) Gang of 'oilmen' under the maintenance department does the lubrication during working day, and also as part of the preventive maintenance programme on weekends.

Lubrication Aids

(4) *Systems of lubrication aids for correct lubrication:* (a) We found small quantities of lubricants stored in a central place in the plant from where operators or maintenance men could conveniently draw out lubricants as and when required; (b) We also found mechanical pumps for transfering lubricants from central storage to various sections; (c) Many firms used mechanical lubricating devices, such as 'lubricars', for speedy lubrication. One lubrication squad thus could attend to 40-50 machines in one shift; and (d) We also noticed 'colour codes' for identifying lubricants with points of lubrication. Colour codes were so designed that they also indicated the frequency of lubrication required.

(5) *Records:* Where 'lubrication squads' were formed, records were maintained of the work done by them.

One important aspect of preventive maintenance check-ups on 'lubrication' to be noted is that corrective action immediately followed the inspections.

The success of any preventive maintenance programme hinges on timely repairs and replacements to avoid major breakdown in future or damage to the machines.

In this respect many of the firms we visited were very fortunate, since they had machine-tools of a wide variety at their disposal to manufacture the spares. Even small units at the Industrial Estate, Guindy, were not badly off in this respect, as they had Government service units to help them. One firm was in the enviable position of using machine-tools made and sold by it. Some firms always gave priority to spares required for maintenance, and built up their stocks as and when opportunity arose. All firms tried to recondition and salvage worn-out spares as much as possible.

Since the plants that we visited had implemented preventive maintenance programmes, and were pioneers in their respective fields, we were anxious to hear from them their assessment of preventive maintenance. Comparative data on working of the plant before introducing and after introducing preventive maintenance were not available in all the plants. One or two plants had started preventive maintenance only recently, and concrete results were yet to be ascertained. In yet another plant, preventive maintenance was practised only in some sections, and hence its results could not be assessed at that stage. In another plant, the preventive maintenance and maintenance practices had been instituted right from the commissioning of the plant, and hence had no comparable data. From these available data, we observed the following:

(a) Machine downtime was within five per cent or even less than the total available machine-hours.

(b) Machine breakdowns and subsequent loss in production was only one to two per cent.

(c) In one firm, the proportion of idle hours had come down from 10 per cent to two per cent or even less.

(d) The mines cannot afford to have any breakdowns or machine failures at all since these would involve the lives of hundreds of men.

(e) Incidence of overtime was less than before.

Most of the factories visited by the team were modern, and had well-planned, "tailormade" preventive maintenance programmes, and the 'best' from each of such programmes have been picked out here for the benefit of others.

For obvious reasons, there could not be well-developed maintenance organisations in the small units at the Industrial Estate, Guindy. Such units could handle their maintenance problems by pooling their resources to form a centralised maintenance gang, or else they could 'contract' out their maintenance jobs to an external organisation. The Government, which has taken the lead in establishing industrial estates, could help in the formation of such a centralised maintenance organisation for the benefit of the various units.

The 'strength' of the maintenance organisations also varied, though in large

First Use of Petroleum

Lubricants are very necessary in our age of machines. They provide the slippery film that reduces wear and heat between moving parts. Practically all lubricants in use today are derived from petroleum which is one of the naturally-occurring hydro-carbons that frequently includes natural gas, natural bitumen, and natural wax. The word 'petroleum' is derived from the Latin *petra* (rock), and *oleum* (oil).

The first actual use of petroleum is said to have been in Egypt, which imported bitumen, probably from Greece, to be used in embalming, as it was a widespread belief of Egyptians that the spirit remained immortal if the body was preserved.

concerns it was within five per cent of the total number of employees. It might be theoretically possible to implement a preventive maintenance programme without any addition to the maintenance force, the understanding being that with less breakdowns more men would be released for implementing the programme. However, we found that in at least two or three factories additional men had to be taken to implement the preventive maintenance programme. The percentage of addition to the maintenance force was as high as 25 per cent in one instance. This aspect might be disturbing to those who want to launch such a programme.

It was not officially admitted that preventive maintenance men were used for breakdown jobs, but it was quite possible to do so. It is almost natural to succumb to the temptation to utilise them on 'breakdowns' in case of emergencies.

The "frequencies" and "schedules" adopted by each factory suited its particular requirements. Each factory had reached some sort of compromise between production and engineering requirements and practical considerations.

However, it was felt that it was more desirable and advantageous to have a fewer number of schedules. In this context, four-monthly and six-monthly 'cycles' appeared to be a satisfactory system of inspections for machine-tools, in contrast with the practice of a concern, with similar machine-tools, to have weekly, monthly, and half-yearly schedules.

There are "consultant firms" which study specific problems of records, and devise and design "forms" to suit the particular situations.

Apart from cooperation and co-ordination between maintenance and production personnel, much also depends on the attitude of top management towards preventive maintenance and production. If production at any cost is the motto then maintenance would suffer, and in such a set-up preventive maintenance could hardly survive even if launched. If, however, the accent is on 'efficient' production, then machines would be taken care of. The top management would, if need be, rule out production demands to keep machines in good shape.

...Much depends on the attitude of top management towards preventive maintenance and production. If production at any cost is the motto, then maintenance would suffer, and in such a set-up preventive maintenance could hardly survive even if launched...

Sole Purpose

After all, the aim and sole purpose of preventive maintenance or maintenance is *to be able to produce more at less cost*. Preventive maintenance would succeed if it could sell "better production" to the production men and the top management.

Apart from "surprise checks", following up of progress "schedules", repair work, etc., by higher authorities, no other systems to check the quality of preventive maintenance work were noticed. One more method was of course there, viz., to hold the man responsible for his work. This did give results.

It was necessary that the *jobs of maintenance and preventive maintenance should not be mixed up*, or else the delegation of responsibility would be rendered difficult. If preventive maintenance man had also to

do maintenance jobs (never mind if it was on the same machine, and based on his own findings of inspections), then preventive maintenance would suffer. There was of course the practice of getting the machine checked and run on trial when it was handed back for production by production men.

Preventive maintenance personnel—men who did the actual checking and reported on the findings—were literate, and could submit reports or fill up the prescribed forms. The records and reports were everywhere in English, and hence it was necessary for them to be able to read and write English.

At this point, we should remember that preventive maintenance cannot be started under all plant conditions. *Before a preventive maintenance programme is launched, the plant has to be brought in shape.* This is analogous to the introduction of work study. For example, *unless proper methods are adopted for production, work study has no value and will be useless.* So also would be any preventive maintenance programme for a plant that is not well-maintained or is not in shape.

It is now accepted that men work better with 'incentives' which should be for all the workers, and not for the production men only. The maintenance men should also share the 'incentives' with the production men. The alternative is that of paying "overtime", in which case maintenance men would be more interested in having breakdowns rather than in preventing them. Hence they should have some sort of 'incentives' to prompt them to keep the machines in good shape.

The incentives to be offered to maintenance or preventive maintenance men should be linked with production, and also with machine downtime, which is the acid test of success of preventive maintenance or maintenance. Such a scheme was not found in practice, though maintenance men were sharing production bonus, etc., with production men. However, many firms seemed anxious to have some sort of incentive schemes for maintenance men. It would be interesting to watch the developments in this field.

Germany has shortest working hours

Thirty-eight hours a week are the average working hours in the most important German industries, the metal, the textile and the chemical industries employing about 60 per cent of all German industrial workers.

Of eight European industrial nations, Germany is, therefore, the country with the shortest working hours, it has been reported as a result of a joint investigation of the German Trade Unions and the Federal Union of German Employers.

Ample Dividends

The team greatly appreciated the modern lubrication system adopted by the factories which it visited. These factories have demonstrated that though initially costly, scientific and systematic lubrication by modern methods pays ample dividends. Machine breakdowns owing to lubrication failures are almost eliminated, ensuring trouble-free, long life.

Particularly now, when procurement of spares is so difficult and the quality of indigenous spares is so uncertain, preventive maintenance would prove useful since it has been proved that it gives a better 'spares control'. It is, therefore, worth-while to launch on a preventive maintenance programme to overcome the difficult spares situation.

Appendix I

Factories Visited During the Tour

	1	2	3	4	5	6	7
Name of Unit	Industrial Estate, Guindy	Binny's Engineering Works, Madras	Dunlop Rubber Factory, Ambattur	Integral Coach Factory, Perambur	Indian Telephone Industries, Bangalore	Kolar Gold Fields, Kolar	Hindustan Machine Tools, Bangalore
Products	Small independent units producing a large variety of articles, spares, components, etc.	Mechanised foundry, sugar making machinery, condensers, vessels drives for sugar plant machinery	Truck and cycle tyres	Integral broad gauge coaches	Telephones, carrier equipments, signalling equipments	Gold	Machine-tools such as lathes, drilling machines, milling machines, etc.
Volume of production		200 tons of castings per month	500 truck tyres/day; 7,200 cycle tyres/day	60 coaches per month	450-500 receiving sets/day	10,000 ozs. of gold per month	About 1,250 machines of all types per year
Types of machines	Specialised machines in each unit to make its particular product	Mechanised foundry, production machine shop, etc.	Presses for making tyres, specialised machines for making this product	Foundry machine shop, specially designed assembly lines, welding and cutting machines, presses, etc.	Presses for casting bodies of telephones, etc., foundry machine shops, special machines	Ore processing plant, mining gear, ore dressing machines, etc.	Mechanised foundry machine shop, sp. machine for planing beds, etc., gear cutting and gear grinding machines
Process	Not continuous	Not continuous	Not continuous, continuous only in sections	Not continuous	Not continuous	Not continuous	Not continuous
Employment	Total strength of 2,544 in a total of 128 units	1,200	900	8,966	9,538	16,283	5,325
Working	2 shifts	2 shifts	3 shifts	2 shifts	3 shifts	3 shifts	3 shifts

Appendix II

Frequencies of Inspection

	1	2	3	4	5	6	7
Products	Various small components, spares, consumer goods, etc.	Mechanised castings, sugar machinery, structurals-fabrication, etc.	Cycle and truck tyres	Integral coaches	Telephones	Gold	Machine-tools
Working hours	2 shifts–6 days of the week	2 shifts –6 days of the week	3 shifts -6 days of the week	2 shifts—6 days of the week	3 shifts –6 days of the week	3 shifts –7 days of the week	3 shifts —6 days of the week
Types of machines	Specialised machines for diecasting, etc., power hammers, common machine-tools, gear cutting machines, etc.	Mechanised foundry machine-tools, gear cutting machines, etc.	Specialised machines for making tyres	Sheet metal presses, large variety of machine-tools, mechanised foundry, mechanised gear and electric welding gears, etc.	Presses for moulding receiver sets, specialised machine-tools, common machine-tools, electrical components, metering machines, etc.	Winding gear, rock drills, compressors air conditioning, crushers, ball mills, etc.	Mechanised foundry machine-tools of all kinds, etc., heat treatment furnaces, etc., gear generating grinding machines, etc.
Frequencies of inspection in operation	Not in operation	(1) Daily (2) Weekly	(1) Daily (2) Weekly (3) Yearly	(1) Daily (2) Weekly (3) Monthly (4) Quarterly (5) Six-monthly (6) Yearly	(1) Weekly	(1) Daily (2) Monthly (3) Six-weekly	(1) Four-monthly cycles (2) Six-monthly cycles

Art of Proper Boiler House Maintenance

The art of raising steam has undergone a major change in the last two decades, and this situation, according to PR Srinivasan, has posed a "real challenge" to maintenance engineers "to keep the boiler plant running under the severest operating conditions." The objective of boiler maintenance is to maximise boiler availability, and he focusses attention on what should be done to ensure perfect boiler maintenance.

PR Srinivasan *Fuel Efficiency Engineer, NPC, Bombay*

THE PROPER maintenance of a boiler house not only aids and simplifies its operation a great deal, but also improves the efficiency of the plant. It is further conducive to the maintenance of a cleaner atmosphere in the boiler house itself.

The art of raising steam has undergone such a revolutionary change during the last two decades that it has posed a real challenge to maintenance engineers to keep the boiler plant running under the severest operating conditions. Because of the attendant risks involved in the raising of steam in a boiler at high pressure—risks not only to the operating personnel but also to the surrounding area—there are certain statutory provisions regarding boiler maintenance. While these provisions are, by and large, complied with, *there has been a general neglect of the entire boiler house as a whole*, and attention to this problem is focussed here.

Except for a brief period once a year, when the law *compels a shutdown* for inspection, boilers are made to generate steam continuously at high efficiencies. Maximum availability between annual inspections is essential for the optimum productivity of a boiler system. In fact, the objective of boiler maintenance is to maximise this boiler availability.

Many factors influence the availability of the boiler, the most important among them being (a) Boiler operation; (b) Fuel selectivity; (c) Instruments maintenance; and (d) High heat release rates. Fuel

selectivity has a direct bearing on boiler availability. For example, when a boiler is forced to burn a fuel of very high ash-content or low-grade fuel, it brings special problems in its wake which have to be tackled successfully to keep the boiler availability high.

"Eyes and Ears"

Instruments are the eyes and ears of the operators, and any defect in them will result in faulty operation which, in turn, leads to decreased boiler availability. Proper maintenance and periodic calibration of the instruments are important to ensure maximum availability of the boiler.

High heat release rates greatly influence boiler availability, because they are responsible for troublesome deposits in the high temperature region, which are frequent causes of boiler shutdown. As far as possible, no attempts should be made to force the boiler beyond its rated capacity.

Since, in a boiler house, the operation of a boiler is so closely linked with its maintenance, it would, perhaps, not be out of place to mention a few points which are often overlooked.

1. Never bring the boiler too rapidly to steaming condition: **As far as possible, boilers should be brought to the steaming condition rather slowly. This is particularly desirable for high pressure boilers where the boiler drums are rather thick and liable to crack, due to abnormal thermal stresses. There is also the possibility of the life of the refractories being shortened, necessitating in frequent renewal.**

2. Do not subject boilers to widely fluctuating loads: **Boilers, as far as possible, should be subjected to steady steaming conditions. Widely fluctuating loads result in wide temperature variations in the furnace, and, as a result, refractories and brickworks are subjected to a thermal cycle. This reduces the durability of refractories and brickworks.**

3. Do not operate the boiler with a high water level: **High water level in the boiler drum always causes priming and foaming trouble, and it will lead to the depositing of solids on the super-heater tubes and their ultimate burn-out.**

4. Do not use a mixture of two fuels: **Sometimes when two fuels with different burning characteristics are used, it is desirable not to mix them. For example, while operating on a chain grate stoker or hand firing, it is preferable to allow the low-grade fuel to lie at the bottom, and the high-grade fuel at the top. This method allows greater time for the low-grade fuel to burn, and also facilitates the burning of both fuels evenly.**

The following points should be borne in mind as regards the maintenance aspects of boiler house:

Brickworks and refractories should be properly maintained, if the boiler is to work efficiently. Brickworks should be periodically coated with leak-proof paint, and refractories should be inspected often and replaced at once in an event of any flaw or cracks. All possible sources of leakage of atmospheric air into the furnace through brickworks should be stopped.

Inspection of Baffles

Baffles are used to increase heat transmission rates and the time of contact of the flue gases with the heat transfer surfaces. Any leakage in the baffle, therefore, would bypass the hot flue gas, thus short-circuiting the heat transfer surfaces. The flue gases in such a case leave at a higher temperature, resulting in increased loss of heat from the boiler. To overcome this defect, baffles should be inspected for leaks, cracks, etc., during the annual overhaul, and any defect noticed should be rectified.

Flue gas sampling probes: This is one item which escapes the attention of everyone, even though it is important from the point of view of boiler operation. Sampling probes are usually made of porous refractories which get clogged very soon with ash and soot deposit, choking the passages completely. This renders the aspiration of the gases extremely difficult, and, what is more, the instrument which is

connected to the sampling point will not give a reliable reading. Therefore, these sampling points should be cleaned often.

Instruments: Instruments in the boiler house are subjected to severely humid and high temperature atmospheric conditions and, therefore, every care should be taken to maintain them in proper condition. For example, the draft gauges have a diaphragm, which is normally made of an organic material like calf leather, to measure the pressure. If they are subjected to severe atmospheric conditions, they may lose their flexibility after a period of time, and the calibration of the instruments may be affected. Hence it is of the utmost importance that they should be maintained properly. Similarly, thermo-couples, used to measure temperatures, should be completely protected by some sort of shielding. Otherwise, there is a possibility of the oxidation of the thermo-couples, with a consequent change in their thermo-electric properties. Pressure gauges should not be subjected to violent fluctuations in pressure, and, as far as possible, high-temperature corrosive fluids should not come into contact with the measuring element of the pressure gauge. Orifice plates, used to measure steam and water flow, should be kept clean. Also, no dirt should be allowed to accumulate on the sharp edges of the orifice, as, otherwise, it would drastically affect its calibration. Strainers or filters should be installed before the orifice plates to filter out extraneous materials.

It is of the utmost importance that, as far as possible, the external heat transfer surface is kept clean, because any accumulation of soot or carbon deposits on it will offer resistance to the flow of heat, retard heat transfer rates, and increase the tube metal temperature. These deposits, which are on the outer side of the tubes, and, therefore, referred to as fireside deposits, should periodically be removed while in operation, by the soot blowing operation, the frequency of which depends upon the type of fuel used. Sometimes, because of the nature of the fuel used, hard deposits are formed on the outside of the heat transfer surfaces. These deposits could be removed either by hand-scraping or mechanical cleaning. To facilitate their removal, however, steam-soaking of the boilers should be carried out, that is, just to allow steam through the soot blowers to fill the entire boiler, so that it will be able to reach all parts of the boiler tubes, some of which may be inaccessible for mechanical cleaning. The tubes should be maintained at a relatively low temperature, and boiler tubes and super-heaters should be filled with water. There is thus a possibility of the deposits in the tubes loosening, as the bond to the tubes is thus dissolved. In addition, a detergent solution is also recommended to be sprayed for easy removal of the fireside deposits.

Removal of Deposits

As regards the removal of the deposits inside the tubes, these have got to be done during the annual shutdown by mechanical tube-cleaning equipment. During operation, however, the deposits on the inside of the tubes should be kept to a minimum by proper water treatment.

Important boiler auxiliaries like feed pumps, fans, coal-handling equipment, economisers, air pre-heaters, oil separators, and oil heaters, should be maintained in proper condition. Economisers and air pre-heaters should be protected against corrosion owing to the presence of sulphur-dioxide in flue gas, by by-passing them while starting and stopping of the boilers. Economisers should not be supplied with feed water less than 120° F to see that the flue gas temperature does not reach dew point. Where air pre-heaters are installed, the inlet temperature of the air should be so adjusted to see that the temperature of the flue gases leaving the air pre-heater is above dew point. To prevent overheating of the impellers of the boiler feed pump, a minimum amount of flow should always be maintained by having re-circulation devices.

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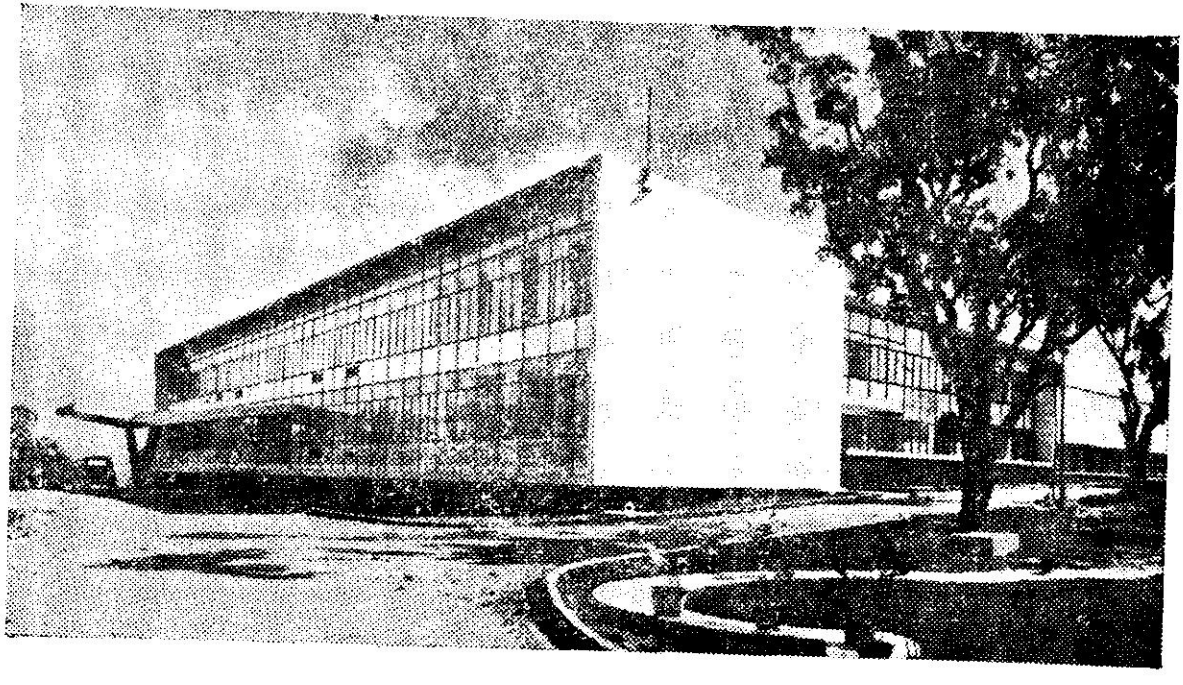

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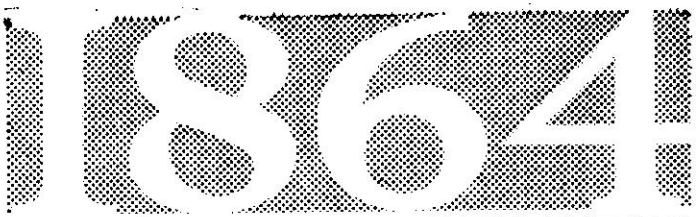

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1853	—	First railway and telegraph
1864	—	**Sam Bird started business in Allahabad**
1869	—	The birth of Mahatma Gandhi
1870	—	**Bird & Co. moved to Calcutta**
1878	—	**Bird's first managing agency — Burrakur Coal Co.**
1881	—	First Indian Factory Act
1885	—	Indian National Congress formed
1904	—	Universities Act
1905	—	**Lord Cable became Senior Partner of Bird & Co.**
1907	—	TISCO founded by Jamshedji Tata

HISTORY IN THE MAKING

1909	—	Morley-Minto Reforms
1917	—	**F. W. Heilgers & Co. bought by Lord Cable**
1918	—	IISCO incorporated
1918	—	Montague, Chelmsford Report
1923	—	Workmens' Compensation Act
1929	—	Trade Dispute Act
1932	—	**Sir E. C. Benthall became Senior Partner**
1935	—	Government of India Act
1939-1945	—	Second World War
1947	—	Independence
1947	—	**Bird & Co. registered in India**
1951-1956	—	First Five Year Plan
1956-1961	—	Second Five Year Plan
1961-1966	—	Third Five Year Plan

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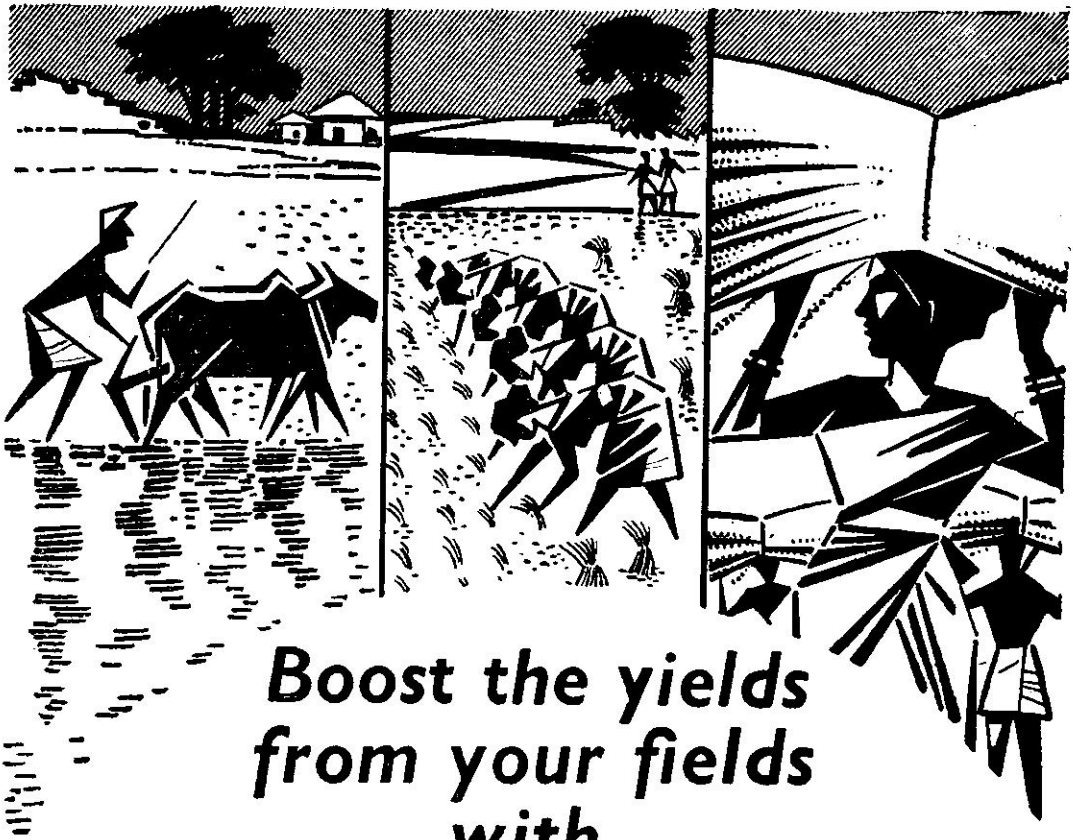

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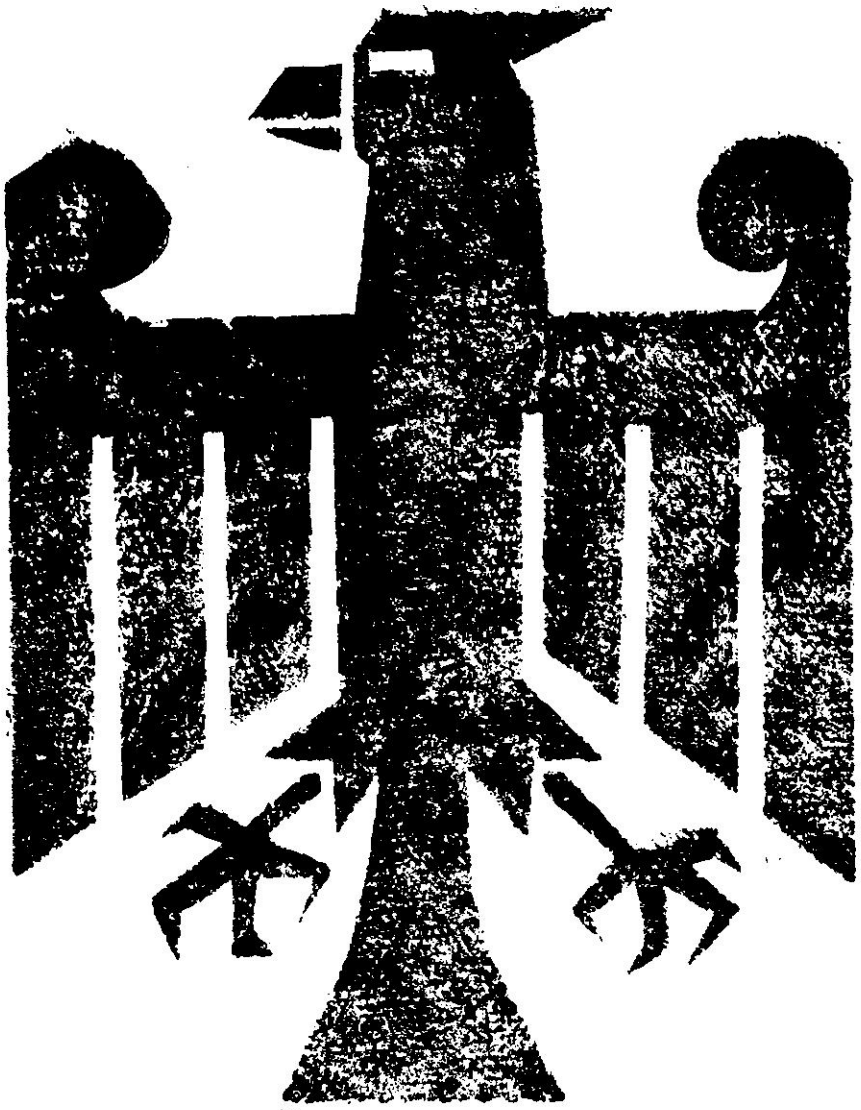


Textile Mills—Case Study I:

Maintenance Technique in a Loom-shed

Textile industry is getting highly mechanised and the huge investment in equipments will not yield the expected results unless the preventive maintenance system is introduced. This paper presents a typical preventive maintenance scheme which was successfully implemented on plain looms in the loom-shed of a textile mill—how the authorities went about the job from the preliminary to the final stage, and how, as a result, there was reduction in downtime, improvement in quality of cloth, and extension of the effective life of machinery, etc.

JP Singhal

Weaving Master, Lakshmi-Vishnu Mills, Sholapur

THE SCHEME of preventive maintenance, which is discussed in this paper. was successfully implemented on plain looms in the loom-shed of an up-country textile mill. Before its introduction, the following steps were taken:

1. The draft scheme was first circulated among all loom-shed assistants for study. It was then discussed at a meeting in which the Manager, Engineer and Storemaster also participated.

2. All the jobbers of different shifts were taken into confidence, and convinced that by following the preventive maintenance system in their sections, they would have less work to do, as it would eliminate a number of big repairs, and prevent the repeated occurrence of numerous odd jobs.

3. The Labour Union was taken into confidence to avoid any misunderstanding.

4. Jobbers, fitters, carpenters, and cobblers were provided with proper tools; and a small workshop, consisting of a lathe, a drilling machine, and a grinding wheel, was established in the loom-shed.

5. A competent and qualified assistant knowing his job thoroughly well, and enjoying the confidence of his colleagues, was deputed from the production side as Maintenance-in-Charge.

6. The existing fitters, slay-makers,

carpenters, cobblers, oilers and loom-cleaners were brought under this department. The departmental store was also given to the Maintenance-in-Charge.

The scheme of preventive maintenance consisted of the following three stages:

I. Checking the looms at the time of beam finish;

II. Fortnightly checking and setting by the jobbers; and

III. Dismantling the loom giving constant trouble by the maintenance gang, for overhauling.

I. Maintenance at beam finish: (1) As soon as a beam finishes, the jobber removes the healds and reeds to examine if the shuttle was running faultily. Healds and reeds are then returned to the drawing-in department. (2) The loom is thoroughly cleaned, keeping aside any nut-bolt, or loom parts which have fallen down for fixing. (3) Then the loom is properly oiled taking all precautions as described under the heading 'lubrication'. (4) After the loom is properly cleaned and oiled, the beam gaiter or assistant jobber or jobbers (depending upon the complement and designation in different mills) fit the parts kept by the cleaner, if any, in its proper position. Then all nut-bolts, screws, and set-screws are tightened. Any serration observed on race-board, reed-cap, lease-rods and back-rest are smoothened and polished. Minor settings like the adjustment of duck-bill heaters or play-in crank-arms are checked and put right. Before gaiting a beam, the side of the pickers and spindles in both the boxes have to be reversed.

II. Fortnightly checking and setting: The different mechanisms of a loom for periodical inspection are divided as below (The jobbers are asked through the respective shift assistants to inspect and put right one mechanism at a time. Each item does not usually take more than two weeks. For such checking the loom of each section may be divided among the respective shift jobbers.):

(1) *Shedding:* (i) Treadle lever notches worn out; (ii) Top-roller shaft or its brackets worn out; (iii) Shedding tappets worn out or out of alignment from treadle lever bowls; (iv) Treadle bowls or their pins worn out; (v) Treadle lever pin worn out; and (vi) Lam rod hooks worn out.

(2) *Picking motion:* (i) Picking nose or any part of the picking bowl assembly worn out; (ii) Picking shaft bracket or footstep or top clutches worn out; (iii) Picking stick not on its proper position over the box; (iv) Picking harsh or weak; (v) Picking shaft jumping too high; (vi) Swell pins or swells worn out; (vii) Picker spindle not set in "up and off" delivery; (viii) Check strap guides loose or worn out; and (ix) Picking stick worn out or damaged by heald frames or loom walls.

(3) *Stop-rod, bow spring and temple bar:* (i) Stop-rod not rotating freely; (ii) Stop-rod bushes or collars worn out or loose; (iii) Stop-rod brackets loose; (iv) Stop-rod support bracket loose; (v) Duck-bills and heaters worn out or improperly adjusted; (vi) Knock-off lever and bolt missing or improperly fitted; (vii) Bow spring and organ-handle bowl worn out or not properly set; (viii) Temple bar not parallel to the race-board or raised too high over the sley; (ix) Temple bracket touching the race-board; (x) Temple bar not swinging back on both sides; and (xi) Temple bracket touching the reed at beat-up.

(4) *Take-up motion and anti-crack device:* (i) Improper mesh and the alignment of take-up wheels; (ii) Ratchet wheel or its pin worn out; (iii) Retaining catch or pushing catch or slip catch worn out; (iv) Teeth of any wheel broken or worn out badly; (v) Anti-crack finger ineffective; (vi) Slip catch missing; (vii) Slip catch ineffective; and (viii) Emery-roll bushes or the emery roll end pins badly worn out.

(5) *Weft fork and brake checking:* (i) Weft fork mechanism improperly adjusted; (ii) Improper contact of grey hound-tail on Tumbler; (iii) Weft fork hammer pin worn out; (iv) Weft fork hammer bush out or worn; (v) Weft fork lever not sliding freely; (vi) Weft fork touching the sley or grate; and (vii) Brake motion not properly functioning, i.e., loom not stopping between bottom and back centres when the shuttle is on starting handle side box.

(6) *All bearings and bushes:* (i) Crank shaft brasses or bushes loose or worn out; (ii) Tappet shaft bushes out or worn and bushes or set-screws loose or missing; (iii) Crank-arm brasses worn out; (iv) Rocking shaft bushes worn out; and (v) Central support bracket brasses worn out.

(7) *Sley height and swing rail position:* (i) Sley too low or too high on both sides; (ii) Sley

. . Technicians should think that it is their moral responsibility to keep machines and equipments in top condition for increased productivity and the survival of the industry . . .

or unequal heights; (iii) Sley swords loose on swing-rail; (iv) Swing-rail not parallel to tappet shaft; and (v) Swing-rail not at proper position to maintain the correct eccentricity.

(8) *Shuttles:* (i) Shuttle wearing at one or more of its four sides; (ii) Shuttle tongue pin projecting at back to damage the reed; (iii) Unbalanced shuttle; and (iv) Shuttle tongue or clips or springs damaged.

(9) *Loom speed:* It is usually observed that the looms are running at lower speeds than required, especially in overhead shafting drive. The supervisor should check the speed of looms in his section, and such numbers of looms running at less speed should be given to jobbers for attending.

(10) *Picking points of crank and bottom shaft wheels:* (i) The two wheels should be in proper mesh and correct alignment; and (ii) For longer life of these wheels, their point of contact at picking should be changed to avoid teeth getting worn out only at particular points. The crank wheel is provided with three key ways for this purpose.

(11) *Warp stop motion:* The warp stop motion, where provided, either electrical or mechanical, should be checked for its proper functioning, and the worn-out or damaged parts replaced.

(12) *Safety devices:* (i) Cog wheel guards worn out or missing or improperly fitted; (ii) Shuttle guards missing or not in proper adjustment; (iii) Eye bolt projecting out too long; (iv) Weft fork hammer swinging over the breast-beam in such a way as to cause an injury on fingers; and (v) Let off weights without proper slot for handling.

(13) *Loose foundation:* The loom numbers with loose foundation may be given to the mason for attending.

In this way each of the above settings are inspected in turn once in six months in the whole shed. Though the work is to be done by the jobbers, the Maintenance-in-Charge has to guide and give them the help of his fitters, carpenters, and others. After each inspection, the Maintenance-in-Charge has to check a few looms at random in each section to keep the jobbers alert.

III. Maintenance of constant trouble-giving looms: When a loom is giving any one or more of the following troubles—

(i) Shuttle flying out, (ii) Shuttle trapping, (iii) Shuttle badly wearing, (iv) Loom getting jammed or heavy, (v) Loom consuming more stores, (vi) Loom producing defective cloth or giving less production, or (vii) Crank shaft bushes broken, or tappet shaft slots damaged or loom wall broken—the same has to be reported to the maintenance department for overhauling.

After a loom is overhauled, it has to be checked by the Maintenance-in-Charge before a beam is gaited. And a record of the parts changed, and the name of the man who overhauled the loom, are maintained for future reference. Follow-up of the overhauled looms is essential.

The scheme was introduced to gain the following advantages: (1) To increase loom-shed efficiency by reducing downtime to minimum; (2) improve the quality of cloth; (3) extend the effective life of the machinery; (4) maximise machine utilisation; (5) reduce store consumption; (6) reduce maintenance and repair cost; (7) save overtime payment to the fitters; (8) reduce power consumption of the drive; (9) reduce the number of accidents; (10) improve the earning of the workers; (11) reduce fatigue of the worker; (12) maintain better employer-employee relations; and (13) to ensure that the cloth is delivered to the dealers as per schedule.

Machines and equipments are the fixed assets of an industrial enterprise. Technicians should think that it is their moral responsibility to keep them in top condition for increased productivity and the survival of the industry.

Textile Mills—Case Study II:

Downtime Halved in Process House

JF Driver

Asst. Manager (Technical Service), Swadeshi Mills, Bombay

The Process House of a textile mill derived seven distinct advantages after following the maintenance procedure described here.

THE FOUR types of maintenance practices are breakdown maintenance, preventive maintenance, maintenance prevention and selective maintenance.

1. *Breakdown maintenance:* There are many factories in India which do just this sort of maintenance. The machine is made to run with no more care than routine lubrication, till some fault or breakdown occurs when that fault is repaired. If it is a very important machine in the factory, then all production is held up, operating labour becomes idle or has to be temporarily curtailed. The other machines in the sequence, both before and after, are adversely affected. The repairs have to be rushed. Many a time they have to be compromised. The total loss to the company is very heavy.

2. *Preventive maintenance:* In the processing sections of one of our textile mills we started this programme about two years ago. We used the Kardex system of control. For every machine we prepared a check-list in which were listed various items to be checked at a predetermined frequency. Initially this frequency was fixed from the experience of our Maintenance Engineer, and it was modified when more experience was gained. Any

. . . One of the biggest causes of high maintenance costs is created at the time of equipment design, lay-out, and installation. While the Maintenance Engineer is helpless regarding the design aspect once the equipment is bought, he can yet play an important role during installation and lay-out . . .

abnormal findings were recorded and taken up for repairs at the most convenient time, after giving notice to the production personnel, and after preparing in advance for the repairs. Although, initially, the maintenance costs increased as the large number of defects observed had to be corrected, later on the overall cost came down substantially, and the downtimes for repairs and maintenance were reduced considerably. Today, the production departments willingly cooperate in handing over the working machine for a routine check, because they are convinced that, in the long run, it leads to lower machine downtimes. Relations between the maintenance staff and production staff have improved.

3. *Maintenance prevention:* This depends on the design features of the equipment, and how it is installed. One of the biggest causes of high maintenance costs is created at the time of equipment design, lay-out, and installation. While the Maintenance Engineer is helpless regarding the design aspect once the equipment is bought, he can yet play an important role during installation and lay-out. The following precautions are helpful:

(i) Avoid laying steam or water pipelines near the electric motor. Any leak will ruin the motor. If that is unavoidable, install a suitable guard.

(ii) Fix a load beam above the machine to ease lifting of heavy parts during maintenance and repairs.

(iii) Install limit switches at strategic places (even though not provided by the manufacturers) which will shut off the machine in case of a fault. This is very necessary in the case of careless workers.

(iv) Properly lay water lines, steam lines, air lines, power cables, etc., for ease of inspection and repairs later on.

(v) Provide doors and aisles of adequate size to permit efficient maintenance movements.

(vi) Provide ample run-in period for all major equipment, with gradual loading up.

(vii) Separate equipment whose operation could affect that of others. For example, keep instruments away from areas where material is spilled or equipment is flushed.

4. *Selective Maintenance:* Basic to any selective maintenance programme are—(1) Determining the importance of the unit in the productive process—the Productivity Rating; and (2) Determining the reliability of the unit —the Reliability Index. Using these two keys to selective maintenance, a maintenance programme can be designed which would reduce the cost of maintenance per unit of production.

Below is given a brief outline of the planned maintenance programme in the Process House of one of our textile mills:

1. For every machine a history record is maintained. The record contains details of the maintenance work carried out on the machine, the names of the persons who did the job, the parts replaced, etc. This is a valuable record. It indicates the types of failures, their frequency, and helps in the stocking of the right quantity and types of spares. Also, it indicates the quality of maintenance work done by the fitters. If a recently repaired part fails again, then we take a very serious view of the situation, and the same is very thoroughly investigated.

2. A detailed preventive maintenance programme has been instituted for all important machines. The Kardex system is used for this programme. Machines are stopped approximately on schedule after atleast giving a week's notice in advance to the production departments. The persons appointed for checking carry the check card in a transparent plastic cover, and check each item as mentioned in the card. Any defect noticed is at once reported to the Maintenance Engineer who decides on the course of action. He may decide to rectify the same before starting the machine, or he may allow the machine to be started up with that defect and prepare for the repairs on the next shutdown or holiday. Fig. 1 shows the typical check cards for the Shearing and Cropping machine.

Desc: Shearing M/c (Old)	Dept.: Finishing			Card No.: 1
Model: Type SGP	Manufacturer: Menforts			Serial No.: 0017652
Date / Inspection by Mechanic clock No.:	Remarks	Foreman's initials	Date of next insp.	Work to be done once a month
				1. Check and adjust the guiders. 2. Check the following belts and adjust their tension: (a) Belt of cleaning section, (b) Belts of main motor, (c) Belts of the fan, (d) Belts of all the four brushes, and (e) Belt of Plaiter. 3. Sharpen all the four ledger blades. Take cutting test for all cutters. 4. Check nylon blocks of all cylinders.

Card No.
Serial No.
Work to be done once in two months
1. Check the surface of the two tensioning rolls and replace felt if not O.K. 2. Inspect fillets of both draw rolls. 3. Inspect and clean the following brake assemblies: (a) On right side of second draw roll, (b) On left top of tensioning roll, (c) Brake roll at right bottom, etc.

Card No.
Serial No.
Work to be done once a year
1. Check the bearings of all the rolls in the cleaning section and that of all the brushes of the machine. 2. Inspect and clean the PIV gear and the other gear box on the right side.

Fig. 1

Defects

The following were some of the defects detected during our preventive maintenance check-up, which, if left undetected, would have caused great damage. As such they were rectified at hardly any expense.

(i) Roller-bearing sleeve, which was found to be loose on the shaft of the mangle roll, was tightened on the shaft. If not detected in time, it would have worn out the shaft, requiring metal spraying and finishing, or entire replacement.

(ii) Cloth alignment motors of the Palmer Unit of our Felt Calender were found hunting because of loose brakes. The brakes were tightened. If not detected in time, the motors and/or their couplings might have been damaged permanently.

(iii) Limit switch stop bracket, which was found loose and out of position, was re-positioned and tightened. If not detected in time,

heavy damage might have occurred, as the protective device had been rendered ineffective.

(iv) Key of the differential shaft of the Hot Air Stenter was found loose in the keyway. If this defect was not detected in time, the shaft would have been damaged.

(v) Chain clip bolts were found considerably worn out, and were replaced. A broken bolt could have very serious consequences. It could even crack the bed of the machine.

(vi) Pressure reducing valve on the drying range was found to be out of order. If not detected in time, it could have led to very serious consequences involving loss of lives.

3. Lubrication schedules have been prepared. Missed frequencies are duly noted down, and taken up at an early date. Oilers are trained not only to lubricate the machines correctly, but to report a hot bearing or noisy bearing. Lubricants, specified by the machine manufacturers, or recommended by the lubricant suppliers, are only used.

Spare-Parts

4. Spare-parts are very carefully ordered. In case of new equipment, the manufacturer is asked to recommend spares. Machine history books also serve as invaluable guides. The spares are well-stored, and protected against pilferage and unauthorised use. An effort is made to keep inventory levels at the optimum.

5. Before a new machine is handed over for regular production, it is given careful trial runs. The operating staff is trained in the operation of the machine. All important operating instructions are explained, and a typed copy is framed and kept near the machine. Any unusual sound or occurrence is reported to the Maintenance Engineer whose permission is obtained before continuing with production.

6. Lastly, we firmly believe that a clean mill is an efficient mill. We lay great stress on house-keeping. The machines are regularly cleaned and painted, and all corrosive liquids and fumes are prevented from contaminating floors and machines.

US Professor on Indian Productivity

Prof Thomas Wilson, of USA, in his recent book on **Planning and Growth,** *refers to the situation in India where "the restlessness of modern industrial society has been condemned and resented as inconsistent with the contemplative life that religion prescribes." Incidentally, he is against that type of planning which involves "preparation of official target and programmes for output." In any case, "controls should not be used to enforce an industrial plan."*

Our manpower is our greatest asset, and we constantly endeavour to improve their skills by sending them to short training courses, through circulation of technical journals, and through contacts with foreign erecters. We equip them with good tools, and modern maintenance equipment.

The above-described maintenance procedure has resulted in the following benefits: Less machine downtime (reduced by almost 50 per cent in the last two years); less overtime pay on rush repairs; fewer large-scale repairs and fewer repetitive repairs; lower maintenance costs (reduced by almost 40 per cent in the last two years); better quality of finished cloth and fewer damages; better spare-parts control, with consequent reduction in inventory; and better relations between the production and maintenance personnel. The pay off is, indeed, very handsome.

Textile Mills—Case Study III:

Effective Check to Fall in Production

SM Misra advances the view that preventive maintenance should be viewed as a leap towards better and increased production, and not as a step towards better maintenance, and cites how the fall in production in a carding and spinning plant of a woollen textile mill was checked and increased as a result of the introduction of preventive maintenance.

SM Misra *Industrial Engineer, Amritsar Productivity Council, Amritsar*

ALTHOUGH preventive maintenance has not yet been recognised as a tool of higher productivity in the developing industries of India, it certainly has been in vogue under a different name. The need to systematise and streamline such activities is urgent, and early steps are called for in this direction.

Preventive maintenance should be viewed not as a step towards better maintenance, but as a leap towards better production. The situation mentioned below will help in an understanding of how better production at reduced unit cost can be achieved (The figures present a simulated condition.) : A machine has been purchased for Rs. 12,000. It has a 15-year life and a production capacity of 18,000 units of output per year. Suppose the variable costs are Re. 0.50 per unit, and the fixed costs Rs. 9,000 per machine per year.

CASE I: Consider a situation where preventive maintenance is totally absent, and that only breakdown repairs are done which result in reduced machine life. At the end of five years, it will be found that the machine is left with a capacity of producing 12,000 units per year. The total life of the machine is estimated only at 10 years, instead of 15 years, under these conditions.

$$\text{Unit cost} = \frac{0.50 \times 12{,}000 + 9{,}000}{12{,}000} = \text{Rs. } 1.25$$

Disregarding the time value of money, i.e., interest,

$$\text{Annual depreciation} = \frac{12{,}000}{10} = \text{Rs. } 1{,}200$$

CASE II : Consider another situation where preventive maintenance is actively applied, and a full life of 15 years is exploited. At the end of five years, the machine is left with a productive capacity of 15,000 units per year.

$$\text{Unit cost} = \frac{0.50 \times 15{,}000 + 9{,}000}{15{,}000} = \text{Rs. } 1.10$$

$$\text{Annual depreciation} = \frac{12{,}000}{15} = \text{Rs. } 800$$

This example shows a saving of Rs. 2,250 per year resulting from reduced unit cost as a result of preventive maintenance. Also, there is an annual saving of Rs. 400 in machine depreciation. If the machine had been used carelessly, the deterioration would have been faster. A plant may have a number of such machines, and the total realisation of savings will certainly justify the introduction of preventive maintenance.

...Preventive maintenance is a tool, and not a target. It is a means to an end, but not an end in itself. In other words, it aims at reducing the production cost indirectly, but does not mean a cost reduction by itself.

In a continuous-process-type of industry, like sugar or cement, the sub-units are linked with each other in such a way as to form an integral part of the whole unit. If any of the units, big or small, fails to operate, the complete plant or the whole unit stops functioning. This involves heavy cost by way of repairs, besides total loss of production, whereas, in a mass production shop, if one machine becomes idle, the other machines operate, and production in respect of only one machine is lost. Preventive maintenance means much more to such industries. This example, however, should not create the impression that industries other than continuous process type cannot benefit from preventive maintenance.

Preventive maintenance is a tool, and not a target. It is a means to an end, but not an end in itself. In other words, it aims at reducing the production cost indirectly, but does not mean a cost reduction by itself. Therefore, the success of the programme depends on how it is organised. It may not give the stipulated benefits, if poorly planned and haphazardly applied.

To be more selective in approach, careful attention is necessary to those factors on which the programme hinges. These include the frequency of inspection, and the number of items to be included in the programme. If inspections are made too often, they involve extra expenses and more *equipment idle time*, and if too few, more stoppages due to breakdowns will occur. A good balance should be struck to avoid such a situation. Also, the inclusion of some minor items will unnecessarily burden the programme. There should further be an understanding on what to inspect in respect of the selected items. In some plants, a check-list or a service and inspection schedule has been developed to operate the preventive maintenance programme. This should, of course, be prepared

in the light of the individual needs of the company concerned. A check-list for one plant may not suit the other.

In the newly-installed carding and spinning plant of a woollen textile mill, the management experienced a considerable fall in production. A study showed that one of the contributory causes was minor and major machine breakdowns in the section. Being a high-speed machine, the production loss was so high that it was decided to introduce a system of preventive maintenance. A check-list was prepared, and the frequency of service and inspection operations determined. Accordingly, the machine was subjected every week to cleaning, oiling, and checking for adjustment and minor repairs. Once in three months, a programme of major repairs and overhauling was undertaken. This proved very effective, and advantageous to the firm.

The following production figures will reveal the improvements achieved:

Before preventive maintenance was applied	1,84,530 kgs. of yarn was produced (for 6 months)
After preventive maintenance was applied	2,29,367 kgs. of yarn was produced (for 6 months)

Growth is not Productivity, but India can have both

To accelerate growth is not the same thing as to increase the utilisation of the existing resources, manpower, and capital capacity...By putting the idle resources to work, consumption can be increased both now and in future. The same is true of other measures to improve the efficiency of allocation of resources. We can all agree, I presume, on the desirability of growth measures free of any cost. If that is the meaning of growth policy, there is no issue.

For short periods of time, stepping up the utilisation of capacity can increase the recorded rate of growth of output and consumption. But over the decades fluctuations in the utilisation of capacity will have a minor influence compared to the growth of capacity itself. To express the same point somewhat differently, the subject of economic growth refers mainly to supply, or capacity to produce, rather than to demand. In the short run, accelerating the growth of demand for goods and services can, by increasing the rate of utilisation of capacity, speed up the growth of output. But in the long run, output and real demand cannot grow faster than capacity. If monetary demand is made to set a faster pace, it will be frustrated by a rate of inflation that cuts real demand down to size.—JAMES TOBIN of Yale University (*Papers and Proceedings of the 76th Annual Meeting of the American Economic Association*).

Scouring Schedule for Ring Frames

The quality of production in textile mills can be improved, and machine breakdowns reduced, if a systematic scouring schedule, embracing all departments, is introduced, as demonstrated here in respect of a batch of 36 ring frames.

RA Namasivayam *Madura Mills Co. Ltd., Tuticorin*

A PLANNED system of preventive maintenance in the textile industry is very essential as, owing to foreign exchange difficulties and indigenous manufacturers not being in a position to supply our demand of textile machinery, existing equipment has to be put to maximum efficient use. This calls for "scheduling" and "routinising" to keep the work-rooms and machines spick and span, besides sending people out to visit some of the best mills in order to learn about techniques or features of new machines and the ways adopted to maintain them.

The textile mills, on their part, should subscribe generously to technical and productivity journals, so that both management and technicians could keep themselves in touch with technical advancements at home and abroad. Suggestions for higher productivity, etc., even though emanating from a junior supervisor, should receive careful and sympathetic consideration from managements.

Table I on next page shows a scouring schedule for a batch of 36 ring frames (24 ring frames of A500, and 12 ring frames of four-roller drafting system). Such a schedule should be displayed conspicuously at the entrance to each and every department in a textile mill, so that even an ordinary maintenance man can understand the frames to be cleaned in a particular day. This will also

DAYS	CLEANING			ARBOUR OILING								
1	1	2	18	30	31	27	13	14	24	7	8	21
2	3	4	19	32	33	28	15	16	25	9	10	22
3	5	6	20	34	35	36	17	29	26	11	12	23
4	7	8	21	1	2	18	30	31	27	13	14	24
5	9	10	22	3	4	19	32	33	28	15	16	25
6	11	12	23	5	6	20	34	35	36	17	29	26
7	13	14	24	7	8	21	1	2	18	30	31	27
8	15	16	25	9	10	22	3	4	19	32	33	28
9	17	29	26	11	12	23	5	6	20	34	35	36
10	30	31	27	13	14	24	7	8	21	1	2	18
11	32	33	28	15	16	25	9	10	22	3	4	19
12	34	35	36	17	29	26	11	12	23	5	6	20

TABLE I

DAY	SECTION
7	C

TABLE Y

A	JOCKEY PULLEY CLEANING 48 DAYS—1,008 HOURS
B	POKER CLEANING 24 DAYS—504 HOURS
C	OIL CHANGING (SPDS)
D	POKER CLEANING 24 DAYS—504 HOURS
	TOPPING 12 DAYS—252 HOURS

facilitate easy checking by the technical staff. A maintenance force of seven men is engaged for this schedule. On a particular day they have to clean three frames, and to arbour oil nine machines. In addition, in one of the four sections A to D, they have to do spindle oiling or jockey pulley cleaning, etc., for the three frames.

Table Y shows the seventh day of cleaning in Section C—that is, during the seventh day of cleaning, the maintenance force has to clean machines 13, 14 and 24. Machines to be arbour oiled on that day are 7, 8, 21, 1, 2, 18, 30, 31 and 27.

Section C involves spindle oiling of frames 13,14 and 24, and after a lapse of 12 days, Section D is taken up. During the period, the poker rods are cleaned thoroughly with black lead powder. After a further lapse of 12 days, jockey pulleys in Section A are cleaned and greased, and Section B is attended to after yet another 12 days. During scouring, topping will also be done except on spindle oiling cycle. Roofs are cleaned once in six days by the same maintenance force.

Such a systematic schedule embracing all the departments will improve quality of production, and reduce machine breakdowns. Ring frames with medium counts and fine counts should be cleaned once in 12 days, and those with coarse counts once in six days, as ring frames are subjected to much accumulation of fluff.

Top rollers should be buffed once in six months as per a systematic schedule for cleaning. If possible, it is better to change the front and back top rollers (only in possible drafting systems) during every scouring. To facilitate this, top roller cots may be ordered in different colours. The best system of maintenance is by the cleaning gang system than to clean all the frames in one day.

Task of Maintenance of Machine-tools

...Machine-tools form an "important contributory factor" of most of the industrial units. They do need periodic attention, and LT Madnani formerly Chief Mechanical Engineer of the North-East Frontier Railway, describes a system of preventive maintenance which may be successfully adopted to keep a group of machine-tools in efficient working condition.

LT Madnani

General Manager, Oil and Natural Gas Commission, Baroda

CONTINUOUS efficient performance of an industrial enterprise depends on the setting up of a maintenance standard for machinery, which would avoid all reasonable chances of an unplanned shutdown. The best standards of performance can be achieved only by adopting a system of preventive maintenance—sometimes termed as pre-planned or progressive maintenance. The system is a logical development in a world of competition, as against the old idea of leaving well alone, and the reluctance to give attention to equipment until it broke down.

Preventive maintenance may be briefly described as a programmed withdrawal from use, for a definite period, of equipment for attention to prevent deterioration which may lead to loss in efficiency or breakdown. The nature of attention given at different periods progressively maintains the equipment to meet the required service efficiently. The system must cover all the contributory sections of the industry, and also every individual item of machinery and plant. A proper assessment must be made of the requirements of power, labour, floor space, maintenance stocks, etc., to meet the needs of the industrial unit. Care should, however, be taken to control the maintenance cost within the limits of economical production. Some authorities

recommend a ratio of maintenance labour force to plant labour force, or a ratio of maintenance expense to value of equipment. These would, however, vary with the nature of industry. Even for the same industry the ratio may be different in different countries.

A detailed check must be made of every machine or contrivance used for examining the functions of various components and subassemblies as parts of the major assembly, and a study must be made of the design features contributing towards the performance of the stipulated functions, particularly the stresses imposed which are likely to cause fatigue and failure. A scheme must be evolved to attend to the over-stressed components and assemblies before they break down. Deterioration usually sets in by one or more of the contributory factors, viz., impact, vibration, corrosion, erosion, and abuse. Attention given may vary from the simple task of providing a proper lubricant at the right time to undertaking of major overhauls giving a new lease of life.

The schedules of maintenance, labour force required, tools and materials necessary, etc., vary considerably in quality and quantity for different industries and size of the units. It is proposed to describe here a system of preventive maintenance which may be adopted successfully to keep a group of machine-tools in efficient working order. The system envisages periodical cleaning, lubrication, inspection, and timely attention to machine-tools. It is broadly divided into maintenance by the operator and maintenance by the preventive maintenance group under the direction of the Plant Engineer.

Maintenance by the operator: The operator should attend to the daily cleaning of the machine-bed and slideways, and lubricate the lubrication points including working surfaces. Where an oil-well is provided, he must check the oil level, start the machine and check the oil flow, before commencing the work. A defect in oil flow, and any defect experienced in working, must be reported to the supervisor concerned. To assist the operator, all

lubrication points should be painted in a distinctive colour. Points which must not be lubricated by the operator should also be suitably marked. To ensure that the operator does not grudge spending a little time daily in cleaning and lubricating his machines, particularly where a system of payment by results is in vogue, a suitable allowance must be made in the time study, and the operator made aware of it.

Maintenance by the preventive maintenance group under the direction of the Plant Engineer: The scheme may be divided into—(1) Daily schedule, particularly for vital, heavy duty or precision machines; (2) Weekly schedule; (3) Monthly schedule; (4) Quarterly schedule; (5) Six-monthly schedule; and (6) Annual schedule. The details of the schedules would vary with the nature of machine-tools. A general outline, which may be modified to suit local and particular conditions, is given below:

1. *Daily* (Maintenance group—in the case of vital, heavy duty machines)
   (a) Clean, oil and grease bearings and slides.
   (b) Check all bolts and nuts.
   (c) Check and lubricate main/counter shaft bearings.
   (d) Check safety devices and overload preventive devices, limit switches, brakes, etc.
2. *Weekly*
   (a) Check oil level and top-up (Maintenance group).
   (b) Check coolant (Operator).
   (c) Check and adjust gland packing wherever necessary.
   (d) Check relay contactors for motor and magnetic clutches.
3. *Monthly*
   (a) Check Suds pump and fittings.
   (b) Clean oil filter strainers, felt wipers, covers, oil slides, adjustment on slides, taking up slack in wedges and liners.
   (c) Check and adjust main clutch, clutch pins, clutch blocks, and brake.
   (d) Check and adjust self-action of slides and turret.
   (e) Check tension and adjust belt.
   (f) Grease all points where indicated.
   (g) Clean and refill coolant tank.
   (h) Check lubricating system and pipes for blocks.

   Quarterly
   (a) Clean and check spindle bearing of headstock and charge with lubricant.
   (b) Check tool posts and turrets.
5. *Six-monthly*
   (a) Lubrication—
      (i) Detail check and repair the lubricating system.
      (ii) Clean, flush and refill lubricating points.
      (iii) Clean, flush and refill feed drive unit.
   (b) Inspection—Check gear shafts, clutches and brakes, bearings, drive gears, shaft-bearing, tool posts, turret slide locks, lead screw, lubricating and coolant pumps, pipes and pipe connexions, tail stock, slides, beds, etc.
6. *Annually*
   (i) Check and adjust alignment.
   (ii) Joint inspection by Maintenance Foreman, Operating Foreman, and Electrical Foreman for alignment, speed and feed, load test, electrical drive and gear.
   (iii) Inspection of electric motors.
   (iv) Annual repair—limited overhaul of machine as may be necessary and as pre-planned, based on inspections carried out at previous periodical schedules, including electrical gear.

To ensure that all machine-tools receive necessary periodic attention, a programme must be drawn up jointly by the Plant Engineer and the Production Manager. The dates when the respective machines will be available for attention should be laid down. The weekly schedules may be carried out during week-days. The monthly, quarterly, and six-monthly schedules may be programmed, as far as possible, for week-ends and holidays to avoid loss of production. The annual schedule may be arranged to coincide

...a study of the repair work carried out can often lead to improvement in design of a particular aspect of the machine-tool which may be causing recurring trouble...

with the annual holidays. On the basis of "time required" to attend to the various machine-tools, they may be divided into broad categories to co-ordinate the preventive maintenance programme with the production programme. The progress of various schedules may be controlled by introducing a schedule board indicating the dates on which the different machine-tools are due for attention, and the dates on which they are actually attended to.

Preventive maintenance records: Proper records of preventive maintenance work must be kept. Firstly, the keeping of records ensures timely attention to the equipment, fixing responsibility for failures, and, secondly, a study of the repair work carried out can often lead to improvement in design of a particular aspect of the machine-tool which may be causing recurring trouble. A History Card should be introduced for each machine-tool. The cards may be grouped to suit the requirements. Each card, in addition to recording the maker's name, local agents, type or model, contract number under which obtained, brief specifications, details of accessories, etc., can also be used to indicate the particulars of maintenance work executed from time to time. An unplanned shutdown causing loss in production may be written in distinctive ink. Cost particulars can also be indicated commencing with the initial cost of the machine, and followed up by cost of repairs indicated as labour and material costs. As the machines get older, the History Card can be used to draw up reconditioning programmes or make replacements.

Reconditioning of machine-tools: It would be of advantage, particularly for a large industrial unit, to provide reconditioning overhauling facilities to avoid increase in capital cost and very often expenditure on foreign exchange. In deciding to take up a machine-tool for reconditioning, the following may be studied:

1. The History Card for repairs carried out over the years and the present condition.
2. Reports of the recent alignment tests.
3. The nature of work performed, and the extent of precision demanded from the machine-tool.

A critical study will reveal whether it would be desirable to procure a more modern machine-tool which may save in cost of repairs and expensive breakdowns, with perhaps increased out-turn resulting from improvement in design, and accuracy in working, or to recondition the existing asset. Reconditioning of machine-tools calls for the setting up of special facilities and training of staff.

The essential spares to be stocked may be conveniently divided under three categories A, B, and C. Category A includes mainly consumable items, which are subject to wear and sometimes breakdown without prior indication, such as belts, ropes, chains, leather buckets, washers, and carbon brushes. Category B includes items also subject to wear, but which do not require to be replaced frequently, and are normally attended to or replaced only during programmed maintenance repairs. Category C may include items not normally requiring replacement, but may have to be replaced due to accidental damage or gross abuse. A careful list of the three categories should be prepared by the Plant Engineer in good time to avoid a hold-up, and waiting for spares. Over-stocking of the spares should, however, be avoided to control locked-up capital. A large unit may consider the setting up of a plant drawing office section to prepare selected drawings of components of the equipment used particularly where the replacement parts are not procurable locally as a standard item, and have to be ordered or manufactured specially.

The task of maintenance has become more specialised with diverse manufacturing techniques. A plant engineer's range of work may broadly cover building construction and maintenance, mechanical and electrical equipment maintenance, plant safety, fire, theft and similar services, maintenance of yard and ground equipment, etc. Specifically it may vary from the simple task of keeping in operation a limited number of machine-tools to maintaining a complicated nuclear plant.

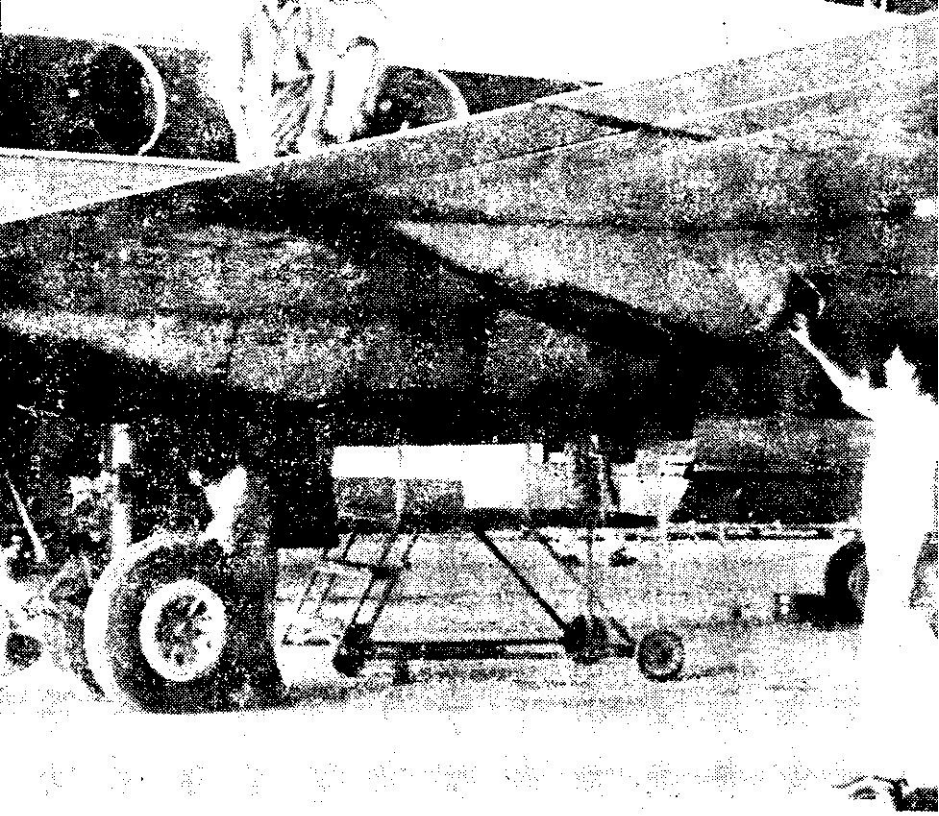
Role of Maintenance in Civil Aviation

JS Parakh

General Manager, Indian Airlines Corporation New Delhi

The task, role, and advantages of preventive maintenance in civil aviation are outlined in this paper by the General Manager of the Indian Airlines Corporation who points out that it plays a role second to none particularly when a round-the-clock operation is necessary with five different types of aeroplanes. IAC has recently set up Air Safety, Research, and Development Sections to conduct studies in the field of preventive maintenance, and it is pointed out that "systems of preventive maintenance can be more effective and efficient if IAC's fleet were to consist of only three types of aircraft."

PREVENTIVE maintenance is an effort to avoid the post-mortem as far as possible. Its task in aviation is twofold—peak maintenance on ground, and safe flying in air. It thus plays a vital role in civil air transport where maintenance of aeroplanes on ground ensures safety in flight and operational efficiency. As a tool of management, it has immense advantages in an airline industry, and these mainly (i) ensure safety in flight, (ii) enhance operational efficiency, (iii) provide comfort for passengers, (iv) prevent delays in departures, (v) afford confidence to operating crew and ground engineers throug intensive checks and counterchecks, (vi) cu



The Indian Airlines Corporation has its own sche maintenance. Before the commencement of a flight, a t the aircraft is made by qualified engineers. Above, e an aircraft.

repair costs, (vii) promote productivity, and (viii) bring about an educational advancement in the most advanced science of technology, viz., aeronautics.

Flight crew proficiency and expert ground engineering service are the two essential pre-requisites of preventive maintenance in civil aviation and human talent has to be trained to the maximum possible ex the tempo of the pre-re highest pitch.

The Indian Airlines Co is a public utility corporati fleet of 65 aeroplanes con Caravelles, 12 Viscounts, 10 ships, three Skymasters, and 3

Check of engine

primary function of the airline is to provide safe, efficient, adequate, economical, and properly co-ordinated air transport service at reasonable charges. Towards the attainment of these goals, preventive maintenance plays a role second to none, particularly when a round-the-clock operation is necessary with five different types of aeroplanes.

In the aircraft industry, it is an accepted service policy to include in the aircraft purchase training of flight crew and ground engineers of the user airlines. Further, the manufacturers provide the airlines with maintenance manuals and other bulletins dealing with the latest developments and modifications as an educational service.

Whenever a new type of aircraft is purchased, IAC takes advantage of such technical services which are a part of the aircraft purchase contract, by deputing selected flight crew and ground engineers for intensive training with the manufacturers abroad.

A larger number of trainees cannot be deputed owing to a policy of conserving the country's foreign exchange. After training, these trainees act as instructors to train the required number of pilots and engineers at the training establishments set up by the corporation in the country. This system of pilot-to-pilot and engineer-to-engineer training, however, has proved a success in IAC resulting in intensive specialisation.

Refresher courses for these key personnel are also conducted as a part of the continuous training programme organised by the corporation at Begumpet, Bombay, Calcutta, Delhi, and Madras. Throughout the training programme of each pilot and engineer, IAC lays emphasis on safety in flight, operational efficiency, and passenger comfort.

Before the commencement of a flight, a pre-flight or a transit check is carried out by qualified engineers. The commander of the aircraft then checks up its functioning through the medium of instruments installed in its flight deck. The Controller of Aerodrome gives the clearance for take-off and landing of each flight. Before take-off and landing, passengers are requested to fasten belts for their comfort and safety.

The maintenance of an aircraft is not merely dependent on how the engineers maintain it on ground, but also on how the crew operate it in the air. Therefore, the engineering and operating personnel are equally responsible for the promotion of preventive maintenance in IAC. The Department of Civil Aviation, Government of India, besides exercising a general control, (i) grants the certificate of airworthiness of the aircraft, and (ii) issues licences to the pilots and engineers after prescribed periodical checks and examinations. The pilots are required periodically to undergo rigorous medical tests to be fit to fly an aircraft.

Airframes, engines and various accessories are inspected and overhauled at prescribed intervals. Besides inspection by the Civil Aviation Department, IAC has an engineering inspection department of its own to follow up the system of preventive maintenance. Even new spares are inspected before they could be used on the aircraft. At the time of each progressive check or overhaul every endeavour is made to restore the aircraft to its original condition. Maintenance inspection and overhaul involve costly equipment. The Directorate of Meteorology and Observatories also

...that a Viscount engine, which was overhauled at the expiry of 1,400 hours in the initial years of introduction, is now being overhauled after every 4,000 hours of use, merely illustrates how efficiency is achieved by the introduction of preventive maintenance...

Cockpit check

helps the operating crew in ensuring safety in flight.

Modifications to aircraft, prescribed by the manufacturers, are carried out whether they are mandatory or desirable. During the life-time of an aircraft, such modifications, which may cost several lakhs of rupees, are made for the safe and efficient operation of the aircraft, even if it means a cut on the pay-load. No money or means are spared to ensure cent per cent safety in flight.

IAC has recently set up Air Safety, Research and Development Sections to conduct studies in the field of preventive maintenance. The causes of accidents to aircraft both in the air and on the ground are thoroughly investigated, and the conclusions drawn are used to minimise mishaps in future.

Inspection Pattern

Various systems prevail pertaining to actual fitment of inspection schedules into the operational pattern, and these vary from airline to airline depending on the utilisation of the aircraft and operational conditions. But most of the operators, including IAC, follow the pattern given below with slight variations:

a) A Pre-flight Inspection is carried out just prior to the first flight of the day.

b) At all transit stations a Through-flight Inspection is carried out each time an aircraft lands.

c) Every time an aircraft returns to base after completing its rounds for the day, a Night Stop routine, also known as Terminal Check, is carried out.

d) There is also a Trip Inspection System which is followed on the basis of flying hours or the elapsed number of days ranging from 30 hours/6 days in the case of Dakota to 100 hours/20 days in the case of Caravelle aircraft. A majority of the world's airlines follow this system with slight variations, and instead of "Trip Certificate" they term it as a "Maintenance Release".

e) Then there are more and more elaborate inspections to be carried out periodically, the quantum of inspection increasing from Check I to Check IV, the latter being a very major check. The life of these checks once again varies with the type of the aircraft.

Besides these routines on airframes and periodical engine overhauls, hundreds of components and systems have to be similarly treated; each little part is dismantled and subjected to a most meticulous inspection.

The progress of preventive maintenance can be measured by setting norms. In IAC, for example, a Viscount engine, which was overhauled at the expiry of 1,400 hours in the initial years of introduction, is now being overhauled after every 4,000 hours of use. This merely illustrates how efficiency is achieved by the introduction of the preventive maintenance system. Similarly, there are periods stipulated between various checks and overhauls of the airframe. To endeavour constantly to obtain from the Civil Aviation Department longer leases on each overhaul is the target, and when a lease is lengthened it is a token of the effectiveness with which preventive maintenance is carried through.

While preventive maintenance has many advantages, it has certain achievement-limitations in a country like India which has to depend upon more advanced countries for the acquisition of technical skills which are rapidly changing from day to day. Not being a manufacturing country, techniques in India in the field of aeronautics have to be acquired at the maintenance level, instead of the basic stage of manufacture. Then there are the peculiar operating conditions in IAC which have to be reckoned

Each part of an aircraft is subjected to a most meticulous inspection. The check before take-off is so rigorously done that nothing is left to chance.

with. The airline has been operating with five different types of fleet consisting of piston engines, turbo-prop, and pure jet aircraft. Indian Airlines, being the integrated corporation of eight different former airlines, has, of necessity, to base its aircraft at five different places operating the network all over the country. Diffusion of location prevents acquisition of more intense technical knowledge from the point of view of specialisation.

Systems of preventive maintenance can be more effective and efficient if IAC's fleet were to consist of only three types of aircraft. Steps to standardise the fleet are under constant attention, although the problems needing solution are rather complicated. Further the specialised technological skill involved in operating and maintaining an aeroplane demands payment of higher salaries and allowances than in other industries. The corporation has already agreed to provide alternative employment or compensation to pilots declared medically unfit for flying, in order to create a proper psychological climate promoting safety of operations. Proposals are under consideration even to reduce their hours of working. All this costs more money to the corporation in achieving its aims at promoting and maintaining the highest standards possible for the development of civil aviation in which safety in flight, comfort for the passengers, and operational efficiency are of paramount importance.

Maintenance in TVS Road Transport

. . . Here is an analysis of the impact of preventive maintenance on the operational efficiency and greater productivity of a motor transport fleet and organisation in South India. The author refutes the arguments put forward in favour of non-docking through citation of experiments and practices, and the results achieved by way of substantial economies, etc., are indicated. "It will be clear," he says, "that each link in the chain of preventive maintenance programme has been tested and proved of carrying the load, resulting in efficiency."

V Gopalan

Works Manager
TVS & Sons (P) Ltd.
Tirunelveli

AN EFFICIENT transport workshop is the real economic base of a road transport organisation. Just as the human body requires care and nourishment, so also vehicles need daily attention through preventive maintenance; otherwise, they rapidly deteriorate and even go out of commission.

Preventive maintenance entails docking at regular mileage intervals. Some arguments, however, put forward in favour of non-docking are:

1. The latest models are specifically designed for reliable operation. With high and rising operating costs, docking is uneconomical because a vehicle on the road earns, whereas a stationary vehicle does not.

2. Further, the normal mileage-based docking does not take into account the factor of terrain over which the vehicle has worked or the loads it has carried.

3. A maintenance scheme cannot take into account the unpredictable failures of material: as such there is no point in aiming at perfect reliability, but only at the best standard which can be achieved economically.

4. The system of ad hoc repairs saves money, labour and time, and "maintenance

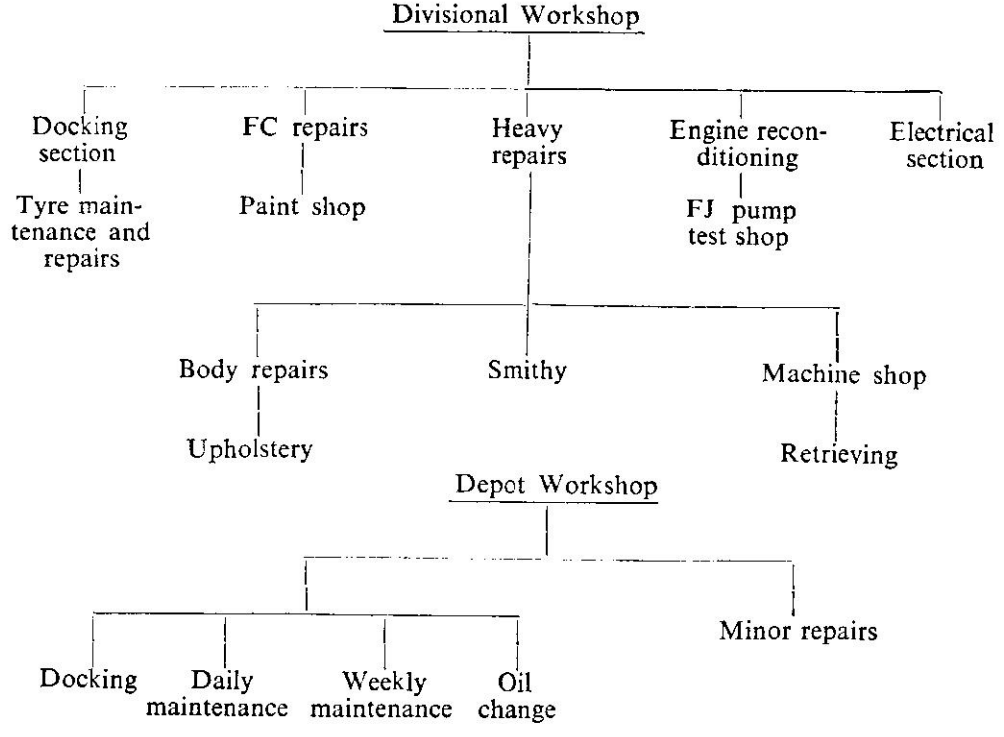
by inspection"; judged by the severity of route, type of service, loading, and also appearance, the smell and sound of the engine are a more workable basis than a conventional preventive maintenance programme.

Results

The arguments detailed above look convincing. This paper is an attempt at refuting them through citation of experiments and practices, for we have in our workshops almost religiously implemented a plan of preventive maintenance. The results achieved are recorded below.

Till recently, there was no method as such in vogue in the transport unit, except that every vehicle was attended to whenever it broke down or called for major repairs. One workshop was in charge of all vehicles, and there was neither proper allocation of work nor co-ordination nor specialisation of jobs. The methods introduced in the new system are:

1. *Rationalisation of workshops:* To have efficient and effective control over labour, consumption of spare-parts, etc., the workshop was divided into two major units—the divisional or district workshop, and the depot. Approved repair schedules were introduced at depot and divisional workshops, so that specialised and skilled jobs were done at the divisional workshop, and minor repairs and simple lubrication at the depot. Rationalisation on these lines determined the degree of efficiency of the entire system.



2. Staff structure and allocation of work classification of mechanical staff:

1. *Head Artisan*	2. *Artisan A*	3. *Artisan B*	4. *Asst. Artisan*	5. *Helper A*	6. *Helper B*
a) Mechanic	a) Mechanic	a) Blacksmith	a) Mechanic		
b) Electrician	b) Electrician	b) Tinsmith	b) Electrician		
c) Blacksmith	c) Blacksmith	c) Carpenter	c) Blacksmith		
d) Turner	d) Turner	d) Painter	d) Turner		
e) Welder	e) Welder	e) Upholsterer			
		f) Vulcaniser/ Tyre fitter			
		g) Bench fitter			
		h) Welder			
		i) Body fitter			

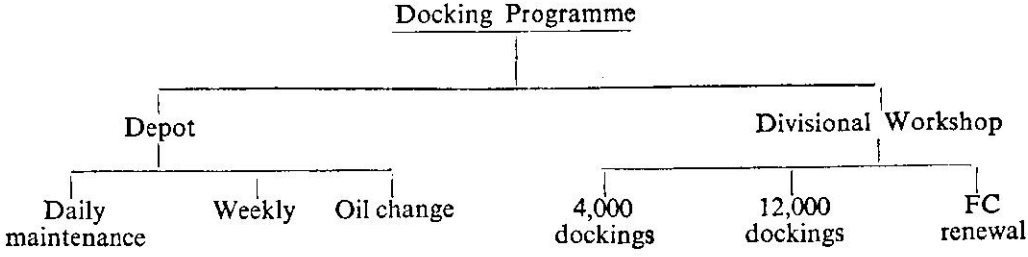
Structure—Workshop and Depot:

Divisional Works Superintendent

Depot—Supdt./ Manager	Divisional Workshop— Asst. Works Supdt.
Foreman	Chargeman/Foreman
Head Mechanic	Head Mechanic
Artisan A	Artisan A
Asst. Artisan	Artisan B
Helper A	Asst. Artisan
Helper B	Helper A
	Helper B

The allocation of mechanical staff was based on the number of traffic schedules; while the divisional workshop was allotted 1.0 man per schedule, the depot had 1.5 men per schedule. By schedule is meant the operation fixed for a vehicle for a day which is made up of one or more trips on one or more routes. Casual operation given to a vehicle would be termed as extra schedule.

3. *Docking programme:* Progressive implementation of the preventive maintenance system was done by the docking programme as indicated below:



The details of work to be done on daily, weekly, 4,000 and 12,000 (mileage) dockings are given separately.

4. *Workshop records:*

(a) *Preventive maintenance chart:* This is a form with three horizontal columns—the first one records the daily mileage performed, the second indicates the programme mileage, and the third the oil change mileage. The programme mileage indicates the mileage from one dock to another, that is, 0 to 12,000 miles, and this would contain two 4,000 dockings in between. Whenever these dockings are attended to, a red square is indicated for 4,000 dockings, and blue for 12,000 dockings. In the same way, whenever oil is changed, it is marked "E" with red pencil, and the mileage after oil change starts again from zero. Weekly inspection is indicated by the letter "W", and this is done every seventh day. It is an important guide for programming preventive maintenance for vehicles on a mileage basis.

(b) *Workshop diary:* This is a record which controls the workshop turnover and production, and the details indicated are vehicle numbers, date 'In' and date 'Out', repairs and maintenance carried out, etc. This is daily kept uptodate, so that it can be checked, and undue delay for any reason investigated. It is maintained both at the divisional workshop and the depot.

(c) *Logsheet defect report:* This document is supplied for each vehicle to a driver who checks up the list of items mentioned. At the same time he can record the defects and deficiencies of the vehicle, so that the Depot Manager can attend to them. In case of accidents owing to mechanical failure, it serves as a certificate for the mechanical condition of the vehicle, and in depot it greatly helps the mechanic to attend to the specific defects mentioned. Besides, it also gives the mileage performed by each vehicle and the fuel consumed, so that the performance of the vehicle could be watched.

(d) *Vehicle logbook:* This gives a complete history of the mechanical maintenance of the vehicle recorded throughout its life-time. The important details are: specifications and departures; standard fittings; certificate of fitness; record of mileages MPG, fuels and oils; record of engine oil changes; oil changes in gear box, steering and rear axle; record of periodical docking; engine repairs; chassis repairs; body repairs; battery record; change of units like engine, gear box, rear axle, starter, dynamo, radiator, FJ pump and servo unit assembly; and major accidents.

(e) *Important feed-back returns:* (1) Progress of periodical maintenance/4,000 and 12,000 dockings; (2) Report on the progress of top overhaul of engines; (3) Report on the 12,000-mile dock and RTO passing of vehicles; and (4) Vehicle History Sheet. These returns, no doubt, keep a check on whether the preventive maintenance system was strictly enforced or not, and in case of delay the matter could be investigated and remedial action taken.

5. *Incentive awards:* It is the experience

. . .It is the experience of our organisation that best attendance awards, incentive awards for individual merit and performance, and personnel publicity in transport house journals pay high dividends. . .

of our organisation that best attendance awards, incentive awards for individual merit and performance, and personnel publicity in transport house journals pay high dividends. Coffee is served free to night-shift workers, and gum boots and gloves are supplied to those who have to work continuously in water. To reduce fatigue, night duty is arranged in rotation.

6. *Disciplinary action:* Disciplinary procedures have been laid down and their strict enforcement has yielded results as evidenced in the statistics given below:

Period	Warning issued	Fines	Suspensions	Recoveries	Dismissals and terminations	Filed	Total
1st 6 months	186	97	4	69	1	8	365
2nd 6 months	74	39	1	36	—	7	157
3rd 6 months	7	32	3	22	2	4	70
Total:	267	168	8	127	3	19	592

7. *Safety methods:* Periodical inspection of machinery includes the safety aspects of machinery, and exhibition of huge safety posters at prominent work places, besides the exhibition of films bearing on the subject which contribute much to make the employees safety-conscious.

8. *Standardisation of vehicles:* The old system of 11 to 12 different makes of vehicles has been reduced to three standard makes, so that a uniform maintenance policy could be effectively introduced.

9. *Stores organisation and control:* Stores organisation and control form a very important part of the preventive maintenance programme. Stores are so organised as to have no standstill. Calendar indents on spare-parts have been introduced, and the quantities required are indented in time based on the consumption of the previous six months. Consumable items like oils, tyres, batteries, cotton waste, and nuts and bolts are ordered on a monthly repeat basis, so that there may not be any hold-up. Norms have been fixed so that consumption can be watched.

10. *Industrial relations:* The Labour Union has been taken into confidence and periodical review meetings are held to get their cooperation to make the preventive maintenance programme successful. Technical classes are conducted for the benefit of mechanics, as also for all levels of supervisory staff.

11. *Machine replacement and retrieving:* Defective machines are generally rectified by retrieving the component to reduce the cost; and very old machines with defective performance are discarded, if they cannot be corrected. The lay-out of the machine shop, with suitable lighting and aisle lines, has made the working easier. Tool-boxes are renewed and recouped whenever necessary. An analysis of maintenance failures on components has been done, and this has brought to the notice of the mechanical staff matter for immediate corrective action.

The results of this planned progressive preventive maintenance policy have resulted in substantial economies as shown in the following operational statistics:

1. *Road breakdown:*

A breakdown is defined as "detention of a vehicle caused by a mechanical defect or a defect of the fuel system or a tyre failure which renders the vehicle immobile or unfit for

continuation of the scheduled trip, without attention to it."

	Per 10,000 miles
Before the introduction of preventive maintenance	13.64
After the introduction of preventive maintenance—	
First year of operation	5.03
Second year of operation	4.70

2. *Fuel consumption (MPG):*

The total gross mileage covered by the vehicle (during specific trip) divided by the consumption of fuel during the corresponding period is termed as miles per gallon.

	MPG (Diesel)
Prior to the introduction of preventive maintenance	11.06
After the introduction of preventive maintenance—	
First year	12.67
Second year	13.36

3. *Cost of operation:*

The cost per mile (spare-parts expenditure to effective mileage done) is given for about eight quarters which will testify to the effect of the preventive maintenance policy.

1st quarter	7.12 paise	Prior to the introduction of preventive maintenance
2nd -do-	6.58 „	
3rd -do-	6.47 „	
4th -do-	6.12 „	
5th -do-	6.53 „	After the introduction of preventive maintenance
6th -do-	5.57 „	
7th -do-	5.35 „	
8th -do-	5.13 „	

4. *Tyre performance:*

	Preventive maintenance		
	Prior to introduction	After introduction	Improvement %
New tyre mileage	42,622	46,528	
Retread mileage	22,463	29,183	

5. *Battery performance:*

Average mileage	32,876	49,519	

6. *Overtime payments:*

Prior to the introduction of preventive maintenance	0.06 of the total expenditure
After the introduction of preventive maintenance	0.001 of the total expenditure

From these results of performance, it will be clear that each link in the chain of planned maintenance programme has been tested and proved capable of carrying the load, resulting in efficiency. The ideas and methods implemented can be safely recommended, provided they are followed up with enthusiasm. Until a determined effort is made in this direction, industry will continue to languish.

Maintenance Problems in Chemical Plant

Plants are highly sophisticated and instrumented in any modern chemical industry, and, not unnaturally, the problems of their wear and tear are complex. Preventive maintenance schedules for a chemical factory, therefore, "have to be built up for each individual machine, co-ordinated for each plant, and then for the entire factory as a result of experience and study of the actual working conditions."

ML Leekha

Chief Mechanical Engineer
FCI, Nangal Unit
Naya Nangal

ALL OVER the world the chemical industry is comparatively new, but particularly in the industrially advanced countries it has developed rather fast. In India, though this industry is yet in its infancy, it is gradually assuming greater importance in the nation's economy.

Chemical industries involve lot of sophisticated equipments, ranging from miniature electronic devices to huge compressors, turbines, towers, material handling equipment, etc., for the erection and maintenance of which mechanical engineers have to play a vital role. The problems of wear and tear of the equipments are complex, and call for greater familiarity on the part of the mechanical engineers and supervisors with knowledge of specialised production techniques.

Beyond designed estimates not much can be done to increase production in chemical industries, as the equipments are usually made to maintain specified flow conditions. Serious difficulties are encountered when the flow system breaks down. To maintain production targets, the shutdown periods should be minimised through preventive maintenance.

Though the preventive maintenance of machines is similar in various industries,

chemical industry has problems of its own. Enemy number one in any chemical industry is corrosion. Metal failures occur either owing to cracking from stress corrosion or eating away of the metal because of electro-chemical corrosion. Strong acids and alkalies are often handled at high temperatures, and the behaviour of different metals under such conditions is quite peculiar. Carbon steels may fail due to intergranular cracking when under nitrate action, whereas the pattern of failure may be transgranular when in contact with certain other chemicals. Though these effects are well known, the correct remedies are still difficult to arrive at.

The Nangal Fertiliser Factory faces the same difficulty. Electro-chemical corrosion in the electrolysis plant draws rather heavily on the plant maintenance team, for it vitally affects the output of the end-product. Chemical and stress corrosion are also being experienced in nitric acid and other plants.

Premature Failures

High, fluctuating pressures cause fatigue of parts, and premature failures. Vibrations, which are associated with high pressure machines, if not suitably damped, are transmitted to various pipes and structures which endanger the equipment and building, and further promote fatigue failures. All these call for vigilance on the part of the maintenance team. Excessively high temperatures also cause the parts to fail under creep. On the other hand, at very low temperatures, now encountered in chemical industry, even the best materials lose their tensile strength and impact resistance. The jugglery of pressures and temperatures are the two important tools available to this industry for combining the elements.

A maintenance engineer has to devote special attention to several hazards peculiar to the chemical industry. Some of the important hazards are due to

(1) Errors in design, such as inadequate radii on the bends of high-pressure pipes, lack of safety valves, rupture discs and vents lines. These are detected gradually as the factory assumes full production.

(2) Mal-operation—due to human error—of automatic equipment causing equipment

Demand for Soviet Productivity

The demand for Soviet books on technology and science is on the increase in India—particularly those on higher physics and steel technology. English translations of Soviet scientific books have been prescribed in the academic courses of many universities and technological institutions in India this year. In all, 30 new Soviet books have been prescribed for study in the various Indian universities in the current academic year. There are 54 other Soviet books on technology and science which are being used by college students in India.

There is also a reverse flow of material from India to the Soviet Union, but it all consists of literary publications, and it is the Soviet Union which has got the Indian books published in Russian languages. Between 1948 and 1963 over 500 books by 17 Indian authors were published in 32 Russian languages, with editions running into 20 million copies. Intensive work on Indian literatures and languages is now being carried out by eight institutions of higher learning in the Soviet Union.

failures from under and over-pressures, water hammers, etc.

(3) Use of defective or improper material.

(4) Corrosion, especially in the bends of high-pressure piping systems and turbine blades.

(5) Carry-over of process materials or over-filling of vessels with liquids, overlooking the subsequent disastrous effects of thermal expansion.

(6) Explosions and detonations resulting from the entering of static electric charges, if the protections and the earths fail to function.

(7) Any other reasons like improper make-shifts, negligence in controlling machinery vibrations to safe limits, ignored high-pressure system leakages on steam, corrosive liquids, or other explosive gas mixtures.

In certain plants, the wear and tear is high owing to the effect of handling of abrasive materials. In such plants if the bearings, etc., are not sealed properly, they have a much lower life than the normal.

Another typical problem is that the production starts after certain conditions of temperature, pressure, etc., have been reached. Thus even if an equipment might be under forced shutdown for only one hour, it may not produce for three to four hours, till those specified conditions have been re-established. This further indicates the need of preventive maintenance.

Economies in maintenance costs can be exercised by using the modern inspection and diagnosing tools like vibroscopes, ultrasonoscopes, industrial stethoscopes, and dye-penetrants which are speedy and do not need equipment stoppages. To cite an example, it is a big job to measure the thickness of a boiler-drum at various places, as it involves the opening of pipes, man-holes, etc., purging it and making it safe for men to go in and then re-assemble the whole system and put it in line. With the help of the ultrasonoscope, however, it is only a matter of minutes. Therefore, in chemical industries, where corrosion eats up the metal shell so often, the ultrasonoscope is a handy tool for inspection, and for keeping a reasonably close watch. Normally, for a chemical factory, ready-made preventive maintenance schedules cannot be had off the shelf: these have to be built up for each individual machine, co-ordinated for each plant, and then for the entire factory as a result of experience and study of the actual working conditions.

In chemical industry, usually the output of one unit is fed to the next to get the end-product, and the process is continuous. In these circumstances, one unit cannot be taken out of the production line without affecting the stream as a whole. As such, the scheduling for repairs, adjustment, and inspection has to be linked up and dovetailed to keep the production loss to the minimum. While doing so, the schedules are made slightly flexible: if, for instance, a change of part of one equipment is due a fortnight after it is due in respect of another equipment in the stream, the job will be accomplished in one shutdown only. This means that either the job has to be done a little ahead of schedule or it has to be delayed slightly to suit the conditions of the stream as a whole.

In any modern chemical industry, the plants are highly instrumented and provided with automatic super-checks through recorded or visual indications about the health of connected equipment, and can be fully relied upon. These must, however, be maintained in perfect working condition as otherwise the operations can become extremely hazardous. The staff must be fully trained in their use, and made conscious of the delicate nature of such appliances.

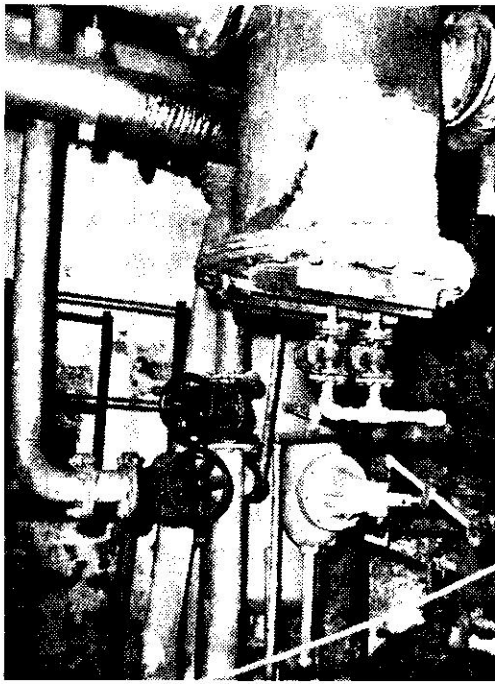
Preventive maintenance in any chemical industry is, therefore, a streamlined system of inspection, planning, scheduling and executing, the success of which depends upon the simultaneous and proper execution of individual functional responsibilities. Even if one link in the chain is weak, the whole programme may crash: hence an appropriate investment in preventive maintenance will pay dividends particularly in the chemical industry.

Only in recent years has preventive maintenance been introduced in industrial enterprises as a systematic and economic concept. Above, a group of preventive maintenance engineers in a chemical factory analysing a typical breakdown of equipment.

Photo Feature on Preventive Maintenance

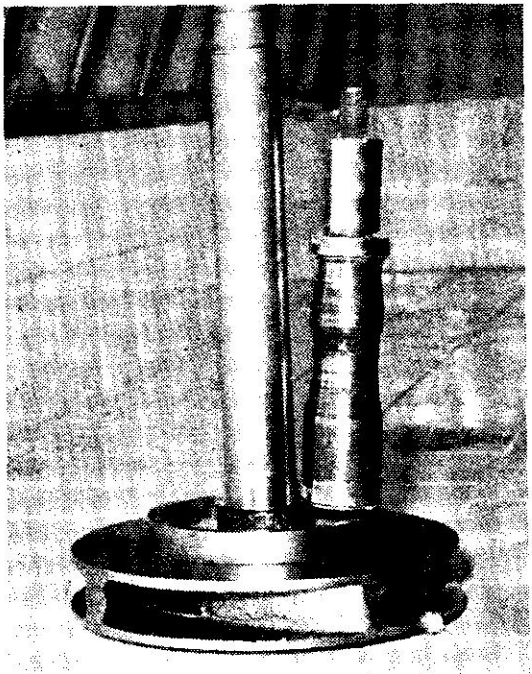
It has been estimated that about 40 per cent of the breakdowns in any industry are associated with lubrication. Periodic attention to lubrication is a vital aspect of any preventive maintenance programme. Left, a preventive maintenance worker attending to lubrication of bearings of a boiler travelling grate.

CORROSION...CORROSION...CORROSION...



Corrosion is Enemy No. One in any chemical industry. Metal failures occur either owing to cracking from stress corrosion or eating away of the metal because of electro-chemical corrosion. A maintenance engineer has to devote special attention to several hazards peculiar to the chemical industry. *Left*, corrosion of brine storage tank in a chemical factory. *Above*, views of corrosion of equipment during the manufacture of caustic soda.

Corrosion Prevention: *Dicyclohexyl ammonium nitrite—Vapour-Phase Inhibitor (VPI)—effectively prevents corrosion of ferrous metals for a long period. Unlike conventional inhibitors, VPI does not seek to exclude moisture or air, but is efficacious in the presence of both. What happens is the solid VPI powder vaporises slowly, the vapours surround the metal and are deposited on it, thus inhibiting that metal surface from corrosion.* **Above,** *the m.s. plate in box containing VPI bag (right) is still shining after six years, whereas the plate in box without VPI (left) is covered with a thick layer of rust. Both the plates were originally cleaned to the same degree.*



Scoured shaft of a centrifugal pump placed along with a new shaft—result of over-tightening of gland packing.

Maintenance System in DCM Chemical Plant

The success of preventive maintenance, as against breakdown maintenance, in the DCM Chemical Plant, is because of the "effective support given by the top management to this activity." The organisational set-up of its Preventive Maintenance Department, and the respective duties of the preventive maintenance engineers and attendants are detailed in this paper which points out that the results of preventive maintenance organisation in any unit "cannot come within a few days or a few weeks, and, therefore, in the initial stages, a continuous encouragement is vital to the success of preventive maintenance."

A GOOD maintenance system is vital for continuous production in any industry. But however efficient and effective this system may be, it cannot work alone to give continuity of operation particularly in chemical industry where corrosion due to acids and alkalies is the biggest single problem to be tackled. The detrimental effects of corrosion can be assessed and forecast only by a regular system of extensive checking and inspection, and follow-up action. The latest thinking on preventive maintenance is to bring about reduction in the volume of maintenance work by improvements in lay-outs, better designs, and better selection of materials of construction.

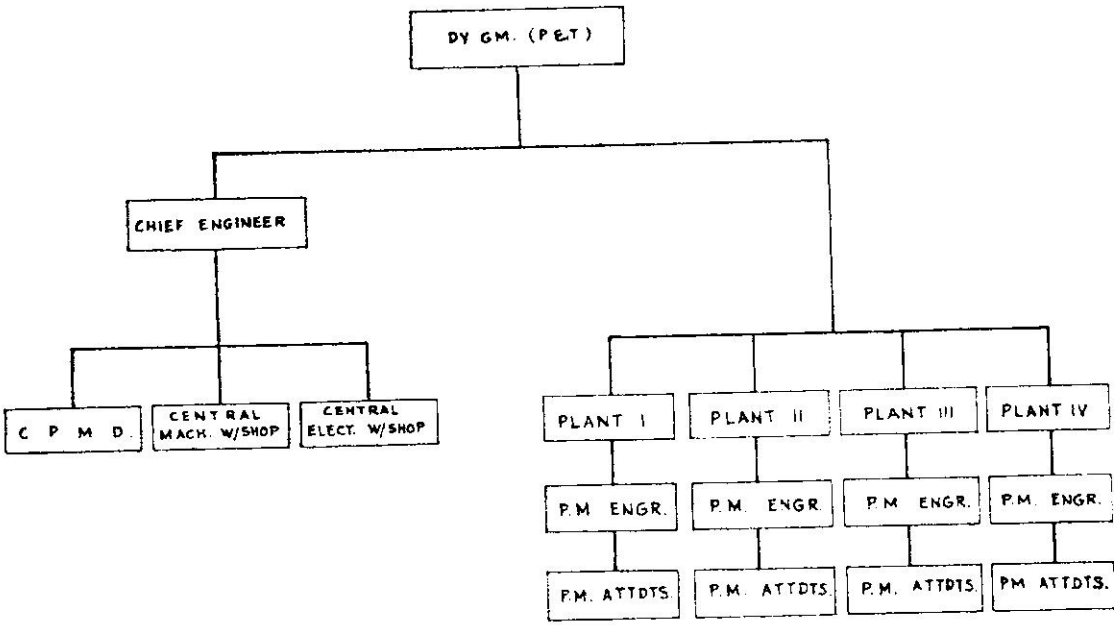
The preventive maintenance set-up in the DCM Chemical Works is on a mixed pattern of centralised and plant/areawise systems. The organisational chart is given in Table I.

Every plant/section has got a Preventive Maintenance Engineer, who is assisted by a crew of attendants, to carry on preventive maintenance work at the plant level. The Engineer, while working under the production chief, plans his maintenance work according to production schedules. The preventive maintenance crew carries out scheduled internal and external inspections and checkings inside the plants, but for overhaulings and repair jobs the crew approaches the central workshops.

There is a Central Preventive Maintenance Department, working under a Chief Engineer. The functions of this department are totally

TABLE I

PM ORGANISATION IN DCM CHEMICAL WORKS



of an advisory and consultative nature, and co-ordination of work between the Preventive Maintenance Engineers of various plants and the Central Mechanical or Electrical Workshops.

Duties

The Preventive Maintenance Engineer and attendants in the plants are responsible for:

(i) Cleanliness of stationary as well as moving equipment, house-keeping, lighting, and ventilation.

(ii) Check-charts: Filling in of external check-charts and of periodic internal check-charts; and action on abnormalities. (Specimens of check-charts are given in Tables II and III.)

(iii) Lubrication: Selection and use of proper lubricants, drawing and following up of lubrication schedules, and proper and clean storage of lubricants.

(iv) Painting of moving equipment: Study of colour schemes for stationary and moving parts for vessels and service lines, and selection of paint as protective coating against alkali or acid corrosion.

(v) Minor adjustments of machines, like tightening or renewal of gland packings, belt adjustments, etc., rousing of valves and their replacement, and other emergency jobs of minor nature.

(vi) Equipment classification according to the criticality of the equipment, depending upon how frequently an equipment can be taken out of line without affecting production.

(vii) Scheduling: Planned stoppage of the equipment for inspection and

TABLE II

Preventive Maintenance Department

Daily Check Chart For Centrifugal Pumps

Plant_____ Section_____ Date_____

HINTS FOR CHECKING ITEMWISE:

Time i)_____ A.M.

ii) _____ P.M.

1. Dirty, Oily, Moisture.
2. In position, Condition.
3. Bolts, Alignment, Sound.
4. Locate the source if possible.
5. Temp., Leakage, Sealing.
6. Drainage.
7. Hot, Sound, Grease, Endplay.
8. Leakage, Temp., Sound.

9 & 10. Pressure, Flange leakage.

Use symbols as: O.K. ✓; Abnormal X; Out of commission O; Not provided or cannot be checked —.

Code No.	(1) Clean-liness	(2) Guard	(3) Coupling	(4) Vibration	(5) Glands	(6) Gland Pocket	(7) Bearings	(8) Impeller Casing	(9) Suction	(10) Discharge

Remarks and action taken:

P. M. Attendant _____

P. M. Foreman _____

TABLE III

Preventive Maintenance Department

Daily Check Chart For Motors & Starters

Plant_____ Section_____ Date_____

Time i)_____ A.M.

ii)_____ P.M.

HINTS FOR CHECKING:

1. Cleanliness (Dirt, Moist, Oil, O.K.)
2. Temperature (Hot, O.K.)
3. Sound (Humming, Noise, O.K.)
4. Bearing (Hot, Leaky, Noisy, Endplay, O.K.)
5. Lubricate accordingly.
6. Guard (out of position O.K.)
7. Junction Box Cover (tight, loose or missing)
8. Locate source if possible.
9. Check connections.

Use symbols as : O.K. ✓; Abnormal X; Out of commission O; Not provided or cannot be checked—.

	MOTOR												STARTER			
Code No.	H. P.	Rated Amps.	Load Amps.	1 Cleanliness	2 Body Temp.	3 Sound	4 Bearings	5 Lubrication	6 Guard	7 Junction Box	8 Vibration	9 Earthing	1 Cleanliness	2 Temp.	3 Sound	Remarks

Detailed remarks and report:

P. M. Attendant_____

P. M. Foreman_____

overhauling, and programming for the next overhauling and/or repair job.

(viii) Spares: Maintenance of a list of the spare-parts corresponding to the criticality of the equipment.

(ix) Maintenance records: These records are essential to carry out preventive maintenance work effectively: These records include mainly—(a) equipment data sheets and job histories (See Tables V and VI); (b) equipment and spare-parts drawings; (c) instruments manuals; (d) drawings and sketches arranged equipmentwise and sectionwise; and (e) breakdown/shutdown records incorporating the expenses incurred.

(x) Maintenance control on repair and maintenance expenses; and planning and budget forecasting.

(xi) Safety of men and machinery which involves proper functioning of our switches, alarms, and guards.

The Central Preventive Maintenance Department, whose functions are of an advisory nature, guides plant preventive maintenance crews, in planning their work. Its other activities are:

(i) Receiving and analysing of breakdown reports from plants. When the breakdowns are repetitive and of a serious nature, CPMD invites all the persons concerned and tries to find out the cause of breakdown through group discussions. A specimen of the breakdown report form is given in Table IV.

(ii) Receiving and analysing of statements from plants relating to repair and maintenance expenses.

(iii) Helping plants in devising external and internal check-charts, and schedules for periodic and planned overhaulings.

(iv) Devising check-charts, lubrication and inspection schedules for new machinery and equipment.

(v) Surveys and standardisation of Preventive Maintenance Stores like V-belts, bearings, packings, jointings, paints and tools—to ensure interchangeability and better store inventory control.

TABLE IV

BREAKDOWN & STOPPAGE REPORT

(To be filled in all cases resulting in cessation of production, plant stoppage, major equipment failures; and sent within 48 hours of occurrence.)

Plant _____ Date _____

Section _____ Shift _____

Equipment (Name, No. & Location) involved _____

Time of occurrence _____

Expected/Actual time of resumption of operation/production _____

Nature of breakdown/stoppage _____

Total period of stoppage _____

Progressive monthly stoppage _____

Progressive yearly stoppage _____

Estimated/Actual loss of production _____

ANALYSIS (in case of breakdowns only)

1. Defective material of construction _____
2. Defective design _____
3. Defective duty selection _____
4. Defective workmanship _____
5. Defective installation _____
6. Defective operation _____
7. Defective maintenance _____
8. Bad lay-out _____

Action taken and suggestions for avoiding recurrence (Attach separate sheet if necessary).

I/c C.P.M.	I/c Plant PME/PMF	Plant Supdt.	C.E.	D.G.M. (P & T)

Copies to:

1. Head Office (Chemical Section) /G.M./DGM-PT/C.E./Plant.

TABLE V

PREVENTIVE MAINTENANCE

MOVING MACHINERY RECORD

PLANT: SECTION:

ITEM: CODE NO.:
DATE OF INSTALLATION:
LOCATION:
DUTY:
DRIVE:
TYPE:
SERIAL NO.:
CATALOGUE NO.:

1) CAPACITY:	1) K. W./H. P.:
2) HEAD:	2) AMPS.:
3) SPEED:	3) SUPPLY VOLTS: PHASE:
4) FRAME NO.:	4) STARTER TYPE:

BEARING (S. K. F. NO.; TYPE, CAT. NO.; SIZE):
PACKING DATA (Size, Make):
LUBRICATION DATA:
FREQUENCY OF P. M. INSPECTION:
FREQUENCY OF OVERHAUL:
LIST OF IMPORTANT SPARES (Give ref. to Spare Parts List or Mfr.'s Cat.):

Any other important information:

(vi) Education and training of plant preventive maintenance engineer and attendants through (a) devising and conducting in-plant training programmes; (b) publication and circulation of articles and material of special interest to preventive maintenance; (c) group discussion on common problems like reduction and control of maintenance and repair bills, regular availability of preventive maintenance stores, etc.; and (d) exhibition of typical failures and breakdowns attributable to bad and defective maintenance.

The effectiveness and results of the preventive maintenance system are intangible, and cannot be measured directly. As the system is being worked enthusiastically for some years, the results are being reflected in:

(a) Fewer breakdowns and reduction in downtime.
(b) Lesser repair and maintenance cost.
(c) Increase in productivity, and reduction in unit production cost.

TABLE VI

Sheet No.....

PREVENTIVE MAINTENANCE

MACHINE HISTORY

PLANT: SECTION:

ITEM: CODE NO.:

DUTY:

S. No.	Date	Job Done	Job Done By	Signatures	
				P. M. Engr.	Plant Supdt.

(d) Better inventory control of stores and spare-parts.

(e) Safety of men and machines.

(f) Longer life-span of machinery and equipment.

One reason for the success of preventive maintenance, as against breakdown maintenance, in DCM Chemical Works is the effective support given by the top management to this activity. The present technique of preventive maintenance is a modern tool, and for maximum efficiency of operation, its potential has to be fully appreciated by senior management. Since the setting up of a preventive maintenance organisation in any unit would initially entail expenditure on additional personnel, equipment, premises, etc., this might appear unnecessary or wasteful to a management whose mental make-up is not attuned to the adoption of the latest and unusual practices in day-to-day working in industry. Its results cannot come within a few days or a few weeks and, therefore, in the initial stages, a continuous encouragement is vital to the success of the preventive maintenance.

Control of Equipment Maintenance Cost

With plants operating round the clock, and rapid development of mechanisation, a very important factor in maintenance cost is the cost of downtime of the equipment. In indicating the significance of this aspect, with particular reference to the cost of maintenance of an aluminium smelter, the author points out that "the most effective level of maintenance is where the controllable maintenance cost is the least." He mentions the factors involved in achieving good maintenance, and works out various indices based on the different variables involved in maintenance to project the trend.

EKA Menon *Engineering Superintendent, Indian Aluminium Co. Ltd., Hirakud*

One of the vital questions often asked by management is how to get the optimum maintenance at the lowest cost, or, in other words, the lowest maintenance cost per unit of production. The maintenance cost is often understood as the sum total of the cost of preventive maintenance, and the cost of repair and maintenance. These two elements in cost do not reveal the full picture of the controllable maintenance cost. The cost of downtime of the equipment—a very important factor in maintenance cost—is often ignored in maintenance cost analysis. With the rapid development of mechanisation and three-shift operation of equipment, the cost of downtime is getting more and more important. The cost of downtime equipment embraces the following factors

1. Profit lost due to lost production;
2. Direct labour paid but not producing;
3. Spoilage of product in process;
4. Defective product preceding and following downtime; and
5. Interest on idle investment.

The total sum in respect of the cost of preventive maintenance, of repair and maintenance, and of downtime is called the controllable maintenance cost. The most effective level of maintenance is where the controllable maintenance cost is the least. The cost of preventive maintenance is directly related to the level of maintenance. The cost of repair

and maintenance and the cost of downtime go down as the maintenance level goes up. Depending on the nature of operation of the plant, the optimum maintenance level has to be worked out keeping the controllable maintenance cost to a minimum.

In highly mechanised plants operating round the clock, the cost of downtime of equipment is extremely high and is a major factor in controllable maintenance cost. In an aluminium smelter, producing 20,000 tons of aluminium ingots per annum, the cost of direct production loss is about Rs. 2,000 per hour, if owing to equipment trouble in rectifier station the smelter power is switched off. Against this, the average maintenance cost of the rectifier station is only Rs. 25 per hour. This clearly shows how important the cost of downtime is in the maintenance cost of an aluminium smelter. With the increased complexity of production processes and techniques it may not be possible always to assess the exact cost of direct production lost due to equipment trouble. If, for example, the tapping of metal is delayed due to equipment trouble in an aluminium smelter, it is difficult to calculate the effect of this on production. If the cost of direct production loss can be high, and cannot be assessed accurately because of the complexity of the production process, it is always considered advisable to have a high level of maintenance.

Optimum maintenance calls for the highest utilisation of major equipment for production. Proper records should be kept about the maintenance history of each equipment to (1) analyse the performance of equipment; (2) assess the average useful life of the various components of the equipment; and (3) calculate the historical maintenance cost for budgeting.

One of the most difficult problems which any maintenance man in India has to face at the moment is with the spares for maintenance. With the rapid depletion of foreign exchange and the consequent restrictions on import, it has become necessary to arrange indigenous substitutes for imported equipment spares. The growth of secondary industries producing spares and ancillaries is not sufficient to cater to the requirements of spares for maintenance. The quality of the indigenous spares is often very poor and inconsistent compared to imported spares. It will take a considerable time to standardise the indigenous spares. In spite of these difficulties, every maintenance man has to make an attempt to use as much indigenous spares as possible in the larger interests of the country. A balance has to be kept, however, in changing over to indigenous substitutes to see that vital production equipment will not be kept idle for a long time for want of proper spares. Detailed planning is necessary to achieve effective utilisation of men, materials and machines. It is necessary to define what needs to be done, how to do it, and how long it will take. It is often said that maintenance jobs cannot be estimated. Even if one accepts that unforeseen difficulties may be encountered during the maintenance of complicated machines, one cannot deny that a majority of maintenance jobs can be estimated with a reasonable amount of accuracy. The preparation of maintenance standards involves the breaking down of the jobs into the various elements, and analysing the necessity and sequence of the elements. Once the proper sequence of

... It is not correct to assume that by putting more men on a job we can get it done quickly. Unnecessary idle time due to excess men on a job will result in inefficiency rather than speedy work...

the necessary elements of maintenance is established, the elemental times can be added to give the standard time for the job. Maintenance standards can be used effectively to plan the job, and to assess the performance of the maintenance crew.

Job Allotment

However much we may schedule or plan maintenance, the effectiveness of maintenance will largely depend upon proper allotment and execution. The following factors are involved in achieving good maintenance:

1. Proper job allotment;
2. Proper job instruction;
3. Cross-checking the maintenance crew's performance by the supervisor; and
4. The trial of the equipment after maintenance.

The detailed daily schedule should take care of the effective utilisation of the skill of the men. For any particular job the allotment of men should be based on maintenance standards. It is not correct to assume that by putting more men on a job we can get it done quickly. Unnecessary idle time due to excess men on a job will result in inefficiency rather than speedy work. The skill of each individual should be assessed to get the best out of the maintenance crew. Even though specialisation is not good in maintenance, because of the variation in skill between the individuals, it is often found that a particular person has a knack of doing certain jobs faster than others. A vigilant maintenance supervisor will always be conscious of this difference between the individuals and the capacities of his men, and will try to utilise his knowledge of men in allotting the work.

All the vital components which are likely to break down in an equipment should be properly inspected during the scheduled maintenance. It has already been indicated that slight variations in the average useful life of any component can be detected only by proper inspection during maintenance. Because of the importance of this inspection in preventing breakdowns, it is necessary that the supervisor should cross-check the performance of the maintenance crew in this regard. This cross-checking by the supervisor will make sure that maintenance is going on in the expected way. If the maintenance crew have skipped some of the vital inspections, it will be detected by the supervisor in time, so that unwarranted breakdowns will not occur. The cross-checking will also help the supervisor to guide and correct the maintenance crew, if necessary.

The trial of an equipment after maintenance is a very vital step. It helps the maintenance crew to detect and correct any flaw which might have crept into maintenance. If it is not possible to try out an equipment after maintenance, the first operation of the equipment should be watched by the maintenance crew so that the operatives will not have to face unnecessary trouble.

To improve maintenance performance, attention should be focussed on the (a) effectiveness of maintenance, (b) maintenance cost, and (c) new ideas in equipment, methods and materials.

(a) *Effectiveness of maintenance:* It is not always easy to measure the effectiveness of maintenance. We can develop some indices based on the different variables involved in maintenance to project the trend. The following indices can be used to assess the maintenance performance:

1. Level of maintenance =

$$\frac{\text{Total man-hours spent on scheduled maintenance}}{\text{Total man-hours available}} \times 100$$

This ratio should be as high as possible.

2. Breakdown maintenance =

$$\frac{\text{Total man-hours spent in breakdown repair}}{\text{Total man-hours available}} \times 100$$

This ratio is a direct measure of the effectiveness of the preventive maintenance programme, and should be as small as possible.

3. Activity ratio =

$$\frac{\text{Time actively at work}}{\text{Total booked time}} \times 100$$

. . . If the maintenance men are aware of the cost of the wastage of material, they will be able to appreciate how important it is to avoid such wastage. For example, if the maintenance man knows that a small leak in the compressed air system will cost the company Rs. 450 per annum, he will see that the system is maintained properly, and that the leaks are avoided . . .

Activity ratio derived by work sampling is a good guide to the effective utilisation of the men. By going round the plant and observing the men at work, we can easily compile this ratio. A good number of observations are necessary to achieve a reasonably good activity ratio. Periodic analysis of the activity ratio will show the trend of manpower utilisation.

4. Equipment availability =

$$\frac{\text{Equipment running time}}{\text{Equipment running time} + \text{equipment downtime}} \times 100$$

This index is very important in assessing the maintenance performance. This ratio should be as high as possible. Increase in equipment downtime (both planned and breakdown) will decrease this ratio.

5. Maintenance breakdown frequency =

$$\frac{\text{Number of breakdowns caused by poor maintenance}}{\text{Total number of breakdowns}} \times 100$$

This index is a direct measure of the effectiveness of preventive maintenance, and it will help the maintenance man to take corrective steps in time.

6. Maintenance improvement factor =

$$\frac{\text{Total controllable maintenance cost for the last period}}{\text{Total controllable maintenance cost for the current period}} \times 100$$

The effectiveness of maintenance will be indicated by this factor which should be more than one.

7. Maintenance cost component =

$$\frac{\text{Total cost of maintenance}}{\text{Total cost of production}} \times 100$$

This index should be minimum, and will come down as the maintenance performance improves.

The above indices, when compiled for a period, will show the trend of maintenance, and help the maintenance crew to take corrective steps in time.

(b) *Maintenance cost:* Critical analysis of maintenance cost should be the first approach to maintenance cost reduction. It is not enough if we analyse the overall maintenance cost of a plant. The maintenance cost of each equipment should be separated out and analysed to find out the major factors which constitute the cost. If these factors are different from the original concepts of the maintenance budget, one should go deep into them and see whether they are unavoidable or not. As the budget is based on historical maintenance cost and the experience of the people who prepared the budget, there is every likelihood of some difference between the actuals and the budget. Moreover, it may not be possible always to take into consideration during budgeting the level of maintenance and the possible developments in materials and methods. Maintenance cost analysis should not only try to keep the maintenance cost within the budget, but challenge the budget to reduce it. Critical analysis of maintenance

cost should reveal the wastage or misuse of material, the improvement factor in maintenance, the cost of equipment downtime, etc. If the maintenance crew is aware of the cost of the wastage of material they will be able to appreciate how important it is to avoid such wastage. For example, if the maintenance man knows that a small leak in the compressed air system will cost the company Rs. 450 per annum, he will see that the compressed air distribution system is maintained properly, and that the leaks are avoided. The percentage of scrap produced in a fabrication shop will show how effectively materials are utilised. The cost of equipment spares should be shown to the maintenance man, so that costly spares will be used when necessary.

Productivity Aspect

With experience, the maintenance crew get more and more familiar with the equipment. This closer acquaintance with the equipment should be reflected in a reduction in the man-hours required for maintenance. To bring down the maintenance labour cost of equipment, this increase in productivity of the maintenance crew should be more than what is necessary to compensate the annual wage increase and the possible increase in attention required by the equipment when it gets old. The productivity of maintenance crew is becoming more and more important especially because labour is more a fixed cost than a semi-variable cost as it used to be.

(c) *Equipment, methods and materials:* The rapid development of new concepts in methods, equipment and materials should always be taken advantage of by the maintenance crew in improving maintenance performance. The following design features of an equipment will help to reduce the maintenance cost: (1) Fast assembly and disassembly; (2) Least number of critical and complicated adjustments; (3) Low aging factor; and (4) Minimum of moving parts, links, joints, etc.

Standardisation of components, drives, transmission, bolts, nuts, fittings, etc., in an equipment should be looked into to reduce spare-parts inventory, increase the flexibility in interchanging parts, and reduce the number of tools for maintenance. Development in equipment design and consequent changes in the machine performance characteristics should always find a place in the search for maintenance improvement.

There is no limit to the possible improvements in methods and techniques. The searching mind of the maintenance crew should always look for better methods and techniques. Every maintenance method should be analysed in detail to see whether it can be improved. The analysis of the various steps in the method will reveal whether all the steps are necessary and in the proper sequence to get the best result. The use of jigs and fixtures, special tools, rearrangement of work, materials handling, etc., are some of the areas which need attention in method improvement. Continuous effort should be put in to see that new methods, which simplify the work and improve the overall efficiency of maintenance, are evolved. *In method improvement, necessary attention should be paid to the people at work. However much we improve the equipment or the process, the efficiency in the final analysis will depend upon the efficiency of the people at work.* The aim of method improvement should be to make the work easier to the men, and in so doing increase their efficiency. The physical actions and mental processes of human beings play a vital part in achieving improvement in productivity.

Revolutionary developments in materials have given maintenance men ample opportunity to improve maintenance performance. Lubricants have undergone revolutionary changes in the past 10 years, and have contributed much to the improvement in equipment performance. Technological innovations in the field of metals have helped maintenance men to improve the useful life of machine parts and combat maintenance problems like creeping, and corrosion. The development in semi-conducting materials, man-made fibres, machine-tools, electronics, etc., can all be taken advantage of in achieving better maintenance.

Factors Affecting Plant Maintenance

Arthur Grace

Chief Engineer, Kanpur Textile Mills, Kanpur

In analysing the scheduling and performance of factory equipment maintenance, the author stresses the need for employers to attract, and ensure the flow of, the right type of educated and trained people into this vital function. Further, the preparation of a workable maintenance scheme alone is not enough; a good system can produce the best results only if rigidly adhered to in practice. In discussing how to obtain the best results in a textile mill, the author throws out some useful suggestions in regard to the maintenance of the blow-room, draw frame, spinning frame, etc.

THERE are those who carry out actual plant maintenance and those whose interests lie in seeing that it is efficiently carried out. To the latter group the soundest advice I can give is to obtain a good plant engineer, pay him well, and after satisfying yourself as to his qualifications, experience, and capabilities give him a free hand. A good plant engineer is the best insurance in which you can invest to continue to get the maximum benefit from your plant. Of the first group, those who practise plant maintenance as a profession, there is much to be said.

Far too long has the study of maintenance of factory equipment lagged behind modern developments. Industrial machines and processes have been improved, accelerated, increased in size, output and complexity, yet the incidence and functions of maintenance have been neglected and ignored or regarded *only as a bridge to be crossed when the time arises*, and certainly not as something to be planned in advance. It would, of course, be absurd to suggest that maintenance itself has been lagging: a simple example is in the number of machines still in apparently useful service with a longevity which is truly amazing, paying tribute to their designers and to the care and attention bestowed on them by their users. Nevertheless, the design of machines has frequently outstripped the design of their maintenance, resulting in fixing the fastest-wearing parts in the least accessible positions, in the mounting of the most sensitive and delicate items in locations where they are most exposed either to vibration or to the lavish laving of cutting oils, and in the assembling of various parts in such a way as to necessitate the removal of the whole machine

from the production line in order to reach one of them, possibly the most vital.

During the last few years, however, plant engineers themselves have realised that organisation and studious forethought can reduce worry, waste, and hard work including weekend work, and have invited or at least allowed specialists in other fields to give their advice, not necessarily to be followed of course. Another spur has been the recent addition of automatic control in machinery: it is not new to the plant engineer, but has, in turn, called attention to the anticipation of events before they happen, and to the problems of servicing the apparatus performing these functions automatically. Again, the emphasis on the purely mechanically engineering aspect of plant maintenance has shifted towards the electrical, the physical, the chemical, and the various integrated combinations of these sciences. There has also been a growing realisation that scientific methods themselves can be applied to maintenance to replace the casual day-to-day progress from one breakdown to another. The plant engineer is a manager, foremost, and must have the self-confidence and authority to control his plant instead of allowing it to control him. No doubt, each plant engineer has had his own special interest as an engineer—civil, mechanical, or electrical—but in factory maintenance he has to combine all aspects of engineering. The principles apply generally to all maintenance of factory equipment, and although it must be assumed that if a factory is working at all, then the equipment must be receiving some sort of maintenance.

A Dictum

A great scientist once said that "*we do not start to understand a phenomenon until we can measure it.*" Doubtless this dictum was first applied to fundamental research, but as he was the same scientist who invented or perfected the familiar kitchen water tap, he probably would have raised no objection to our applying his lofty admonitions to the taking of measurements in our ordinary everyday problems. How hot is a hot bearing? How many amperes above rating is the overload on an electrical motor, and for how long? What is the actual percentage of CO_2 in the flue? How many feet or yards has a maintenance man to walk for a ladder he needs? How far away does the electrician find the diagram he needs for the machine he is to service? As for that loom which the manager complains "is always breaking down," how many stops does it really make, and what is the loss in output while it is being attended to?

Imagine a factory with a lighting installation consisting of carefully designed standard fluorescent tubes to give specified illumination at a cost related to the funds and to the functions. Statistics based on lengthy tests are available to give a reasonable forecast of the average number of hours of burning of these lamps. Further data will show how the useful life of these lamps is likely to be affected by the frequency with which they are switched on and off. Some of the lamps will become dim prematurely, and others again will, if allowed to remain in service, maintain a rated output for a period far in excess of the declared life. All the fittings, too, will, sooner or later, require cleaning, depending on their situation and use. What is the programme to be? Are the lamps to be allowed to run until they fail completely, and then be replaced individually when they do? Or, should they be replaced in groups after the expiry of their rated life, after two-thirds of that life, or some other period, whether any or none has failed before then? Is the removal of dirt, grime, cotton fibres, or even dust to be regular, organised, programmed, casual, or omitted altogether? And, are lamps to be changed when fittings are cleaned, or, are the two operations to be divorced?

There are, indeed, many questions here involving motors and lamps, combustion and ladders, and some of them refer to what might be regarded as trivial operations in the activities of a large healthy enterprise. Some of them, too, seem to preclude any possibility of study by scientific approach and methods. However, they all indicate

one vital common principle applying most certainly to all aspects of plant maintenance—the need of measurement. In all the problems just cited, measurement will first indicate the relative importance of the problem, and the priority in which it should be attended to.

A machine is designed to perform a specified operation within defined limits, a certain number of times for a certain overall cost in capital and running. The calculation for maintenance to achieve this economic efficiency is made on the following considerations. Certain parts of an aeroplane, for example, must not be allowed to fail when it is about to take off, or is airborne, or is over the sea, or is always over land, or is loaded or light. Certain other parts are comparatively less important in each set of conditions and the maintenance programme is, therefore, economically tailored to the calculated conditions. While certain maintenance operation must be carried out in relation to the flight schedule, others are related to the flying hours, and others again can be deferred until an opportune occasion arises. The analysed details are then incorporated into an overall economic plan related to the conditions. On these lines are drawn up the weekly, monthly, half-yearly or yearly programmes on preventive maintenance for all sections of the plant, buildings, fixed plant, boiler house, transmission, and electrical equipment.

Technicians' Job

The performance of factory equipment maintenance is increasingly the job of technicians. There is need to ensure that the flow of properly educated and trained people into this vital function is adequately sustained. Training takes the place of "coming up the hard way." It produces effects in much less time, makes useful citizens at an earlier age, and redirects misfits while they are still pliable. Those facilities are now becoming available, but employers with vision will have to attract the right type of technologist, technician, and apprentice, and *take care of the present, while investing in the future.*

To obtain the best results in a textile mill, it is essential to establish an efficient system of cleaning, oiling, scouring and maintenance, and to ensure that this system, once in operation, is not allowed to lapse. By cleaning is meant the regular removal of waste, fluff and fly at short interval, whilst scouring is the less frequent, but more thorough, cleaning of the machine as a whole.

No Rigid Scheme

Conditions in the mill, quality and counts of the spun yarn, class of cotton, type of labour available, and number of machines are the main factors affecting the schedule of the maintenance system employed. All these factors may vary, and consequently it is impossible to lay down a rigid scheme suitable for universal application. Each individual mill, in working out its own routine, should adopt the basic scheme to its particular requirements.

Oiling should be carried out with care. It is better to lubricate frequently with small quantities of oil than to over-lubricate at irregular intervals. Contamination of the lubricant by solid matter or fluids, especially waste, must be avoided, or, otherwise, the bearing surface will deteriorate quickly.

Finally, it must be emphasised that the preparation of a workable maintenance scheme is not enough. It is essential that all the operations are carried out regularly at the specified time, and that no items are missed or work carelessly performed. A good system will not produce the best results unless it is rigidly adhered to in practice.

Blow Room

Hopper Bale Breaker, Hopper Feeds, Crightons Double Opener, and Scutcher.

Maintenance

Every 8 hours: Lubricate all points, clean upright lattice grid and floor under machines.

Every 50 hours: Check all bearings for wear. Examine all lattices and rollers for damage to

lattices, spikes, etc. Clean inside lattices and remove all hard bumps of cotton jammed between the lattice and canvas. Clean inside machines. Brush grid bars.

Every 250 hours: Examine all gearings for damage. Clean fan runners.

Every 1,000 hours: Remove ball-bearings and wash in paraffin. Check all settings.

Every 2,500 hours: Remove all belts, cones and guards. Dismantle, clean and check all bearings, gearing shafts, lattice fan and lubrication points. Thoroughly clean inside of machines. Reset all adjusting points.

Cards

Every hour: Clean the doffer cover, fly comb box, draw box and coiler head, paying particular attention after stripping.

Every 4 hours: Remove the licker-in-cylinder undercasing fly. Brush down the card backs.

Every 200 hours: Grind the card. Reset Emery.

Every 2,500 hours: Overhaul the cards, dismantling the flats and setting all the points.

Draw Frame

Every 8 hours: Lubricate all the points. Brush down the machine in general, and clean the electric top rollers.

Every 50 hours: Thoroughly clean all exterior surfaces of the draw frames, gearing and coiler tube wheels. Ensure neat; all contact points necessary to operate the electric stop motions are clean.

Every 1,200 hours: Inspect the components for wear. Replacing, if necessary. Remove the grease and waste embedded in the fluids of bottom rollers and electric rollers by means of a brush with stiff bristles, or a piece of card clothing.

Spinning Frame

The frequency of scouring depends mainly on the type of cotton used, the hanks produced and the quality of the yarn. Under average conditions the frequency is—

Once in every 8 weeks	For coarse and soft spun yarn
Once in every 10 weeks	For yarns up to 30s
Once in every 13 weeks	For yarns from 30s to 50s

The following are schedules for maintenance of winding, warping, sizing and weaving:

Winding: (a) Oiling of oil places to be done twice a week; (b) Visible oil level to be maintained about half the height of glass window in gauge; (c) Cleaning of the machines to be done once a week; (d) Correct recommended oil to be used for lubrication: and (e) Oil pump to be cleaned every three months, and all ball-bearings to be levelled and checked.

Warping: (a) Cleaning of machine to be done every week; (b) Oiling and greasing once in every month.

Sizing: (a) Machine to be cleaned when the set finishes, and oil it; (b) Squeezing roller and copper rollers to be scrapped every three months, and squeezing rollers coated with white paint; (c) Sow boxes to be cleaned and washed once a week; and (d) Sizing becks to be cleaned once a month.

Weaving: (a) When the beam finishes, looms to be thoroughly cleaned, oiled and all bolts to be tightened. Cleaning gang to be kept for above loom cleaning and oiling; (b) Thorough overhauling to be done once a year; and (c) Oiling gang to be kept so that all looms are oiled twice a week.

The following is the maintenance schedule for Sundays (see also Appendix on page 716):

1st Sunday: Motor alley, weaving, sizing, cloth room and winding, and warping switches.

2nd Sunday: Top and middle spinning room, individual motor switches and motor. Cleaning blow room individual motor switches.

3rd Sunday: Motor alley, weaving, sizing, cloth room and winding, warping motor switches and motors cleaning.

4th Sunday: Blow room solenoids and motor cleaning *Bleach House* Individual motor, switches and motors cleaning.

5th Sunday or every 2nd month: Boiler, well and tube-well water softening plant. Mechanic shop motor-starters and motor cleaning Hosiery switches.

Note: *Weaving motors cleaning is done every Sunday. Weaving and spinning block lighting cleaning is done once in a month. Motor-alley motors are cleaned daily in the morning shift at recess period. Sub-station LT and HT switches are examined after every three months.*

Appendix

Engineering Maintenance Schedule

1st Sunday	*2nd Sunday*	*3rd Sunday*	*4th Sunday*	*5th Sunday or every 2nd month*
Cleaning of weaving shed wall, ceiling and shafting	Cleaning of the spinning block walls, ceiling and shafting	Cleaning of the weaving shed ceiling, bearings and shafting	Cleaning of blow room and carding wall, ceiling and shafting	Chain pulley block, rope pulley block
Electric hoist to be examined	Baling press, damping machine	5 Bols washing mangle (bearings, reduction gear, etc.)	Boiler pump, spinning and weaving humidifier pump	Adjusting 'V' ropes of the motors
Kier pump, packing jiggers, drying range, stenter, piler pumps and gears, hosiery calenders, hosiery press	Sprinkler installation to be examined	7 Blow calender bearing, reduction gear, packing, etc.	Well pump, water softening pump, overhead tank feed pump, water supply pump, humidifier feed pump	Cleaning and applying rope dresses to all cotton rope drives. Hydrant and stand pipes to be checked

Note: Every Sunday maintenance of Sizing Department: Examining of the cylinders, packing, ball-bearings, steam valves, steam pipe, water valves, mixing tank fan and plunger pump, etc.

Every Sunday during February to March: Spinning line shaft, oil bearings to be examined

Every Sunday during September to October: Spinning line shaft, oil bearings to be examined

Holi and Dussehra: Weaving line shaft, ball and roller bearings and card line shaft of the Top Room to be examined. Boiler flue cleaning.

Cooling plant during summer months (March to September):

1st and 3rd Sundays—Spinning cooling plant nozzles to be cleaned

2nd and 4th Sundays—Weaving cooling plant nozzles to be cleaned

Water softening plant, lime soda process—daily checking to remove both temporary and permanent hardness from the water by the addition of hydrated lime and sodium carbonate—daily beck washing, weekly cleaning of the tanks, etc.

Should Old Machines be Replaced?

True, the tendency in recent years is to get industries equipped with modern machines, assuming that just by replacement better results can be obtained. But is there real need to undertake costly projects of outright replacements of old machines? In this study, Manoharlal Jain points out that "new machines alone are not going to yield a high level of production," and indicates that even on existing machines the adoption of preventive maintenance can help to achieve greater production. It is his view that improvement of old machinery by overhauling and regular maintenance may ultimately show surprisingly good results without undergoing the excessive cost of replacement.

Manoharlal Jain

Planning Officer, JC Mills, Gwalior

PREVENTIVE maintenance has acquired a special importance in Indian industry owing to the peculiar economic circumstances that prevail at the moment. On the one hand, a total replacement of worn-out, old machinery is not possible on account of inadequate resources, increased requirements of capital outlay and, above all, stringent foreign exchange conditions. On the other hand, we are faced with the task of fulfilling planned development which involves improving our competitive capacity by reducing costs.

Proper maintenance of productive capacity is one of the ways of effecting cost reduction. The cost of production is closely related to economic working. This postulates efficient maintenance, which is, therefore, a necessary and important economic service. Preventive maintenance really means a smaller aggregate of periodical small items of expenditure in place of large capital outlay, and enables proper use of depreciation reserves, reducing the risk of its being utilised as working capital.

Preventive maintenance can never be regarded as an end in itself but a vital service to production. The service can only work well through a genuine spirit of co-partnership of both maintenance and production teams. Further, it should be appreciated that a sound maintenance programme cannot

be implemented overnight. The maintenance engineer of today must apply the scientific management techniques, e.g., methods study, scheduling and planning, process study, work study and statistical controls. There is a tendency to get the industries equipped with modern machines discarding the old ones, assuming that just by replacement, they can obtain better results. Before undertaking such costly projects of outright replacements of old machines, it is worthwhile to apply our minds to the improvement of the old machinery by overhauling and regular maintenance, which may show surprisingly good results without undergoing the excessive cost of replacement. New machines alone are not going to yield a high level of production unless suitable maintenance and overhauling schedule is brought into force compatible with intricate constructional features of new machines. Modernisation of industry is no doubt an essential task to be undertaken without delay, but this does not mean that the upkeep of the machines in good working condition should be neglected on the ground that they are to be discarded in the near future. Only persons having special aptitude for maintenance work and ability to carry out assignments without constant supervision should be chosen.

The elements of good maintenance are:

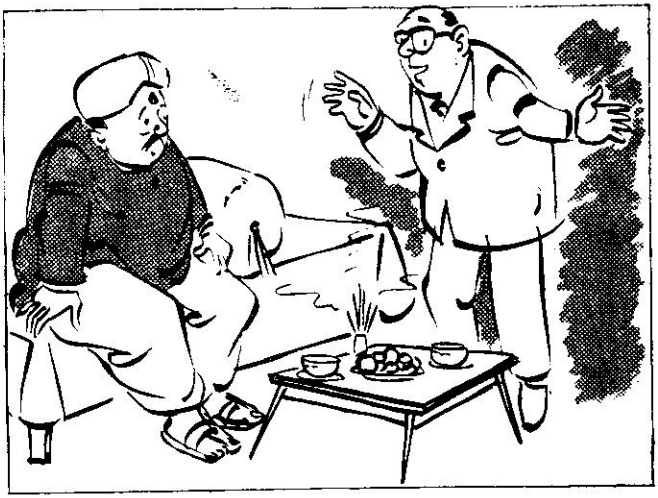
(1) Organisation;
(2) Engineering records;
(3) Inspection;
(4) Lubrication;
(5) Engineering analysis;
(6) Planning and scheduling;
(7) Inventory control of maintenance store and spares;
(8) Workshop, tools and maintenance facilities;
(9) Standardisation;
(10) Training of maintenance personnel;
(11) Maintenance standards; and
(12) Budgeting and cost control.

Details relating to some of these items are given on the next page:

Mohan Lal Learns a Lesson *(Contd.)*

"But did you write to the suppliers of these machines?"

"No...but I feel that the machines are very delicate and not so sturdily built as they used to be in former days...My workers say, new machines generally give trouble, and have to be cared for like a sick child."



"That is all wrong...Come to my factory, and see...The latest machines have more precise design, greater mechanisation, and sophisticated electronic, and hydraulic controls to stand greater stress...and are designed to run at higher speeds. There are also numerous devices to protect them in case of faults..."

Organisation: (a) Proper realisation of the importance of maintenance and its replacement at par with production is essential for the healthy growth of industry.

(b) There should be a genuine spirit of co-partnership of both the production and maintenance teams which should be welded together by mutual confidence and honesty of purpose, and not otherwise as we find it sometimes.

The Objective

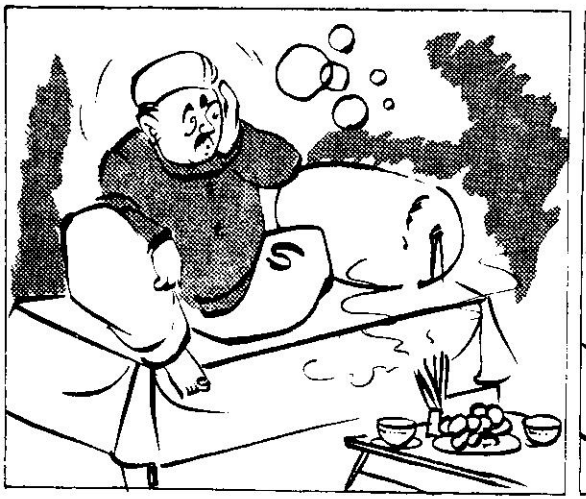
(c) Maintenance activity should start right from the selection of the proper equipment for the plant, because apart from the production need, the need of maintenance is vital to achieve the objective of high production with lost cost.

Engineering records: The essential records to be maintained are: (a) Equipment data, (b) Equipment history, (c) Drawings and sketches, and (d) Instruction manuals. They should be available to the maintenance staff at a moment's notice. The maintenance men may add to them their own experiences to supplement information given on them on trouble detection and rectification to make the records more useful.

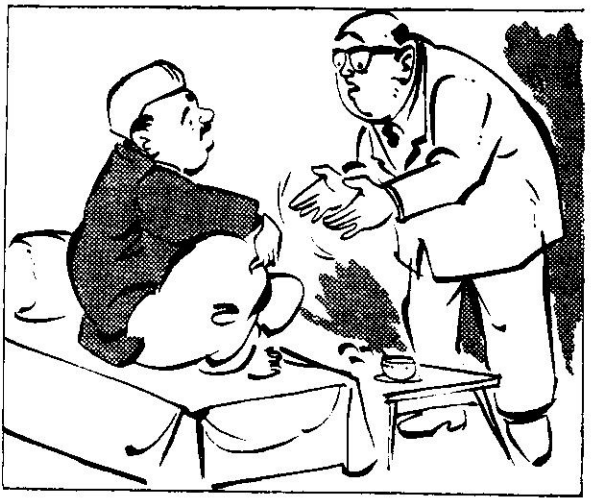
Inspection: An effective maintenance programme is based on systematic and intensive inspection of the equipments at proper intervals. Inspection is of two types—(a) Visual or external, and (b) Detailed or internal. To aid correct and thorough inspection, check-lists are of supreme importance. Preparation of check-lists calls for a lot of judgment, experience and a thorough study of the drawings.

Lubrication: In order to ensure that all the lubrication points in any equipment get their proper requirements of lubricant at the desired interval, lubrication check-forms on similar lines as inspection check-forms have to be developed.

Engineering analysis: In spite of best inspection and attention, plant failures are likely to occur. A careful study and analysis of plant failure reveal many interesting



Mohan Lal thinks...But why are my machines so bad...I have spent over Rs. 5 lakhs on modernisation and expansion of my factory...



You should know, Mohan Lal, that no machine when in operation is supposed to fail without reason...Higher speeds of modern machines demand much closer tolerances in their manufacture. The machines require more skilled attention, and planned maintenance to ensure their efficiency.

[Turn to pp. 754-755

data. These data would highlight factors that may call for revision of inspection schedules, lubrication schedules, etc. Therefore, the recording of delays or plant failure, and critical analysis of the same, have significant bearing on good maintenance and maintenance costs.

Planning and scheduling: Planning aims at determining materials, tools and methods and the preparation of workable estimates of time and manpower required. The reasons for variations between the estimated and actual time and costs are noted down. When the same job is done a second time, the planning method is modified from the records made during the first study and lapses are corrected.

After the job is done a couple of times, a "standard practice" is established, which is extremely useful for future guidance.

"Not Too Costly"

Training of maintenance personnel: Just as the strength of a chain is that of its weakest link, the efficiency of any plant is no better than that of the lowest level of operating or maintenance personnel. Good operators reduce the volume of maintenance work.

Serious efforts should be made to train more and more technical personnel. No amount of effort in the direction of training can be regarded as too costly or too elaborate. The maintenance technician must be specially trained beyond the level of ordinary skilled craftsman. It is very useful if the operators and key maintenance technicians are assigned full time during the period of installation and erection of a new equipment.

It is desirable that as much attention is paid to the maintenance of buildings, lighting, etc., as to the maintenance of machinery, and, therefore, the upkeep of buildings, and cleanliness, should not be confined only to the extent required to satisfy the regulations of the Government.

An important aspect of maintenance is avoidance of the accumulation of dust. Dust is the potential enemy of all machines. Dust-free atmosphere is not only necessary from the workers' health point of view and for materials handling and storing, but is also essential for preventive maintenance.

It is rather high time that industrial managements in India recognise the vital role of preventive maintenance. If quality products are to be produced, a sound maintenance organisation, at par with production, is a *must*.

...Dust is the potential enemy of all machines. Dust-free atmosphere is not only necessary from the workers' health point of view and for materials handling and storing, but is also essential for preventive maintenance...

Role of Work-sampling in Maintenance Efficiency

How far the analytic tool of work-sampling or ratio-delay can contribute to effect reduction in maintenance cost is discussed by BO Parikh who indicates the procedure for its application, and its utility in the evaluation of maintenance efficiency, the measurement of man-machine efficiency, and in exploring the possibilities of technical improvement, work simplification, etc.

BO Parikh

Asst. Plant Engineer, Polychem Ltd., Bombay

MAINTENANCE engineering today occupies a place of prime importance, and, not unnaturally, the maintenance group in any industry plays a major role. It is a fact that maintenance expenses have obviously a greater bearing on the ultimate cost of production. But the application of industrial engineering techniques can certainly help reduce considerably these expenses. Let us see how far work-sampling, which is gaining increasing acceptance as an analytic tool, can be helpful in this direction.

The National Survey in the United States has shown that the effectiveness of maintenance labour is about 50 per cent. In the absence of data, it is not possible to give any definite figure for Indian industries, but it can be presumed that it will be lower than the US figure. Why is this so? Is it because maintenance personnel are unwilling to work? Or, are they lazy? Experience has shown that the following are among the major factors:

1. Improper or insufficient tools and equipments.
2. Inefficient location of equipments.
3. Poor planning and scheduling.
4. Material or spares shortages, because of poor control.
5. Inadequate transportation facilities.
6. Inadequate engineering and supervision.

Work-sampling or ratio-delay is a practical technique to analyse current conditions, and to get at the facts quickly, accurately,

and economically. It does not directly improve efficiency, but it does point out areas where losses in efficiency occur. It is based on the theory that a reasonably large number of items chosen at random from a large group has the group characteristics. To get the desired results from work-sampling, the following procedure is recommended:

1. Define what is to be done.
2. Determine the elements to be followed (men, machines, etc.)
3. Estimate the number of observations and randomise them to cover all significant conditions. The accuracy required in an answer depends upon the number of observations. Tables, charts, and graphs are available to determine the number of observations, and to ensure the randomness.
4. Train the observer and persons involved.
5. Record observations, and determine the level of reliability of results.
6. Make recommendations based on the study results.

Evaluation of Results

Work-sampling can be applied in maintenance for (1) the evaluation of maintenance efficiency; (2) the measurement of man-machine efficiency; and (3) exploring the possibilities of technical improvement, work simplification, and the evaluation of the results for improved operations. In maintenance, the ratio-delay can be the ratio between the actual maintenance time (repair time) and such avoidable and unavoidable delays as waiting for equipment shutdown, clean-up time, crew-balance, job preparation, required facilities such as tool, material, etc., and receiving instructions. When these delays are pinpointed by ratio-delay, detailed studies can be made of each lost time item for reducing or elimination.

To determine delays in maintenance, the observations can be grouped under the following categories:

1. Actual maintenance time: The worker is at the job site doing the maintenance work.
2. Direct delay: The worker is at the job site, but is not working. This can be further elaborated by the mention of reasons for not working such as waiting for (i) equipment shutdown, (ii) tools, materials, etc., (iii) clean-up time, (iv) information or instructions, (v) transportation, (vi) additional labour force, (vii) interference from other departments, (viii) exchange of information, and (ix) deficient scheduling.
3. In transit: The worker is travelling away from or near to the job site. This can be further detailed by indicating the reasons for transit, such as (i) for tools, equipments or material, (ii) picking up or delivery of equipment, (iii) checking the job, (iv) back to job site after break period, and (v) for personal reasons.
4. Indirect delay: The worker is not at the job site. He might have gone to some other department for information, for medical reasons, for personal reasons, or for attending some meetings. He might be reporting late from, or leaving early for, break periods.
5. Not observed: The worker is not at the job site. The reasons are not known.

Once the specification of the observations are established, there should be proper selection of the observer who should have the confidence of both the workers and the management. He has to be objective, so that he can do his job without being involved in personalities, and be thoroughly conversant with plant maintenance and operation. Also, he should be well-acquainted with the maintenance personnel, so that he can identify them, and know what they are doing. In short, he has to be a camera that reports exactly what he sees. The success of the ratio-delay programme depends a great deal on his ability to follow the procedure objectively and consistently.

Spot-checking

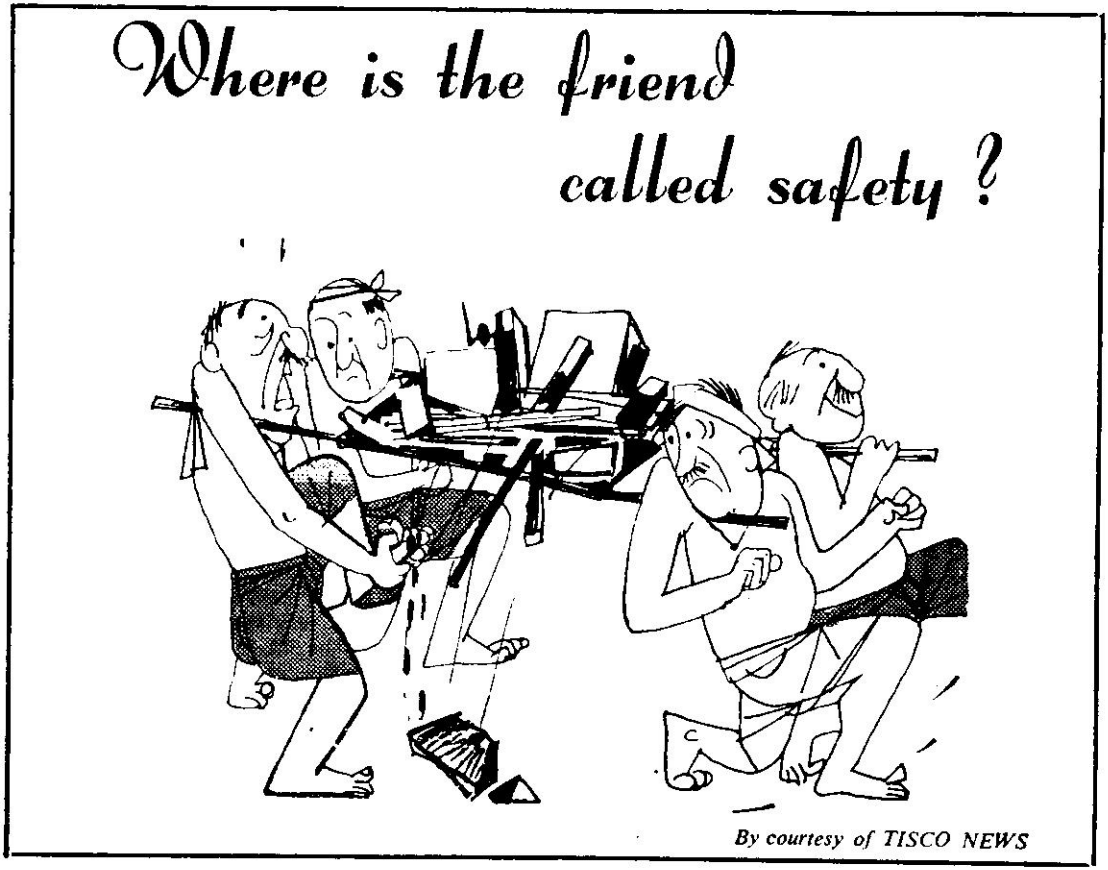
It is also important that employees should cooperate during the study by conducting themselves in such a way, as if nothing extraordinary was going on. After they are introduced to the project, the observer can begin making observations. This entails spot-checking of activities over a period of time.

On making his rounds, the observer records the activities of the maintenance personnel at a predetermined time. Observations are made and recorded at the time he identifies

the worker. He questions a worker only when he cannot see or figure out what he is doing. With a veteran on this job, such occasions, however, will be rare. If the worker is not at his job, there is no hunting for a missing worker who may be spotted later. All unchecked workers are recorded as unobserved. The theory is that if a given percentage of observations indicate a particular type of activity in progress, then approximately the same percentage time of the operators or group is devoted to this activity.

When the observations are available, the causes of delay and percentages of delay can be worked out. From these results, maintenance management can take corrective action by providing better transport facilities, efficient tool and material storage, and distribution system, efficient communication, better supervision, personnel reassignment, work-load adjustment, and improved planning and scheduling.

The ratio-delay is the only practical method to determine the most efficient distribution of a given work-load. Thus it can help us in deciding on the minimum number of assigned maintenance personnel to service an area containing a specific amount of production equipments.



By courtesy of TISCO NEWS

Manpower for Preventive Maintenance

B Mukherji

Works Engineer, Burn & Co. Ltd., Howrah

INDIA is building up in industrialisation against various odds, and there can be no two opinions that factories should be run with the utmost economy and efficiency. It should be clearly understood that preventive maintenance is not a luxury, but a *must* in the days of competition before us. The main techniques for preventive maintenance are (a) Method study, (b) Quality control, (c) Controlling cost of maintenance, and (d) Incentive methods. The application of these techniques naturally involves materials research, design changes, maintenance training, operator training, equipment study, standardisation, protective methods, maintenance records, etc.

It is not easy to lay down a formula as regards manpower for preventive maintenance, as it depends very much on the size, capacity, type of products, manufacturing methods, etc.

Quality control includes the quality of the process as well as the materials. For instance, two pieces of metal may be joined by rivetting, bolting, or welding. Which should be the correct procedure in a particular case? And even when you have a decided particular process, the process can be carried out in an efficient or less efficient manner. Preventive maintenance decides the process, and there is always room left to improve on any process.

The effectiveness of the maintenance efforts will, on the average, be found as follows:

(a)	Unorganised maintenance	50%
(b)	Scheduling and planning with rough job times	60%
(c)	Scheduling and planning with work-measured time and control	70%
(d)	With incentive in addition	100%

The total maintenance cost can be grouped as under:

	Direct		*Indirect*
(a)	Lubrication	(a)	Procurement
(b)	Cleaning	(b)	Spares
(c)	Adjustment	(c)	Off-time
(d)	Repairs	(d)	Depreciation

The expense under 'depreciation' is reduced year after year, but expenses under 'adjustment' and 'repairs' grow more rapidly. It is the algebraic sum of these expenses that should serve as a guide when thinking of capital replacement.

In spite of variations, it is possible to develop a simple Maintenance Productivity Index which may be written as

$$\mu = \frac{\text{Output of product}}{\text{Cost of maintenance labour and materials}}$$

This index in any one shop is influenced by yield efficiency of the raw materials, additional maintenance justified for increased output, or increased maintenance with reduced output due to depreciated equipments.

Each factory should estimate this index for particular shop, and should be checked from time to time to ascertain the effect of preventive maintenance on the maintenance costs.

The factors which affect the index and over which the Maintenance Engineer has some control are:

(a) Number and duration of scheduled shutdowns,

(b) Number and duration of breakdowns, and

(c) Slowing down of production due to defective plants.

The factors affecting cost of maintenance labour and materials are (a) overhauling method, (b) inspection devices, (c) frequency of overhauls and inspection, (d) design of parts affecting maintenance methods (In many cases the design may be modified to simplify maintenance methods), (e) inferior materials used for construction, (f) overstocking of spares, (g) excessive use of consumable stores, (h) standardisation of hand tools, pipes, etc., (i) labour performance, and (j) overtime work. The third step is to apply techniques which will improve the above factors. These are generally (a) scheduling, (b) planning, (c) method study, (d) process study, (e) statistical analysis, and (f) incentives.

Capital Replacement

The importance of capital replacement at right times cannot be over-emphasised. The problem is not so easy as it involves financial, commercial, operational maintenance problems as well as the future policy of the company. From the purely maintenance point of view, when the maintenance cost of an equipment exceeds the depreciated value, it requires replacement. But it may have to be replaced long before this, owing to its lower productivity compared to similar machines of more uptodate design. Both viewpoints are important as in either case the purpose is to reduce the manufacturing cost.

There is no doubt whatever that a great sense of achievement is experienced from the maintenance of a sound incentive scheme as it testifies to clear thinking, fairness, goodwill, perseverance, and the ability to overcome practical difficulties. It helps to create a good employer-employee relationship, without which even the best designed and maintained schemes are doomed to failure. There are so many ways to give incentive bonus to the operating staff either on individual

... Simplification of maintenance inspection methods and procedures should always be aimed at with the help of time studies ...

or collective basis. But the problem is not easy for maintenance men inasmuch as their efforts cannot always be directly estimated except for repetition jobs. In discussions with leading maintenance executives in West Germany, the UK and the USA, the writer did not find any regular incentive system applied to maintenance men. In some cases, an ad hoc prize is paid to a group of workers who have completed a repair in less than the planned time. But in many cases, the maintenance workers on the whole are paid slightly higher wages than the operators.

In India, experiments have been made by introducing a bonus scheme to the maintenance based on finished goods outputs billed for in a given time, but such a scheme can only satisfy the labour as a whole when the outputs are normal. It can have a difficult time whenever outputs are held up for reasons beyond the managements' control.

If you have a maintenance force of 100 or more men, you will need a full-time preventive maintenance engineer. In carrying out the programme, you should never allow this to be interrupted by other maintenance work. Secondly, the routine work in preventive maintenance should follow the same administrative processes as regular maintenance. It should be under the same executive who directs all other maintenance efforts.

A good inspector is generally a craftsman with top skills who can test, adjust, and repair the unit he inspects. It is desirable he be a trained trouble-shooter.

It is not easy to lay down a formula as regards manpower for preventive maintenance, as it depends so much on the size, capacity, type of products, manufacturing methods, etc. The following average statistical figures may act as a guide:

Primary metal industries	—42% of total maintenance manpower
Machinery manufacturer	—15.8% of total maintenance manpower
General manufacturing	—10% of total maintenance manpower

Preventive maintenance inspection is usually very much repetitive, and hence simplification of inspection methods and procedures should always be aimed at with the help of time studies. Regarding clerical help, the usual trend is two clerks for every 100 maintenance men to cover both preventive maintenance and regular work.

Periodic control report is necessary at least once a month to keep a check on preventive maintenance performance. The report should summarise (a) Number of inspection scheduled, completed and uncompleted with reasons, and (b) Number of work orders issued and completed.

It will be interesting at this stage to know what various factories in industrially advanced countries like the USA are doing, and the relation of their maintenance in the factory cost and organisation (please see Tables I, II, and III).

Table I*

Industry	Production function %	Maintenance function %
Machinery and allied equipments	91.8	7.1
Primary and fabricated metals	84.9	13.6
Chemicals, petroleum, and rubber	77.6	20.9
Stone, clay, and glass products	84.3	15.2
Average of 20 industries of all sizes	88.6	11.1

Table II*

Manpower yardsticks for maintenance and plant engineering

Functions	Machinery and allied equipment	Primary and fabricated metals	Chemicals, petroleum, and rubber	Stone, clay, and glass products	Average of 10 industries of all sizes
General administration	4.7	3.7	3.7	3.8	4.9
Electrical maintenance	14.1	12.6	8.5	11.2	9.9
Mechanical maintenance	20.1	39.0	46.3	43.6	31.6
Building maintenance	26.3	18.7	15.0	18.6	17.7
Power plant operation	3.6	5.8	8.2	3.8	9.8
Cleaning and sanitation	22.1	12.2	12.2	11.3	15.2
Maintenance stores	4.5	3.2	2.6	3.7	3.5
Others	4.5	4.0	3.4	3.9	3.7

Table III*

Maintenance cost guide

Industry	Maintenance cost as % Net Sales		
	Minimum	Maximum	Arithmetic mean
Heavy engineering process	0.83	15.92	6.03
Light engineering process	0.04	10.38	2.06
Heavy fabrication	0.34	17.46	4.02
Light fabrication	0.12	8.62	2.72
Stone, clay, and glass products	1.98	11.31	5.48
Iron and steel foundries	4.47	7.47	6.68
Fabricated structural metal	1.31	2.92	2.53
Machine-tools	0.51	3.86	2.62
Electrical industrial apparatus	1.14	2.94	2.03
Average of 687 concerns	0.04	17.46	4.12

Approach to Workers

To explain the methods of preventive maintenance to the ordinary worker, I would at once recommend that he should observe the rules of health for the machine as the first step. These rules are:

1. See that the machine is in correct place, ie, free of dust, smoke, not exposed to weather, and on a good foundation (*NB:* This is done once for all at the time of installation).
2. See that the machine is lubricated at correct intervals, by correct method, at correct points, and with correct lubricants.
3. See that the machine is kept clean and well supplied with coolant, where necessary.
4. See that the machine is not overloaded by the careless operator (*NB:* In India most damages are caused by untrained operators).
5. See that belts, clutch plates, brakes, electrical contacts, and fuses, etc. are inspected periodically at weekends.

If these rules are observed regularly, then there can be no stoppages except by accidents. But there will be normal wear and tear which at one time will offset the precision of the performance.

To enable the Maintenance Engineer successfully to pursue the preventive measures, he has to maintain a series of important records. Without going into details, the minimum number of records required are:

1. *History Cards*, for each machine, will give the age of the machine, when it was procured, new or second-hand, what was the price, the power unit, major breakdowns, etc.
2. *Spare Parts Card* will show the list of essential spares to be maintained, their stores index number, their annual consumption and replacements.
3. *Inspection Schedule* will show the dates of inspection, results and recommendation.
4. *Lubrication Schedule* will show the recommended lubricants, lubricating points, intervals of lubrication, etc.

*Adapted from *Factory Management and Maintenance*, McGraw Hill Publishing Co. Inc., New York.

A more esthusiastic Maintenance Engineer will also undertake the following analyses:

(i) *Work Study:* Studying each operation involved, proper tools and personnel necessary to complete the work within the minimum time without sacrificing the quality of work.

(ii) *Method Study:* Investigating if this method adopted is the correct one. Could this be improved upon?

(iii) *Trade Sampling:* This is a new idea, and is meant to find out how the skilled maintenance workers are being employed. Is the skilled fitter generally doing a fitter's job as he is expected to do? Or, is his time being wasted to run to and fro to call men, collect tools, take materials to the machine shop, wait for instructions or materials required for his work? We should be surprised to find out that in most cases his service as a skilled fitter is not being utilised and there are so many scopes to cut down wastages of our technical manpower.

Preventive Maintenance organised on these lines should, therefore, be a very profitable investment and it will be a benefit to the management and the workers as well. The maintenance workers will know their responsibilities for production, and operators can turn out their highest. If this condition can be maintained, as it should be maintained, the workers as a whole will be ensured of a constant benefit added to their income as incentive.

Productivity slant in ads.

One of the obvious and significant indicators of productivity consciousness created by NPC's efforts is the format and tone of advertisements appearing in the names of industrial firms. A big plastics factory of North India, for example, advertised recently for "a Production Manager well-versed in SQC, Time and Motion Study, Cost Control, etc." In fact, the factory needs a productivity expert.

Advertisements of this type have become common because of the large number of training courses in these subjects which NPC has been conducting throughout the country since 1959. In pre-NPC period, there was hardly a mention in any of the advertisements about these subjects which had been made familiar to Indian industry by NPC.

In another prominent advertisement, recently in the *Times of India*, an industrial firm notified the vacancy for Head of the Quality Control Department, who should have minimum three years' experience in Industrial Engineering/Statistical Quality Control, with good knowledge of the use of different kinds of measuring instruments. His job responsibilities include not only the organisation of the Quality Control Department, but also the training of line supervisors in the measurement of quality. The position offered is permanent, with wide scope for advancement, and "selected candidates may be sent to Japan for training." Once again, it is obvious that such advertisements never appeared anywhere in the pre-NPC period. This is all evidence that industry is demanding productivity.

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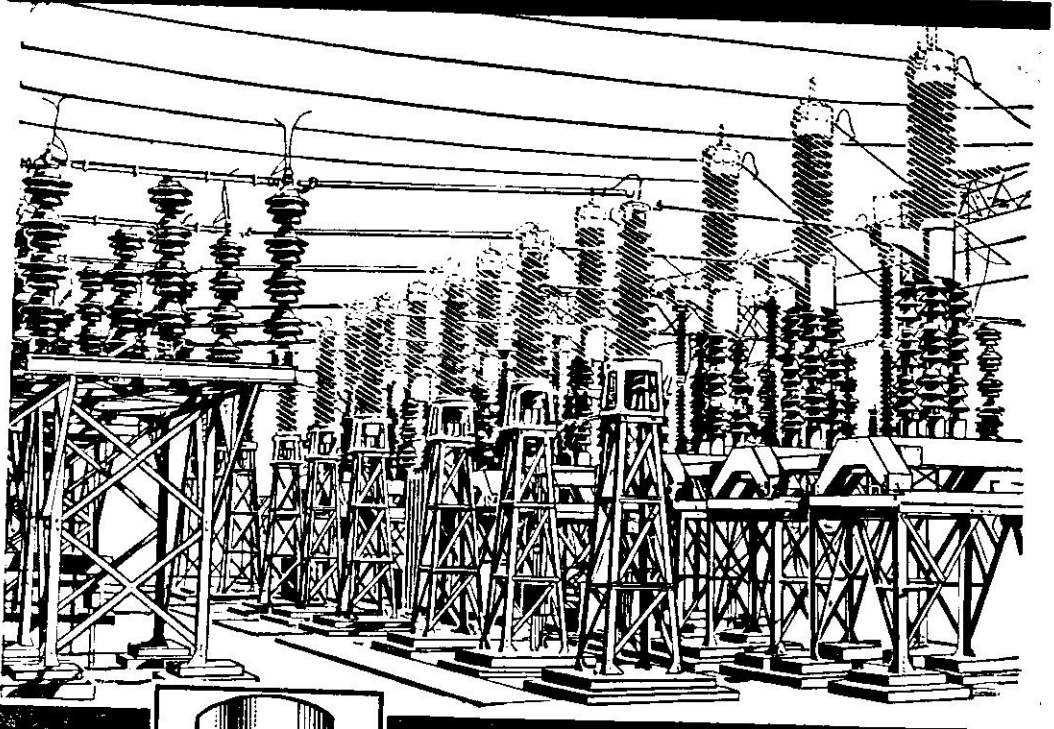

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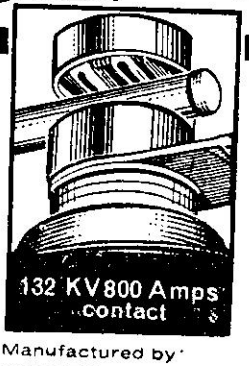

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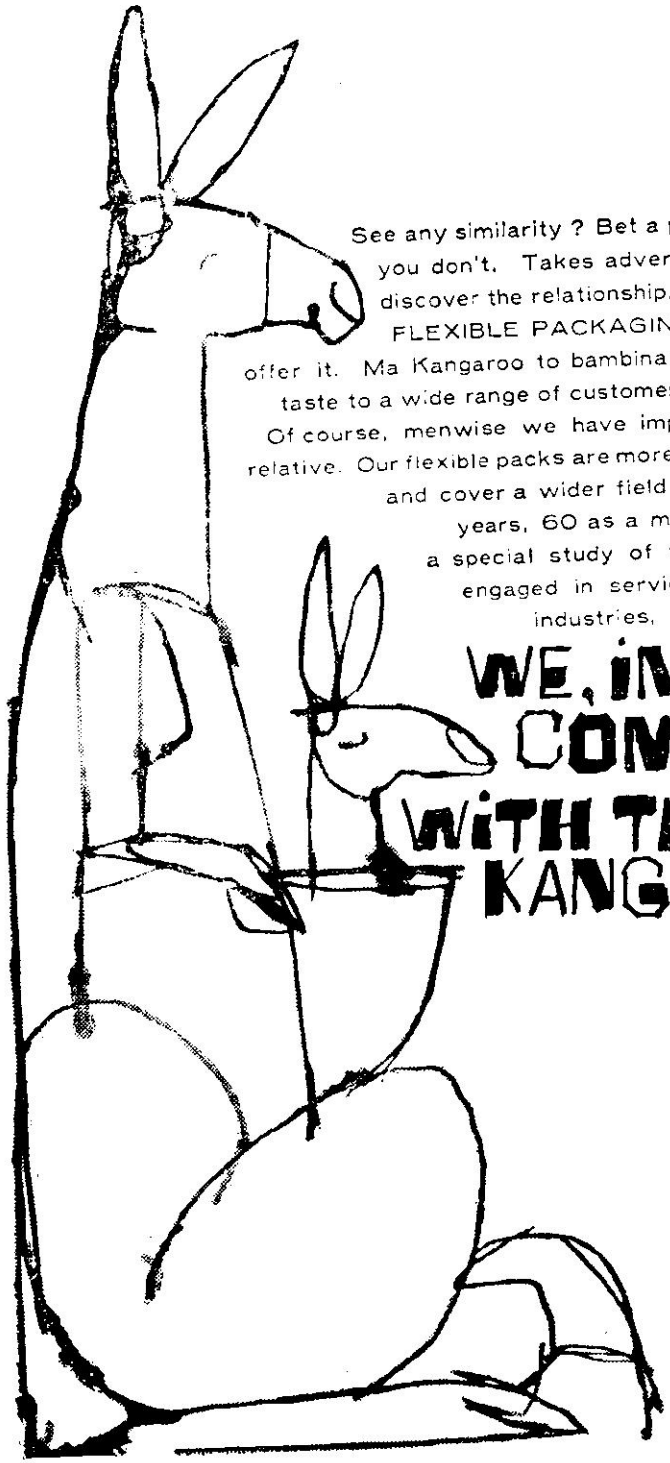

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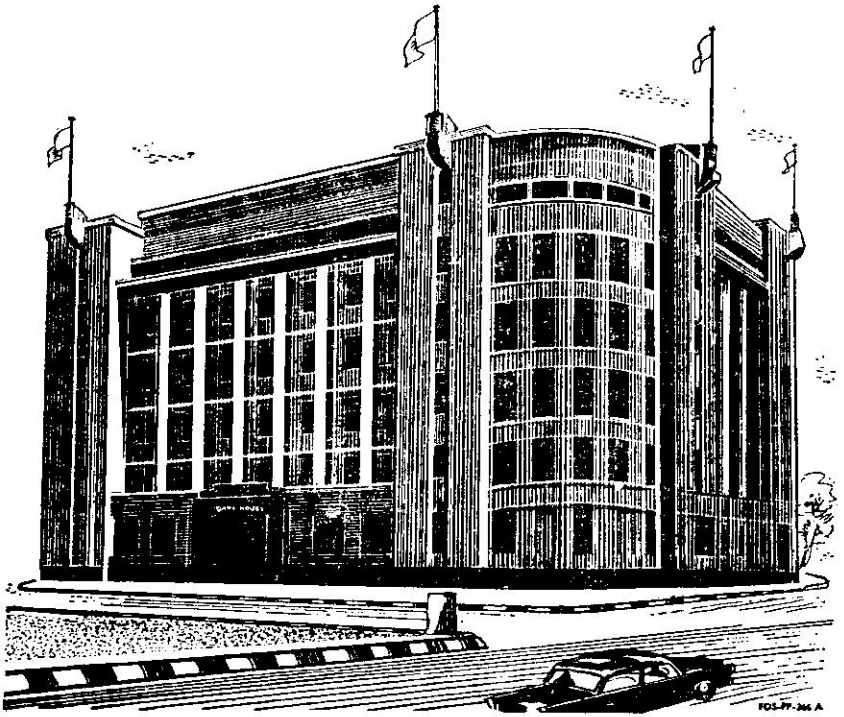


PLAY YOUR PART IN THE NATIONAL DEFENCE EFFORT

What should be the number of subordinates which an executive or manager can effectively and efficiently supervise? Studies have been made on this controversial point in foreign countries, but as regards the practice in Indian industry, research material is totally lacking. This NPC research analysis of the trend of span of control practices in Indian industry, based on a small but significant sample drawn primarily from the middle management level, reveals results which are different from the study conducted by the American Management Association in 1951, though "the range of these differences is not great."

Span of Control Practices in Indian Industry

John R Kennedy
Vice-President, George Fry & Associates Inc.

THE NUMBER of subordinates which an executive or manager can effectively and efficiently supervise, has been, for decades, a controversial point among students of management and practising managers. In 1951, the American Management Association surveyed 100 large companies to ascertain the trend of span of control practices in the USA. This sample dealt with top executives only, Presidents or the equivalent of the Managing Director in India. The survey showed a median of nine subordinates in the large companies. The AMA later surveyed 41 smaller companies, and found the median to be eight.

This NPC research article is based on a smaller but random sample, as the author exercised no selective powers relative to the respondents. The size of the companies surveyed ranges from small to large, i.e., from

50 employees up to 5,000 or more. Also, this sample is drawn primarily from the middle management level. So, a direct comparison of the two sets of data is not logical. However, AMA's findings are of interest in terms of background and future analysis. The results of our research are different from the AMA work, but, surprisingly enough, the range of these differences is not great. In the opinion of the author, *the principles of organisation over-ride cultural differences, and the span of control for the Indian executive would not vary greatly from his American contemporary.*

Scope of Study

During the past two years NPC has had the opportunity to conduct several advanced production management training programmes in some of the major industrial areas—Bombay, Bangalore, Calcutta, Kanpur, and Cochin. An integral part of this programme was the discussion of basic organisation principles and their application to the Indian industrial scene. Participants, for the most part, were functioning as executives or departmental heads. These training sessions thus offered a unique opportunity for research into current Indian industrial organisational practices. A total of 54 participants took part in this research, and they represented 36 organisations covering a good cross-section of Indian industry, in both the public and private sectors. Industries covered included aircraft manufacturers, electronic manufacturers, food products, textiles, pencil and pen manufacturers, steel furniture, mining and fertilisers.

Each participant was shown how to compute his own "Span of Control". This term was defined as the number of people reporting directly to the manager-participant whose work interlocks.

The following formula was used to compute the span of control:

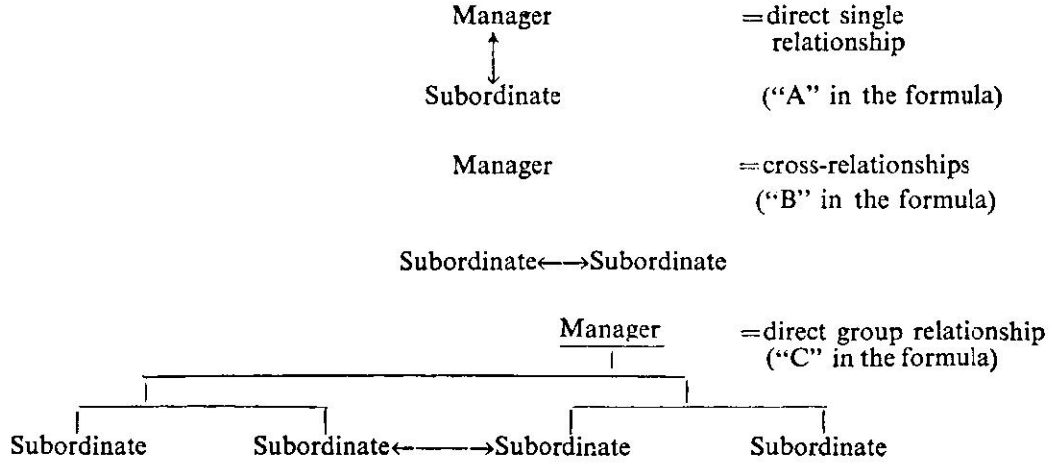
$$A = N$$

$$B = \frac{N}{2}(N-1)$$

$$C = (2)^{N} = (N+1)$$

$$F = A + B + C,$$

Where N=number of subordinates; A=number of direct single relationships; B=number of cross-relationships and C=number of direct group relationships. These relationship concepts were operationally defined as follows:



. . . When a manager takes on too many supervisory responsibilities, the increase in potential decision-making starts to multiply beyond the scope of a single individual regardless of his energy or brilliance . . .

It can readily be seen that as the number of subordinates (N) increases, the relationships in (B) and (C) increase geometrically. A total of all relationships is the value "F". Consequently, when a manager's span of control becomes too large he normally loses effectiveness as a leader. His energies become dissipated over too many situations, and his management decisions tend to become erratic, being effective only in a few segments of his control span and at varying points in time. Many decisions have to "wait their turn". This point can best be illustrated by taking some actual cases from the data accumulated.

TABLE I

Case No.	*Case samples of span of control*				
	N	*A*	*B*	*C*	*F*
1	5	5	10	26	41
2	8	8	28	247	283
3	13	13	78	8,178	8,269

These figures illustrate the fact that *if (as in Case No. 3) a manager has 13 subordinates reporting directly to him, he may be required to deal with as many as 8,269 problems within a given span of time.* When a manager takes on too many supervisory responsibilities, the increase in potential decision-making starts to multiply beyond the scope of a single individual regardless of his energy or brilliance.

It should be further emphasised at this juncture that this analysis and the preceding formula pertain to those subordinates whose responsibilities vary, but whose work interlocks. For example, it is possible for a foreman to handle effectively 20 or more production workers. This is because their (workers') responsibilities are similar, and their work is largely segmented or cellular. However, it is not advisable for a manager to attempt to handle 20 departmental heads, because their responsibilities and job duties are varied, and usually interrelated. The Quality Control Supervisor, for example, has a different type of responsibility compared to the Industrial Engineer, and they both are working in an entirely different managerial matrix than, say, the Production Superintendent; yet all their efforts interlock.

Optimum Number

A span of control analysis indicates the possible maximum number of manager-subordinate relationships (and their potential number of problems or decisions) in any heterogeneous organisation structure. What then is considered to be an optimum number of subordinates under the conditions outlined? *Research and practical application of organisation principles indicate that between five and seven subordinates offer the maximum utility of an executive's managerial talent.* Less than this he is under-utilised; more than this, he tends to become overburdened, and communications, decision-making, etc., start to bog down.

What has been the practice in Indian Industry? Our research shows the following:

TABLE II

Bombay Area

Managerial title	*Industry*	*N*	*A*	*B*	*C*	
Technical Adviser	Fractional HP motors	2	2	1	1	4
Senior Officer	Mining	4	4	6	11	21
Senior Asst. Officer	Mining	4	4	6	11	21
Director	Textiles	4	4	6	11	21
Section Head	Battery manufacturing	4	4	6	11	21
Asst. Production Manager	Paints	4	4	6	11	21
Production Manager	Furniture manufacturer	5	5	10	26	41
Dy. Works Manager	Diesel engine manufacturer	6	6	15	57	78
Director	Ball point pens	6	6	15	57	78
Director-in-Charge	Textiles	7	7	21	120	148
Chief Chemist	Pharmaceuticals	7	7	21	120	148
Dy. Works Manager	Chemicals	7	7	21	120	148
Production Manager	Pencils	10	10	45	1,013	1,068
Senior Engineer	Machining	11	11	55	2,036	2,102

In this sample, the average value of N is 5.18. Based on N, the values for A, B, C, and F are 5.78, 13.80, 26.62, and 46.2 respectively. The mean generally follows the optimum organisational arrangement regarding span of control, as does the median. The mode, however, is 4 which indicates a trend to under-utilisation of managerial skills in this sample.

TABLE III

Bangalore Area

Managerial title	*Industry*	*N*	*A*	*B*	*C*	*F*
Dy. Manager Prod. Con.	Electronics	5	5	10	26	41
Asst. Engineer	Mft. telephones	5	5	10	26	41
Ind. Engin. Manager	Aircraft mfg.	6	6	15	57	78
Works Manager	Castings mfg.	6	6	15	57	78
Cost Accountant	Auto ancillaries	6	6	15	57	78
Dy. Gen. Manager	Electronics	7	7	21	120	148
Works Manager	Electric meters	7	7	21	120	148
Senior Engineer	Mfg. telephones	8	8	28	247	283
Chief Accountant	Auto ancillaries	8	8	28	247	283
General Foreman	Transformer mfg.	8	8	28	247	283
Prod. Con. Manager	Auto ancillaries	10	10	45	1,013	1,068
Factory Manager	Electric meters	13	13	78	8,188	8,279

In this sample, the average value of N is 7.42. Based on N, the values for A, B, C, and F are 7.42, 23.8, 120.42, and 150.84 respectively. The mean generally follows the optimum organisational arrangement regarding span of control, as does the median. This group has a bimodal distribution, one of which is within established limits (6). The other (8) is only one unit beyond the recommended upper limit.

TABLE IV

Calcutta Area

Managerial title	*Industry*	*N*	*A*	*B*	*C*	*F*
Sales-in-Charge	Textiles	2	2	1	1	4
Asst. Superintendent	Quarry mining	3	3	3	4	10
Incharge Batching & Winding	Textiles (jute)	3	3	4	10	17
Incharge Weaving	Cotton mfg.	3	3	3	4	10
Factory Manager	Cotton mfg.	5	5	10	26	41
Production-in-Charge	Mining	8	8	28	247	283
Factory Manager	Food	9	9	36	502	547
General Supervisor	Textiles (jute)	12	12	66	4,083	4,161

In this sample, the average value of N is 5.6. Based on N, the values for A, B, C, and F are 5.6, 12.9, 60.9 and 63.3 respectively. The mean is within acceptable limits. However, the median and mode indicate a trend towards under-utilisation of executive talent.

TABLE V

Kanpur Area

Managerial title	*Industry*	*N*	*A*	*B*	*C*	*F*
Production Con. Manager	Steel fabricator	2	2	1	1	4
Technical Executive	Paint	3	3	3	4	10
Technical Adviser	Heavy electrical	4	4	6	11	21
Works Manager	Conveyors	5	5	10	26	41
Production Manager	Precision inst.	5	5	10	26	41
Dy. Gen. Manager	Steel mfg.	6	6	15	57	78
Administrative Officer	Textiles	6	6	15	57	78
Office Superintendent	Textiles	7	7	21	120	148
Production Manager	Textiles	8	8	28	247	283
Director	Safe mfg.	8	8	28	247	283
Managing Director	Steel fabricator	8	8	28	247	283
Personnel & Purchasing Manager	Conveyor mfg.	8	8	28	247	283

In this sample, the average value of N is 5.83. Based on N, the values for A, B, C, and F are 5.83, 14.10, 51.57 and 71.50 respectively. The mean falls within the optimum control zone as does the median. The mode, however, is 8, and indicates a slight trend towards a too large span of control.

TABLE VI

Cochin Area

Managerial title	*Industry*	*N*	*A*	*B*	*C*	*F*
Senior Engineer	Heavy Chemical	2	2	1	1	4
Workshop Supdt.	Fertiliser	2	2	1	1	4
Planning Engineer	Steel & Plastics	3	3	3	4	10
Sales Manager	Containers	3	3	3	4	10
Plant Supdt.	Fertiliser	4	4	6	11	21
Engineering Supdt.	Rare earths	6	6	15	57	78
Factory Supdt.	Pesticides	8	8	28	247	283
Prod. Control Mgr.	Rayons	10	10	45	1,013	1,068

In this sample, the average value of N is 4.75. Based on N, the values for A, B, C, and F are 4.75, 8.90, 25.25 and 38.90 respectively. The mean is slightly below the optimum range. The median is significantly below the optimum range. The bimodal distribution also is on the low side of the optimum managerial utilisation. This sample indicates a trend towards under-utilisation of managerial talent.

Compiling all data from the five areas surveyed, the following results were obtained:

TABLE VII

	N	*A*	*B*	*C*	*F*
Mean	6.46	6.46	17.63	85.98	112.07
Median	6.50	6.50	17.87	88.50	112.87
Mode	8.00	8.00	28.00	247.00	283.00

It will be noted that the differences between the arithmetic means and the medians are not statistically significant. A Correlation Chart illustrating a compilation of data from all five areas is shown in Table VIII:

TABLE VIII

Span of control values

N	*A*	*B*	*C*	*F*
1	1	0.5	0	1.5
2	2	1.0	1.0	4.0
3	3	3.0	4.0	10.0
4	4	6.0	11.0	21.0
5	5	10.0	26.0	41.0
6	6	15.0	57.0	78.0
7	7	21.0	120.0	148.0
8	8	28.0	247.0	283.0
9	9	36.0	502.0	547.0
10	10	45.0	1,013.0	1,068.0
11	11	55.0	2,036.0	2,102.0
12	12	66.0	4,083.0	4,161.0
13	13	78.0	8,178.0	8,269.0
14	14	91.0	16,369.0	16,474.0
15	15	105.0	32,752.0	32,872.0

By way of summary, 37.0 per cent of the managers surveyed in this research were in companies which were so organised as to permit them to operate in what we would call an "Optimum Control Zone", that is, they have five to seven subordinates whose work interlocks; 33.3 per cent of the managers surveyed fell below the "OCZ"; and 29.6 per cent were organised in such a fashion that they operated above the "OCZ".

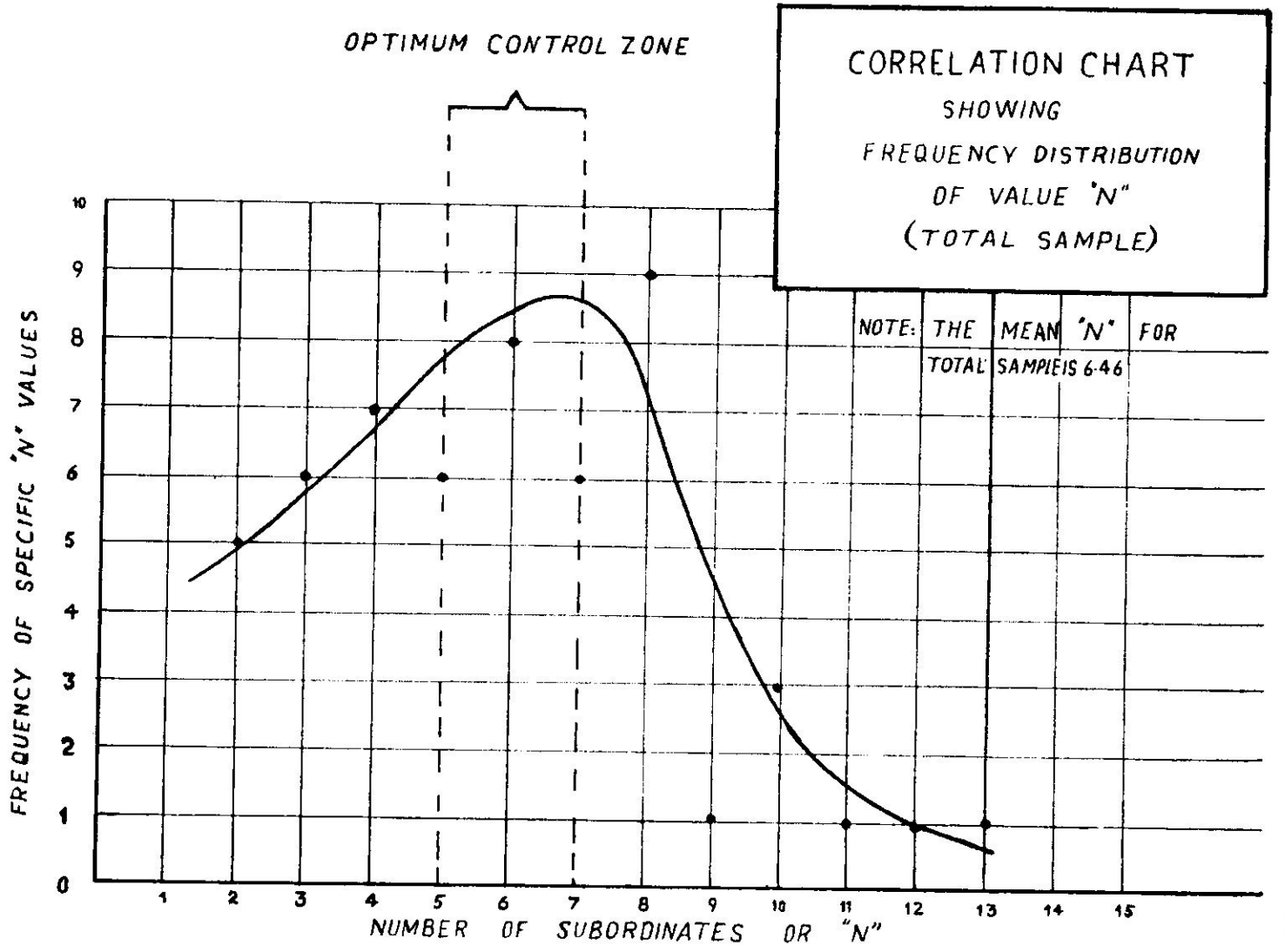
. . . When a manager's span of control becomes too large, he normally loses effectiveness as a leader . . .

Of managers sampled, 62.9 per cent were operating outside the "OCZ". However, these figures are not as alarming as they may seem, because the total statistical pictures indicate that the arithmetic mean for the entire group sampled is 6.46 per cent, and is almost in the centre of the "OCZ" (see Correlation Chart on page 745). Those managers operating outside the "OCZ" more frequently are operating below what we would refer to as "optimum use of managerial talent".

For the benefit of the reader, Table VIII has been prepared as a ready reference for checking span of control values (through an "N" of 15) based on the formula mentioned earlier.

We realise that this is a relatively small sample of the Indian managerial community. However, it is hoped that this work will stimulate the reader to make a critical and objective analysis of his own organisation practices.

There are, of course, variables other than statistical factors which affect the ability of a given executive to control a given number of subordinates. These are essentially qualitative concepts such as "force of personality", "energy", "span of knowledge", and so on. These concepts are difficult to measure, but, to a greater or lesser degree, all managers possess them. These concepts often may permit a manager successfully to deal with a larger than normal span of control. The true test of this, however, is in the success (or failure) of that manager's department or organisation.


OPTIMUM CONTROL ZONE
CORRELATION CHART
SHOWING
FREQUENCY DISTRIBUTION
OF VALUE 'N"
(TOTAL SAMPLE)
NOTE: THE MEAN 'N' FOR TOTAL SAMPLE IS 6·46
FREQUENCY OF SPECIFIC 'N' VALUES
0
1
2
3
4
5
6
7
8
9
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
NUMBER OF SUBORDINATES OR "N"

Control of Progress in a Developing Country

"Planning for progress is a management responsibility...and progress is most certain when there is a dynamic control system overseeing progress...," says RF Bruckart who advocates a wider use of the Programme Evaluation and Review Technique which is a management tool for the planning and control of development projects.
Developing countries are in "unflinching haste" to accomplish "miracles of economic renaissance," and the author, who has spent a few years as Consultant of the National Productivity Council, says that in the context of the situation in India she has much to gain by the application of this simple technique of PERT.

RF Bruckart *Industrial Adviser, AID/Auerican Embassy, Jordan*

Charteris: ...What hurry is there? Can't you give the man time?
Craven: Time! What for?...
The Philanderer, GB Shaw

"PROGRESS" is like Motherhood, my Country, and Virtue: everyone is for it. Developing countries are striving for progress, and enormous money and effort are being expended to achieve it. Generally, these efforts take the form of schemes to accelerate the degree of industrialisation, for, *in modern manufacturing industry, we presumably have a magic wand which, on the waving, will convert developing countries and their economies into affluent societies*— or so it may appear to the casual observer. At least, governments throughout the world are undertaking developmental programmes and many of them receive aid from friendly governments whose interest is consistent with the aims of the developing country.

Governmental agencies concerned with industrial development take many forms, but usually include some form of planning agency or office under the direction of a minister or department of the national government. These organisations constitute the

"management" that directs these programmes. Their responsibility, of course, is to initiate, manage, and control activities that will achieve the objectives of the programme.

The functions performed by these "managers" of governmental programmes are like those of industrial managers in general, i.e., (1) the undertaking of risk and the handling of uncertainty; (2) planning and innovation; (3) co-ordination, administration and control; and (4) routine supervision. Unlike the operation of a small company, however, these functions cannot be performed by a single person, or, as in larger companies by a hierarchy of individuals in an independent organisation.

Red-tape

Instead, governmental projects are usually administered and managed through a seemingly impossible tangle of governmental regulations, red-tape, and frustrations. Little wonder then that those who are observers of government programme implementation too often see newspaper headlines proclaiming: "Industrial Growth Below Target—More will be spent, less achieved"; "A New Look at National Planning—Basic Change in Approach—A Fuller Life for the People"; "Industrial Projects Behind Schedule—Mid-term Appraisal of Plan's Progress"; "Plan Targets for Jobs may not be met". True enough, it is *better to have a "plan", and to revise it from month to month than to have no plan*, and have to improvise from day to day to claim any progress worth mentioning. Obviously, however, it is better still to have a plan and be able to achieve the goals it lays down. Administration of governmental projects, however, is far different from an equivalent programme of smaller scale undertaken by private industry. Take the efficient manager from private industry and put him in the civil service undertaking similar goals, and he finds himself in a world where his energies are inhibited and his faculties are paralysed.

The reason for the doleful headlines and the constant shifting of goals and expectations is clear enough when we understand the characteristics of the civil service mentality at work. As Toynbee has told us,

> "In the world of civil service, plunging into action is the archcrime. When you sight an objective, you must not head straight for it. You must consult a thousand colleagues who have a right to file objections in the names of a hundred other government departments that are all great powers, and you must not feel frustrated or guilty when you find yourself bogged down. The civil servant's duty is not to achieve desirable results; it is to follow the correct procedure."

Toynbee points out that whether the civil servant makes a success or a failure of the particular job of the moment, it makes no particular difference to the public weal, as it is only one of thousands of other jobs of no lesser or greater importance on the public agenda. But it will damage the public weal, and perhaps seriously, if in some unprofessional eagerness he creates an unfortunate precedent. This might affect adversely the hundred thousand transactions in the same category that will come along in future years. Toynbee concludes:

> "It is one of the fundamental rules for doing governmental work that no particular piece of work may be dealt with on its own merits. Every decision must be determined by its possible bearing on innumerable other decisions that other people will be taking at some future date."

So it is clear why, in one respect at least, successfully reaching goals set for Five-year Plans and for specific programmes, making up those plans is so very difficult. It is easy to see why the headlines shout "More expenses —Less accomplished". Truly a sad commentary . . .

One more aspect is worth mentioning. Management of projects and programmes may be said to involve responsibilities of the executive function, which is, according to Appley,

> "...to determine what you want people to accomplish, to check periodically on how well they are accomplishing it, and to develop methods by which people may perform effectively ... *Management is the development of people and not the direction of things.*"

For the administrator, however, this seemingly simple requirement is complicated

by the need to explain the programme and gain the enthusiasm of everyone concerned. In developing countries, where the less enlightened portions of the population are relatively large, presentation of the programme to these persons and statements of their responsibilities to make it a success must be dealt with through carefully designed explanation. This explanation is imperative, if the desired motivating forces are to be unleashed.

Ample records are available of failures in this task. A recent article concerning this matter reports on reactions to the Five-year Plan of one developing country (not India!). A reporter, paying a visit to one of the many villages in that country, reports:

> "Then I asked them what they thought of the new Five-year Plan, which I had been hearing so much about...A middle-aged man said, 'The time to answer your question is at the end of the first five years. The plans made by people... who have never dug in the earth do not interest me. Our problem here is simple enough—there are too many people and too little land... *In Capital City they can live on their plans.* We need land...They tell us to use new fertilisers. But there is not enough water here, and the fertilisers will burn the soil...The directions are written by people who are not peasants but sit at desks,' said the old man."

As usual, what the uneducated peasant knows instinctively, the sophisticated expert discovers after years of exhausting analysis and study, viz.,

> "In spite of the crying needs for trained personnel in all these countries, we find that in many of them there now exists an *academic proletariat.* As a matter of fact, one of the politically most unstable elements in many underdeveloped countries consists of the intellectuals and semi-intellectuals who have received the wrong type of training and are maladjusted. They are doomed to remain without roots..."

Fortunately, however, it is not as if no disciplines were available that are worthy of the prowess of this academically trained "proletariat". On the contrary, there are more challenging analytical procedure available now than have ever been known before—yet, precious few explorations of their potentialities have been undertaken.

. . . One characteristic almost universally common among the developing countries is their unflinching haste to accomplish their miracles of economic renaissance almost overnight . . . Everyone is in a vast hurry . . .

For example, theoretical mathematical studies abound and cry out for the imaginative explorer who is prepared to find in them new solutions to ancient problems experienced by the ordinary citizen. In the broad field of operations research, limitless numbers of scientific formulations await application to problems of the developing countries of the world. Consider, who is willing to put our extensive knowledge of the queueing theory to use in solving the traffic problems of India, where traffic consists of undetermined mixtures of bicycles, bullock carts, motor trucks, wandering cows, and scampering pedestrians? Who is to put his name on an application of linear programming in the process of developing scientifically correct mixtures in India of capital-intensive versus labour-intensive industry, or "heavy industry" versus "light industry"; or the many other permutations and combinations of economic variables that arise daily? Who is to find important economic indicators

for India through the use of stochastic sampling plans? Who is to establish the probabilities for success of the components of the Five-year Plan, including all pertinent parameters? Who, indeed? Perhaps there is too little time.

Truly, one characteristic almost universally common among the developing countries is their unflinching haste to accomplish their miracles of economic renaissance almost overnight. Even ignoring the powerful new tools of programme planning available, suddenly everyone is in a vast hurry: Accomplishments that required decades in the developing countries are set up as goals to be reached in a few short years by the new and developing countries. Skills that were acquired only through years of trial and error in the advanced countries are to be obtained immediately in developing countries—preparatory stages of development are to be skipped completely or leapt over lightly in a headlong flight towards a better life. Instant prosperity is to be the order of the day!

"Not Easy"

In passing, one may conclude that perhaps it is this very preoccupation with *time* and its ramifications that is generating those doleful headlines—"More spent, less accomplished —Projects behind schedule—Plan targets may not be met"—and so on, *ad infinitum*.

It is true enough, of course, that meeting schedules under frequently prevailing conditions in developing countries is not easy. In a recent management meeting, Peter F Drucker, the well-known management consultant and educator, "...produced a formula for estimating how long a particular task would be likely to take. Multiply the scheduled time for the job by 4, and you would almost always find that this was the actual time taken." This need not be. New tools of planning and control are now available, waiting for the right man to put them to use. For instance, let us look at an example of one of the many new analytical aids to planning. Let us take PERT (Programme Evaluation and Review Technique). Project managers in industry and Government have long been looking for better controls of complex sets of activities, and PERT, developed in 1958 for military purposes, has now found its ultimate use as a multi-purpose tool of management. PERT uses a "network" analysis, based on the recognition that some activities of a programme are dependent on the completion of previous activities; while others are independent of each other. The network establishes a clear inter-relationship among these activities.

Let us assume, for example, that the underdeveloped country of Transylvania has a section called Ruritania in which it is interested

PMs' Productivity

"Baldwin", writes Malcolm Muggeridge in the *New Statesman* (Oct. 16, 1964), "used to disconcert the more earnest among his supporters by sitting for hours and hours on the Government front bench, apparently dozing or turning over the pages of a magazine."

"Churchill's mental powers," he adds, "were already seriously impaired when he came to form his post-war Government. In conversation, one of his visitors told me, he was liable to confuse the 1939-45 war with the one of 1914-18... He forgot faces and muddled up names. Men called to Downing Street found themselves addressed as someone else... Macmillan, one gathers, was always surprisingly available. Visitors would find him sitting ruminatively before an empty desk...Even Home, who as far as paper work is concerned, is what French school masters call a *retardataire*, has been able to absent himself from Downing Street for a good proportion of his short period of office without, apparently, suffering any ill-consequences. There seems to have been no particular need for him..."

in increasing the industrial component of its economy. It first undertakes to create a pilot industrial site, where new industry may be located, and where nothing now exists but rural pasture-land.

A listing of the known activities necessary for undertaking this programme might appear as shown below, with activities approximately in the sequence in which they are to be performed. Of course, this list has been simplified and shortened for purposes of illustration, but it will serve to illustrate the principles involved. Time estimates are also shown.

Example of activities occurring in the construction of an industrial site

Name of activity	*Estimated time in months*
Select site	4.2
Purchase land	6.3
Make preliminary physical design	1.8
Prepare budget	2.4
Water and soil mechanics tests	1.1
Triangulation and topographic survey	4.6
Prepare contour interval map	2.3
Receive contract proposals	2.0
Renew bids and select contractor	1.0
Prepare final physical design	1.8
Prepare work schedule	2.3
Undertake preparation of industrial performance standards	2.1
Undertake preparation of industrial building code	1.8
Erect primary transmission line	2.7
Construct transformer building	0.9
Take delivery of water supply equipment	6.3
Construct stand-by well	3.1
Excavate primary supply conduit trench	1.7
Excavate reservoir site	4.0
Lay conduit pipe	3.6
Erect transformer	0.2
Erect internal distribution system	3.2
Erect street lighting system	2.8
Excavate road base	5.1
Erect collection system for sewerage	3.1
Erect collection system for drainage water	2.4
Stabilise road base	3.1
Erect carrier conduit	1.1
Surface road	2.1
Erect street lighting system	1.9
Lay curbing blocks	2.4
Erect management structures	0.8
Install telephone communications	1.5
Sell industrial sites	6.2

Several things may be noted about these activities and their times:

1. It would be incorrect to add all the time estimates and call this the overall time for the project. Obviously several activities may occur in parallel.
2. Some activities depend on the conclusion of previous activities before they can be begun, e.g., "purchase land" cannot begin until "select site" is concluded. Others are independent of each other, but have significant relationships, e.g., "prepare budget" is related to "select site", but is not dependent on it.
3. There is one longest time-path through a "network" that may be constructed of these activities. It is these activities and these alone that will determine the length on time needed to complete the project. These activities lie on the "critical path", and may constitute as few as 10 per cent to 20 per cent of all the activities. Only these need to be expedited, as "slace time" exists in the other activities and their completion is not "critical".

The appearance of the network for our example, showing the critical path through the network, is provided in Fig. 1. The "earliest expected completion times" for activities have been accumulated in a "forward pass" through the network; then the "latest allowable completion times" have been accumulated in reverse form by a "backward pass" through the network. The critical path is the path determined through activities in which these two time requirements are

. . . There is much to gain from an application of the relatively simple technique of PERT for the control of development projects and national programmes . . .

equal. This path isolates the activities that need to be controlled and expedited.

Having determined the critical activities needing careful controls if the schedule is to be met, it is desirable to convert the network form into a bar-chart form, or as is shown here, a "Squared Network".

A portion of the Squared Network for the activities shown in Fig. 1 is illustrated in Fig. 2. A time-scale along the horizontal axis then makes it possible to compare progress of the critical activities with the planned schedule. Action may be taken when implementation falls behind, and the schedule brought uptodate—or at least the status of the project is made quite clear, even if expediting is difficult. Succeeding activities may then be revised if maintenance of the schedule warrants it.

Benefits of PERT

Although the details of the preparation or maintenance of a PERT programme need not be given here, it should be observed that the benefits any application will provide will be derived from the following facts:

1. PERT requires the establishment of detailed plans;
2. PERT provides the opportunity for "management by objectives";
3. PERT makes a rapid programme analysis possible;
4. PERT points out potential slippages before the fact;
5. PERT aids in formulating new schedules if needed;
6. PERT establishes the sequence and relationship between significant programme events;
7. PERT provides economy by isolating the few critical activities that need to be watched and expedited; and
8. PERT serves the planning and evaluation interests at all levels of command.

So it is evident that there is much to gain from an application of this relatively simple technique for the control of development projects and national programmes.

We may conclude by consolidating a few of the lessons that planning for progress has taught planners of many nationalities. A few of these are:

1. Planning for progress nationally or otherwise is a *management* responsibility. Just as the management of any activity—sports, industrial, social, or otherwise—requires the respect of certain principles of management, so progress planning employs similar principles. Good management *is good management.*
2. No progress plan is self-implementing—there is nothing automatic about it. Human judgment is required, and techniques and procedures are used only to achieve a better application of that judgment.
3. *Progress is most certain when there is a dynamic control system overseeing progress;* and for taking action appropriate to the condition when progress is not made. Once the programme is under way, there should be no turning back. But this is easiest to achieve with good control of the programme!
4. Rigidly standardised control methods are less suitable than flexible procedures. These methods should be adaptable to fit specific needs. Each project or programme brings with it its own brand of deterrents and difficulties. A flexible procedure is required to deal with these—and Governmental procedures are notoriously inflexible!
5. The adaptation of modern planning and control procedures, derived from new scientific developments, to planning for progress provides the greatest assurance of success.

The need for a progressive spirit clearly is implied by the items on this list.

We have been told that "all progress is initiated by challenging current conceptions, and executed by supplanting existing institutions." The real question, therefore, in progress planning is: are we progressive in our thinking? And do we adapt our actions to this progressiveness?

Reason for Low Productivity

"Many industrialists", says *Mass Production*, "would rather spend £100,000 on new plant and equipment than £1,000 on planning how to use it . . ."

There is no denying the fact that a satisfied employee gives the best—though it is too complicated to understand the nature of satisfaction. In this study are presented the results of an investigation of the attitude of the textile personnel in the weaving departments of 22 mills in Bombay. Workers at three levels—weavers working in looms, jobbers, and junior assistants—were taken as sample, and the investigation covered such aspects as their attitude to working conditions;

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Job Satisfaction of Workers in Textile Mills

job, pay and security; promotional possibilities; supervision/management; and welfare activities. There is useful information to which mills could pay attention: Mills differ widely in the levels of satisfaction, and one of the findings is that weavers and jobbers are not prepared to leave their jobs for any other job with the same pay, though they are not keen to send their children to the textile industry!

THE AIM of any industry is to obtain the maximum out of its resources, manpower being the most important amongst them. To get the maximum out of man, it should consider the various factors which affect his life. A company pays the same for labour whether it is managed well or not, but what it gets out of its labour depends upon not only the methods and equipment that the management provides, but also whether the employees work with a 'will'. What affects this 'will to work' has been under investigation for long, and different concepts like morale, attitude, and job satisfaction, have been used to explain it.

The present investigation was undertaken to study—

1. the variations in the degrees of satisfaction of workers in different mills;
2. the differences in levels of satisfaction of workers belonging to two different categories;
3. the comparative levels of satisfaction for different aspects; and
4. the attitude of workers for introduction of automatic looms in the mills.

The questionnaire was designed in such a way that the workers' attitude could be studied in terms of (a) Working conditions, (b) Job, (c) Pay, security, and promotional possibilities, (d) Supervision/Management, and (e) Welfare activities. Each of these five aspects was represented as a section in the questionnaire.

Section I (Working conditions) included 10 items related to the existing conditions in the mills, e.g., noise, fresh air, space, lighting arrangement, fluff, temperature, and cleanliness. *Section II* (Job) contained 10 items representing the factors which contribute to the job attitude, e.g., monotony, opportunities for initiative, strenuousness to sense organs, and fatigue. *Section III* (Pay, security and promotional possibilities) had 10 items which dealt with earning, promotion, security, training of the workers, etc. *Section IV* (Supervision/Management) was composed of 15 items related to the workers' impressions about the supervisory practices, instructions, management policy, communication, suggestion system, etc. *Section V* (Welfare activities) had 15 items about the

welfare facilities provided in the mill, as, for example, precautions for safety, canteen provision, medical facilities, leave conditions, and provision for games and sports.

The items belonged to the opinion statement type. The response to each item was classified under four classes as shown below:

A—Agreement to the statement.

B—Neutral attitude.

C—Refusal to respond.

D—Disagreement to the statement.

Scope of Study

The survey was carried out in the weaving departments of 22 mills of Bombay. Two shifts, day and night, were covered by the survey. The individual interviewing technique was used. The time taken to interview a worker was, on an average, an hour. Complete privacy was ensured at the time of interview.

Workers at three levels—(a) weavers working on two looms, (b) jobbers, and (c) junior assistants—were taken as sample for the investigation. In each mill, five per cent of weavers, with a minimum of 40, and 20 per cent of jobbers, with a minimum of 12, were selected on random basis. For assistants, however, no percentage could be fixed, but an attempt was made to interview as many as feasible. The total number of workers in each category, for which results have been analysed, is as follows:

(a) Weavers	972
(b) Jobbers	256
(c) Junior assistants	68

Composite responses were calculated separately for (i) mills, (ii) weavers, and (iii) jobbers, for different sections of the questionnaire. This was done by totalling the frequencies of responses for all the items in each section. These composite responses were transformed into percentage composite responses to give a clear picture for comparative study. By pooling the frequencies of all responses of all the mills, mean composite responses (in percentage) were calculated separately for weavers and jobbers.

It will be observed from Table I that the mills differ widely in the levels of satisfaction on all the five aspects as indicated by the attitude of the weavers and jobbers. Only the highest and the lowest composite responses have been presented here to give an idea of the range in which the mills lie. It will be seen that the maximum range is for 'Job', and the minimum for 'Pay, etc.', for weavers, and in the case of jobbers the maximum disparity is for 'Welfare activities', and the minimum for 'Pay, etc.'

Table I

Highest and lowest composite responses as indicated by weavers and jobbers

Attitude towards	Satisfaction level			
	Weavers		Jobbers	
	Highest	Lowest	Highest	Lowest
Working conditions	87.40	45.58	95.00	46.67
Job	89.00	37.69	83.33	38.33
Pay, etc.	64.18	27.50	64.17	26.67
Supervision/ Management	79.70	38.33	85.56	42.22
Welfare activities	70.00	27.50	77.22	27.50

To study the differences in the levels of satisfaction of weavers and jobbers, a comparison was made between the mean composite responses. The values are given in Table II.

Table II

Mean composite responses of weavers and jobbers

Attitude towards	Satisfaction		Significance level
	Weavers	Jobbers	
Working conditions	67.23	68.95	
Job	60.59	60.12	
Pay, etc.	50.22	50.94	
Supervision/ Management	63.33*	67.97	* $p < 0.1$
Welfare activities	47.37	48.78	

Table II indicates that the jobbers have significantly a higher level of satisfaction than the weavers for 'Supervision/Management' aspect. It can also be noted that more than 60 per cent of weavers and jobbers have shown satisfaction for 'Working conditions',

'Job', and 'Supervision/Management'. But the remaining 30 per cent to 40 per cent workers form quite a sizable proportion which undoubtedly needs the careful attention of the management. For 'Pay, etc.' the workers are divided almost into two equal groups for satisfaction and dissatisfaction. It is disheartening to note that more than 50 per cent of the workers have shown dissatisfaction for 'Welfare activities'.

It would be interesting to see the comparative picture of the five aspects of job satisfaction among weavers and jobbers. The mean composite responses of weavers and jobbers for five aspects of job satisfaction have been arranged in descending order, and are presented in Table III.

Table III

Mean composite responses for weavers and jobbers

Rank	Aspects	Satisfaction	
		Weavers	Jobbers
1	Working conditions	67.23	68.95
2	Supervision/Management	63.33	67.97
3	Job	60.59	60.12
4	Pay, etc.	50.22	50.94
5	Welfare activities	47.37	48.78

Ranks as given in Table III show that the weavers and jobbers have the same order in levels of satisfaction for five aspects. The highest level of satisfaction for both the weavers and jobbers is for the 'Working conditions', and the lowest for the 'Welfare activities'.

An analysis of all the items of the questionnaire presents useful information to which mills could pay attention. For discussion, we shall consider only those items which need careful consideration. The weavers and jobbers have shown very poor level of satisfaction for space provision and temperature of the working place. However, the workers seem to be satisfied with working in shifts, lighting arrangement, and cleanliness in the loom-shed. They have shown poor satisfaction for monotony, preparedness to send their children to the textile industry, and tiresomeness. But they are not prepared to leave their job for any other job with the same pay. For salary, promotional possibilities, training, and bonus, they have responded negatively. On the other hand, they think that their jobs are quite secure. They feel that their complaints do

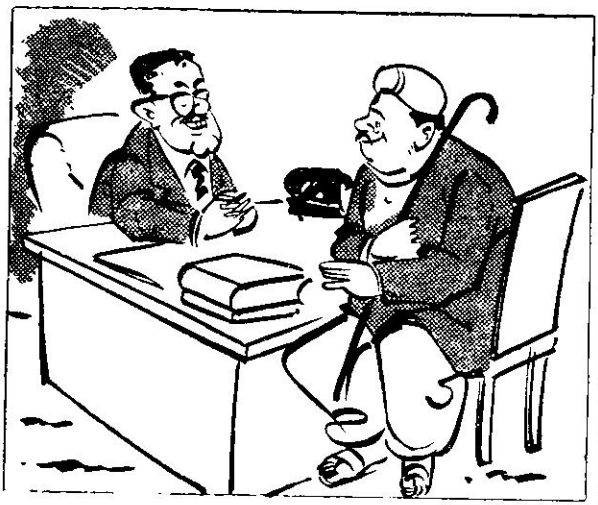
not reach management, and that it does not care for their participation in policy-making. However, they have expressed a good degree of satisfaction for the treatment they receive from their superiors.

Low Productivity

The responses of the weavers and jobbers to safety precautions, medical facilities, facilities of cooperative credit society, provident fund, and ESI Scheme indicate that the majority of them react favourably to these facilities. But they have not responded very favourably towards the provision of canteen. It appears that the present form of this service is not very attractive to the majority of them, and it may be that certain positive steps need to be taken so that they are attracted to it. As regards facilities for games and sports, literacy and educational scheme, library and reading room, the responses of the workers are rather discouraging. The overall picture of the welfare activities as indicated by the responses to the item, 'Management looks after the welfare of the workers sufficiently', is discouraging as only 24 per cent of the weavers and 27 per cent of the jobbers gave positive responses.

The textile industry is conscious of the fact that productivity of labour is low as compared even to that of some other developing countries. Amongst the reasons advanced to explain this low productivity, is the existence of outdated machinery and the unwillingness of labour to work on more/or automatic looms. It is against this background that two open-end questions were included to gauge the feelings of the workers on these two issues, i.e., (1) "Are you agreeable to work on more looms?" and (2) "Are you agreeable to work on automatic looms?". The details of the responses for questions (1) and (2) are given in Tables IV and V respectively.

Analysis of responses for question (1) (Table IV) indicates that a total of 73.45 per cent of weavers and 85.04 per cent of jobbers are not in favour of working on more looms. When analysed age-groupwise, 61.90 per cent of weavers in the 'below 30 years' age-group were found to be against the idea of working



Mohan Lal contacts an expert...the expert tells him that the "just-keep-it-going" attitude should give place to "keep-it-going-the-right-way" through Preventive Maintenance...which alone can ensure uninterrupted utilisation of available capacity and avoidance of heavy costs usually associated with emergency operations consequent on sudden and unforeseen breakdowns.

Six months later...Mohan Lal is a very happy man. He has introduced the preventive maintenance system...and now there is less machine downtime ..lower maintenance cost...less unforeseen breakdowns...better quality of goods...less overtime payments for rush repairs...

on more looms. This percentage of negative attitude in the case of weavers goes on increasing with the increase in age, and in the 'above 50 years' age-group, it is 93.65. However, in the case of jobbers the percentage of negative responses in the 'below 30 years' age-group is 100.00, and for '31 to 40 years' age-group, it is 80.30, and then it goes on increasing with the increase in age. It may be mentioned that the number of jobbers in the 'below 30 years' age-group is only three which is a very small sample for generalisation. Thus, on the whole, it can be said that with the advancement in age, the weavers and jobbers show more and more unwillingness to work on more looms.

Table IV

Positive and negative attitude of weavers and jobbers towards working on more looms

Age-group (in years)	Weavers		Jobbers	
	Yes %	No %	Yes %	No %
Up to 30	38.10	61.90	—	100.00
31-40	30.11	69.89	19.70	80.30
41-50	14.49	85.51	16.49	83.51
Above 50	6.35	93.65	8.82	91.18
Average	26.55	73.45	14.96	85.04

The analysis of the responses to the question "Are you agreeable to work on automatic looms?" (Table V) reveals that 44.91 per cent of the weavers and 47.01 per cent of the jobbers are in favour, and 55.09 per cent of the weavers and 52.99 per cent of the jobbers have negative attitude for automatic looms. Age-groupwise analysis points out that the older the workers, the more the negative attitude they have for automatic looms, with the exception of jobbers belonging to the 'below 30 years' age-group, where the number is only three which is too small a sample for generalisation.

Table V

Positive and negative attitude of weavers and jobbers towards automatic looms

Age-group (in years)	Weavers		Jobbers	
	Yes %	No %	Yes %	No %
Up to 30	67.20	32.80	—	100.00
31-40	46.97	53.03	63.64	36.36
41-50	28.50	71.50	48.45	51.55
Above 50	17.46	82.54	30.88	69.12
Average	44.91	55.09	47.01	52.99

In industrial units, it is not feasible for the management to come into direct contact with workers. It is the supervisor who shoulders the responsibility of attaining the desired goals of management. Thus it is he who is concerned with the maintenance of good relations with workers. Under these conditions, supervisor's attitude affects the workers' attitude. It was, therefore, felt desirable to study the attitude of supervisors towards the five aspects. Since the free interviewing technique was employed, only a

general outline of the supervisors' attitude, and not the statistical analysis of the responses, can be given.

In all, 68 supervisors covering both the shifts were interviewed. They are known in different mills by different names like supervisors, junior assistants, departmental assistants, first line supervisors, and weaving assistants. Their age-groups are given below:

Age-group (in years)	Number
20-29	16
30-39	23
40 and above	29
Total	68

An analysis of their educational qualifications shows that 52 of them (76.47 per cent) have technical qualifications, while only 16 (23.53 per cent) do not possess any technical qualification, but only have practical experience in the field. Of these 16, 14 have their general educational level below SSC, and most of them know only the three Rs.

Their monthly pay varies from about Rs. 150 for the apprentice-supervisor to Rs. 750 for the supervisor either with long-established service or with very high educational qualifications, especially technical. Some have steady service in the mills for about 20-25 years, while others have changed as many as six mills. Generally, the stationary group is found to be more satisfied. It is observed that, in general, supervisors with low educational level, who have come up from the lowest category of job to the present one, are more satisfied, while supervisors with higher educational qualifications and belonging to the younger group are more dissatisfied especially as far as salary is concerned. This is in conformity with the general belief that in the same job-category, dissatisfaction increases with rise in educational level. Hence it is this group which frets more about the promotional policy and training facilities.

Even though some supervisors express satisfaction with their present condition, most of them are unwilling to send their children to the textile industry; on the other hand, very few of the dissatisfied group are willing to change the job with the same pay. Though pay is the main ground of dissatisfaction for almost all the supervisors, a number of them have come out with suggestions in the fields in which they are dissatisfied. These can be summarised thus:

1. There is the need of definite and uniform promotional policy for the entire textile industry. It should not be left to the caprice of the immediate boss.

2. The top management should be directly approachable for the supervisors, and the supervisors should be invited to conferences on safety, work improvement, etc. Since they are the first-line people who know the workers and the working conditions better, their suggestions should be invited and heeded to. Smooth relations between the supervisors and their immediate superiors would lead to higher efficiency.

Approach to Workers

3. There should be more systematisation of work as far as the inter-departmental organisation is concerned. Shortage of stores and raw materials often experienced in so many mills can be easily avoided with better and advance planning in consultation with supervisors.

4. A majority of them agree that the time is past when workers could be disciplined with a rod. Persuasive methods are the best to get the best out of them. At the same time, they regret their inability to be very effective in the field, and hence they emphasise the need of training courses in human relations to be conducted by the mills.

...The bonus system needs to be regularised, and many favour efficiency and production bonus, and not just annual bonus...

5. They believe that with better understanding of the psychological and emotional needs of the workers, the workers' allegiance to the trade union can be more rationalised, and coercive practices of the union leaders can be minimised.

6. In almost all mills, the supervisors complain about the canteen facilities for the technical staff. They are almost unanimous in demanding canteen facilities in the night shift too, and subsidised lunch.

7. Need for transportation facilities by mills is expressed by many supervisors.

8. Absence of a separate room for the technical staff is a cause of dissatisfaction to many of the supervisors.

9. Too much pressure of work on the technical staff can be avoided by increasing the number of technical personnel. This would also improve the leave conditions for which many supervisors seem to be fretting.

10. Almost all the supervisors complain that the ESI Scheme is not managed properly, and that it had led to increase in absenteeism among workers.

11. Most of the supervisors, excepting new entrants and the senior ones who are not keeping good health, express that they are used to the shift system. But, at the same time, they would like to have a special allowance for the night shift.

12. The bonus system, it is felt by the majority, needs to be regularised, and many favour efficiency and production bonus, and not just annual bonus.

"Source of Insecurity"

The following other points are made for consideration: (1) Need for medical insurance by mills for staff not covered by the ESI Scheme; (2) Provision of staff quarters and library and sports facilities; (3) As family and personal worries lead to lower efficiency among workers, counselling by the labour office would be highly paying; (4) Constant change in managerial staff is considered as a source of insecurity to them; (5) Education of workers in civic duties would contribute towards more cleanliness in the loom-shed and the entire mill; (6) The bond system is not liked by quite a few supervisors, but some find it as a source of security; (7) Supervisors who are old in age feel that they cannot stand the continuous noise, the shift system, the lack of fresh air, and the fluff in the department. The younger generation does not mind all these, though they would prefer some improvement in these conditions; and (8) Some supervisors are of the opinion that the incidence of tuberculosis is greater among textile workers, and hence they need to be given rest after every three or four days—an item of investigation.

In the light of the findings, the following conclusions may be drawn:

(i) Mills in Bombay differ widely in the levels of satisfaction.

(ii) For all aspects of job-satisfaction, excepting the "Supervision/Management" aspect, the levels of satisfaction for both weavers and jobbers are almost the same. For this aspect, however, the jobbers are more satisfied than the weavers. The statistically significant difference is observed.

(iii) Levels of satisfaction as expressed by the weavers and jobbers for different aspects are different, i.e., the maximum level of satisfaction is for the 'Working conditions' and minimum for the 'Welfare activities'.

(iv) The weavers and jobbers are not prepared to work on more looms than at present handled by them, viz., two looms.

(v) On the question of introduction of automatic looms, the weavers and jobbers are divided into two almost equal groups.

(vi) Supervisors with low educational level have expressed more satisfaction than those with higher academic achievement.

(vii) The younger group of supervisors is less satisfied than the older group.

PRODUCTIVITY IN THE NEWS

***Ways to Step up Productivity *Human Factor *Productivity in Administration *Stress on Efficiency *Management Education *Manpower Utilisation *Production and Productivity *Productivity in Small Sector *Materials Management *Exports and Productivity *Productivity in Shipping *Petroleum Productivity *Productivity in Education *Army Becoming Productive *Doctors to be Productive *India's Low Productivity *Steel Productivity Prospects *Bangle Joiners' Productivity *Productivity from Abroad.**

SOUND labour-management relations for harmonious industrial progress, need for hard and concentrated work and reduction of waste in all spheres, change in the present stereotyped way of functioning of the administrative machinery, full utilisation of available materials, and stress on efficiency—these and many other suggestions for increased productivity have been made by the Prime Minister, Sri Lal Bahadur Shastri, Ministers, leading economists, and others. Speeches and statements made by them in recent weeks are full of ideas bearing on productivity.

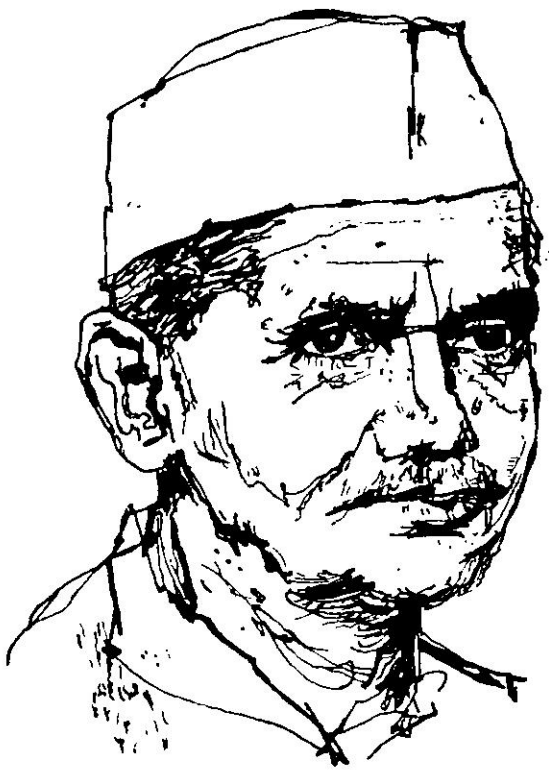
★ Ways to Step up Productivity

Speaking at the centenary of Jessops in Calcutta, the Prime Minister felt certain that efficient management and good administration alone led to an increase in productivity, either in the private or the public sector. There should be healthy relations between the workers and management, otherwise "production will be hampered." These ideas also found expression in the speech of the Gujarat Chief Minister, Sri Balwantrai Mehta, when he inaugurated recently the Employees' State Insurance Scheme at Ahmedabad. Industry needed peace as much as it needed capital and good management, and unless this view was accepted, industrial production would not go up. Management and Government should be solicitous of labour welfare, and Sri Mehta felt certain that the ESI Scheme, though "belatedly implemented" in Ahmedabad,

would provide a number of benefits to as many as 10 lakhs out of 14 lakhs workers in the State.

★ Human Factor

The Director of Ordnance Services, Maj. Gen. SN Muhayi, made yet another point when he said that the management, besides providing dynamic leadership, and good working conditions, should "*win the willingness of the worker who should get the feeling that he was being treated as a human being.*" At the concluding session of the Appreciation Course of the Defence Institute of Work Study, held at New Delhi on Oct. 19, he referred to management's role in raising productivity, and in the process underlined the need for work study in improving methods of management. Management was both science and art, and its task was to organise and control human activity to achieve certain specific purposes. Reduction of waste of time and effort should be the object of the managerial authorities.



...Real progress depends on changes in the present stereotyped way of functioning of administrative machinery... — *LB Shastri*

★ Productivity in Administration

There is new thinking all round as to how productivity in administration can be improved. Even in the UK, where the civil service is considered the best, there is a move to associate economists, professors, engineers and other trained personnel with the administration to bring about "freshness." Sri Lal Bahadur Shastri has called for changes in the present "stereotyped" way of functioning of the administrative machinery if India is to make real progress. For instance, there had been so many meetings of committees, etc., at the Centre daily that he suggested that on one day in the week there should be no meetings at all. The Cabinet Secretariat has now asked all Central Ministries to observe every Wednesday as "meetingless day". The Prime Minister has also desired that meetings should be held after careful preparation, that representatives of various Ministries and departments should ordinarily have the authority to take final decisions in the meetings themselves, and that the follow-up action on decisions taken at the meetings should be quick. Really this is a step in the right direction to increase productivity in Government offices.

Addressing the third annual conference of the rural industries projects, sponsored by the Planning Commission, Sri Shastri said: "We are resting too much on the district administration, and we have no alternative but to take more and more work

from them." A change in the present administrative pattern has become a matter of the highest importance. Surely this will contribute to higher productivity.

★ Stress on Efficiency

Maintenance of efficiency certainly involves a number of administrative steps. So far as the trunk telephone exchanges are concerned, India's Communications Minister, Sri Satya Narayan Sinha, expressed the desire that "*surprise checks at various hours*" should be made. At the meeting of the informal consultative committee of the Department of Communications, he outlined steps being taken to modernise telecommunications to the extent possible "within the available means."

★ Management Education

Some very pertinent observations were made on the role of scientific management in industry at a recent Bombay seminar on "Organisation and information for Top Management Control" which was co-sponsored by the Bombay Management Association, the All-India Management Association, and the US-AID. Pointed attention was drawn by the Chief Management Adviser to US-AID, Dr Howard K Hyde, to the fact that application of scientific methods to the solution of management problems, as in USA, could result in "improved production and cost savings that were spectacular." The seminar indicated the need for top management to limit itself to only very vital decision-making, leaving the rest to people working under it.

Such decentralisation and division of work necessitates a system of information feeding, with computers and machines speedily providing a basis for making decisions. Dr Hyde, who has studied some of India's managerial problems, emphasised that "information systems can be designed and applied generally in India to facilitate the tasks of Top Management." In a growing economy like that of India, such a modern management information system "can help better to utilise available resources." Technological developments like automation, computers and communication media make quickly available to managers information necessary for making decisions.

Higher productivity also depends on the quality of the managerial personnel. Sri Jehangir Ghandy, Chairman of the All-India Board of Technical Studies in Management, speaking at a meeting of the Board, made it clear that it was of the utmost importance that management education was kept under constant review. According to the report of the Managerial Personnel Committee appointed by the Board, the Fourth Plan requirements of managerial personnel for industrial and non-industrial sections are estimated at 13,250 on the technical and 26,500 on the general and commercial sides—the respective estimated figures for the Third Plan being only 7,000 and 13,000.

★ Manpower Utilisation

A pre-requisite of successful industrial development and increased productivity is the effective use of available manpower. Hitherto, Indian employers had neglected the study of manpower and its best utilisation, because they thought that there was no dearth of labour. The fast developmental activity in the country, however, had exposed the drawback in this line of thinking. Non-availability of enough skilled personnel was being felt by every industry. This aspect was stressed by Sri D Sanjiviah, India's Labour Minister, when he inaugurated recently in New Delhi a two-day seminar on employment information and manpower utilisation, organised jointly by the Employers' Federation of India and the All-India Organisation of Industrial Employees. He pointed out that human resources constituted a valuable asset for the country's development and their optimum utilisation was one of the main objectives of planning.

Employers' organisations—both public and private—and other institutions engaged in planned development of economy should devote more attention to the problem of utilising all the available manpower, and

thus contribute to raising productivity and reducing unemployment.

★ Production and Productivity

If the rate of increase of industrial output continues at current levels, it is very likely that the Third Plan target will end up with no more than a 50 per cent achievement. According to the latest review of industrial production trends during the first half of 1964, the rate of growth by 6.8 per cent is very much lower than the 8.2 per cent recorded during the corresponding half of 1963. The key issue is not one of maintaining the rise in production, but that of attaining a rate of growth adequate to carry the production index to 240 as stipulated in the Third Plan.

During the first three years of the Third Plan, India has not been able to attain the target rate envisaged of nearly 11 per cent. The annual rate of increase was 6.5 per cent in 1961-62, 8 per cent in 1962-63, and 9.1 per cent in 1963-64. It is possible that, with improved productivity techniques now in operation, the target rate may be reached at least in the current year.

★ Productivity in Small Sector

Dr PS Lokanathan, Chairman of the National Productivity Council, had a word of praise for the productivity achievements of the small-scale industries sector in India. Presiding over the seminar on "Productivity in Small Industries", organised by the Ahmedabad Productivity Council, recently, he did some plain speaking on the role of the small-scale industries. An astonishing feature of the country's industrialisation was the "rapid growth" of these industries, but it was his considered opinion that they should "move increasingly into the middle-size sector by adopting improved techniques of production, improving quality and cost standards, and achieving still greater diversification."

Though it might be argued that the small-scale sector was essential to counterbalance the big units, he felt that "the small

"Sit Down; Be Relevant; Be Brief; Be Gone" —which sounds much like Bernard Shaw's "They say; What do they say?; Let them say..."—was the British Officer's Productivity Formula in India, and was the actual text of a placard, exhibited in full view of visitors, in the office of the Divisional Commissioner (Nagpur) in British times! Now that the British are gone, what is the appropriate Productivity Formula for the Indian District Officer in 1964-65?

units should eliminate the desire to remain small to avail of the assistance made available to them by the Government." The small units should explore more and more foreign markets for their products while constantly improving standards of quality and achieving higher productivity.

⋆ Materials Management

At the Ahmedabad Productivity Council Seminar, Dr Lokanathan also emphasised the need to develop ancillary industries, and suggested that productivity councils should be able to help these units in developing quality and cost controls, so that they could meet the requirements of bigger industries without sacrificing standards of quality.

The productivity movement should contribute substantially in utilising scarce resources for achieving maximum results in all sectors. In implementing any scheme of national productivity the management of available materials and its full utilisation should be given high importance. Dr Lokanathan stressed this aspect when presiding over the concluding plenary session of the two-day conference of the NPC foreign programme participants and productivity institutions at Bombay: He opposed the suggestion to award the best performance in productivity, and said that the economic gains resulting from the good performance of a firm itself were an award. The session discussed the productivity needs of industry, impact of productivity programmes, co-ordination and collaboration by various agencies in productivity activities, and evaluation of productivity programmes.

⋆ Exports and Productivity

Historical experience shows that it is only through increased productivity that developed economies have been able to build up an export trade in finished goods. At a recent meeting of the Export-Import Advisory Committee, Sri Manubhai Shah, India's Minister for Commerce, referred to the Fourth Plan target of Rs. 51,000 million, and said it could be achieved only through larger export of processed and finished goods. Such exports have two advantages, viz., (i) weight for weight, the export earnings are higher; and (ii) the labour content is much larger.

Analytically, it really means the export of raw materials plus the export of labour. The Fourth Plan target can only be achieved if Indian industries adopt productivity techniques.

⋆ Productivity in Shipping

Achievement of export targets raises a number of problems as, for example, the need to step up ship-building activity in the country so that Indian shipping could carry a major portion of the overseas trade. No doubt, Indian shipping has increased its productivity: Sri Lal Bahadur Shastri, in fact, paid a tribute to this achievement at a meeting of the National Shipping Board recently. The Shipping Corporation of India—a public enterprise—has increased its tonnage during the last six to seven years from 1.26 lakhs to 2.42 lakhs. The private sector, too, has displayed a considerable spirit of adventure and increased its tonnage in the same period from 4.56 lakhs to 11.17 lakhs. The Prime Minister indicated that the Fourth Plan target might well be set at about five million tons, and hoped that Indian shipping would carry at least half the overseas trade.

To increase the productivity of Indian shipping, he felt that the facilities of the minor ports should be expanded. He expected that the ports of Mangalore, Tuticorin, Paradeep, and Haldia would be developed into major ports during the Fourth Plan period. Immediately significant from the productivity point of view was his suggestion to mechanise loading and unloading work at ports. This might raise some labour problems, but he hoped that it would be possible to strike a balance between automatic and manual operations. The lack of mechanised unloading devices, he pointed out, had recently proved to be a serious handicap in the

despatch of the much-needed food to the deficit areas.

★ Petroleum Productivity

As India is short of petroleum, the Government has been taking a number of measures to increase productivity in the line through training courses, industrial research, location of new supplies, drilling operations, etc. Early in September, Sri Humayun Kabir, Minister for Petroleum and Chemicals, inaugurated a post-graduate course in petroleum technology at the Indian Institute of Petroleum which is an important link in the chain of National Laboratories set up by CSIR. Eighteen scientists, most of them directly recruited, and others sponsored by the public sector refineries, defence research laboratory, etc., will undergo training for 15 months, and, according to the Minister, "they will play an important part in the inauguration of the Petroleum Age in India."

The Minister also spoke of the prospects of oil in the Doon Valley, and of the deep drilling at Mohand, which had been undertaken in collaboration with Italian experts.

While the country is thus being developed in respect of oil supplies, the Institute of Petroleum is doing a good bit of research so as to make the most productive use of the existing facilities and lubricants. The Executive Council of the Institute recently considered some of these productivity measures.

★ Productivity in Education

Though education had for long been regarded as a social service, and the money spent on it as unproductive, it was now considered as an investment in the development of human resources, which, in turn, would contribute to greater social and economic development. Voicing this view, Sri Prem Kirpal, Secretary and Educational Adviser to the Government of India, (inaugurating a seminar on adult literacy and adult education at New Delhi recently), said that the human factor in economic growth had become a major subject of study in the economics of development. Even if education was to be only skill-oriented, it had to be recognised that there was need for a broad base of general education including literacy which was a pre-condition to acquiring skills. Literacy and education play an important role in enabling individuals to acquire knowledge from available literature.

One of the main causes of the poor productivity of Indian universities has been the inability of most students to purchase costly books which are necessary for prosecuting studies. The University Grants Commission has initiated a scheme of assistance to universities for construction of student-homes. Under this scheme, each home will provide reading facilities for 100 students at a time, and have a well-equipped library, cafeteria, and other facilities. The UGC will also give grants for the purchase of library books, maintenance of the home, etc.

★ Army Becoming Productive

Productivity in the armed services has been of a remarkably high standard in the last two years, as nearly 300,000 men and 10,000 officers have been selected, trained and equipped. This achievement, besides being a feat of organisation for the Army authorities, marks the completion of an important phase in the nation's defence plan, as the emergency recruitment drive launched soon after the Chinese aggression is being discontinued.

Another instance of productivity in the Army comes from Kashmir where Army doctors are collaborating with the Government to make medical advice and treatment available to villagers in the State. About 10,000 patients have been examined by these doctors so far. Under the scheme, the Army provides doctors and transport, while the State Government provides compounders and medicines.

★ Doctors to be Productive

Speaking of doctors, Dr Sushila Nayyar, India's Health Minister, recently expressed

the view that the state of the people's health was an impediment to higher productivity in nation-building activities. Speaking at the opening of the Rs. 1.5 million building of the Indian Medical Association at New Delhi, she said IMA should start refresher courses for doctors, and expressed the Government's preparedness to subsidise it. President Radhakrishnan, who opened the building, urged doctors to keep in touch with the latest advances in the field of medicine, and cooperate in the nation's productivity efforts by helping to eradicate diseases and serving the masses.

★ India's Low Productivity

A recent study has revealed that the productivity of Indian labour is less than a fifth of its counterpart in the USA. The study, which relates to the Indian cotton mill industry, was conducted by the Indian Cotton Mills Federation.

Here are the highlights of the study: The Indian cotton mill industry employs at least five times the number of men to do the same job in spinning departments, and three times the number in weaving departments compared to the US mills.

The total number of workers employed in the American textile industry is estimated at 423,700—comprising 105,600 in spinning, 233,200 in weaving, and 84,900 in man-made fibre weaving. In 1962 (for which figures are available), Indian textile industry engaged 7.98 lakhs workers, consisting of 3.22 lakhs in spinning, 2.76 lakhs in weaving, and two lakhs in other departments including processing and finishing.

The installed spindleage in the American industry is of the order of 19 million, of which 18.6 million spindles are active. The average number of workers required per 1,000 spindles in the USA is 1.9 as against 10.36 in India.

On the basis of 48-hour-week, yarn production per worker per annum in the USA amounts to about 43,320 lb. compared with 6,054 lb. in India which works out to one-seventh of the production of the American worker. Cloth production per worker in America comes to 45,060 yards per annum, as against 17,710 yards in India. The production per weaver in India works out to one-third of that in the USA.

★ Steel Productivity Prospects

Dr GF Drath, leader of the German team of technicians at Rourkela, recently sounded a note of caution: if productivity efforts in the steel industry were to be crowned with success, certain *human problems should be given enough attention.*

Steel technology is fast developing in India—from a modest production of about one million tons ingot steel at the end of the First Five-year Plan, a target has been set to produce 18 million tons of ingot steel by the end of the Fourth Plan (1971).

"One of the most vital aspects for improvement and expansion of the iron and steel industry in India," Dr Drath said, "would consist in the development of congenial human relations, without which even the most modern techniques and processes will not yield the desired results. Opportunities for adequate training should be given to workers at all levels to assume the responsibilities assigned to them. Continuity of service, retirement benefits, and wages to ensure a basic minimum standard of living should be provided. Suitable transport facilities to bring the workers from their homes to their place of work and vice versa should be planned. This problem is particularly acute in Rourkela because of the lack of an adequate public transport system."

★ Bangle Joiners' Productivity

There are a number of ways to increase productivity, and one such is through better industrial relations. The case of the glass

bangle joiners of Ferozabad, who normally work on a piece-rate system, is an instance in point. They went on strike on June 22, 1964, demanding a rise in wages. There are 50,000 of them, and they have their own association.

The Glass Industrial Syndicate, for whom they work, declared lock-out on July 29. On Sept. 5, after an 11-week strike, which caused the industry a loss of Rs. 5 million, they have now come to an understanding by which they will get increased wages. The factory owners will also compensate them for breakage of raw bangles during processing, besides payment for the fuel consumed.

★ Productivity from Abroad

To make our stock exchanges really productive in the service of the economy, the Government has deputed a senior officer to the USA to make a special study of the working of stock exchanges there.

Sri RC Dutt, Chairman, Company Law Board, will, on his way back from the USA, make a similar study of stock exchanges in Britain. The reason for that is that the Government of India desires to take steps to regulate the working of stock exchanges to prevent speculators and others from putting undue pressures on the country's economy by manipulating the markets through stock exchanges.

Magnifies two million times

Objects can be magnified two million times their normal size with a new instrument that employs the electron microscope and television.

This instrument, which increased the capability of the ordinary electron microscope tenfold, and had 2,000 times the magnifying power of the best light (optical) microscope, was demonstrated recently by the Radio Corporation of America (RCA) at Camden, New Jersey. It is a refinement of the first television-electron microscope, developed in the USA by Westing House Corporation a year ago, which has a magnifying power of one million. The basic concept originated at Cambridge University, England.

However, the RCA instrument is less powerful than another device—the field ion emission microscope—with which scientists can see individual atoms. It can resolve only clusters of atoms (molecules). A field ion emission microscope in use since 1962 at Columbia University achieves direct magnifications of two million, and this image can be optically enlarged 10 times over.

productivity abroad

Productivities in UK: The Old and the New

Of the four startling events of Oct. 16, 1964, one was the Labour victory in the UK elections (the others were the Jenkins affair in the USA, Khrushchev's replacement in Russia, and China becoming the world's fifth nuclear power). The Labour Party squeezed into power with a precarious small majority—the smallest House of Commons majority in modern history after the tensest electoral battle for more than a decade.

"...If there were no ideological differences at all between the parties, there would still be an overwhelming case for removing the present British Government. It is tired, demoralised, ill-led and accident-prone. When governments reach the stage where everything goes wrong, it usually means that Ministers have run out of energy and ideas. So it is with the Tories...," writes Mr John Freeman in the *New Statesman*.

"But, of course," says Mr Freeman, "there is an ideological difference as well, and the effect of Labour votes will be far more constructive than merely to kick out a tired, discredited Government and replace it by men who are fresh and full of new ideas. British politics are essentially about priorities. And Britain requires today a change of priorities as much as it does a change of leaders...

Our economy today is purposeless, many of our industry ramshackle and riddled with nepotism; our share of world export markets has already declined, our production is nearly static, *our overall productivity has actually been falling*, and in almost every respect we are less competitive in the world than we were 13 years ago...Secondly,

in addition to squandering the portion of our gains which should have ensured a solid, competitive future, the government has bestowed the rewards of affluence with cynical disregard for need or justice: the greatest prizes have gone to those who have contributed least; the greatest burden has been borne by the weekly wage-earner and the salary-earning, tax-paying professional; the greatest—and least necessary—hardship has been reserved for those whose need has been the greatest—the sick, the poor, and the lonely.

What Britain now needs is a new deal which will assert a whole new series of priorities... It is not by divine law that the gamblers, the property racketeers and the clip-joint sharks have pillaged the cream of affluence; it is the direct result of Tory priorities. A new Government which asserted top priority for the schools and homes of our people, and for the machines which make our wealth, which release the flood of talent and energy, now dammed up by the barriers of class and privilege, could do more than make Britain once again a competitive nation. It could make us a healthy society, in which individual citizens would see in their Government an affirmation of the same values decent people accept in their personal lives. The divorce between public and private standards is perhaps the greatest abuse this Government has committed on the people of Britain...

Are we to refuse the challenge of the future and settle for the old, complacent ways? They will lead to a gradual rundown of our national resources and a widening of the social divisions between our people.

Or can we find a new release for our energies in an all-out effort to meet the challenge of tomorrow? To meet that challenge, we need new ideas, a new set of priorities and new men..."

Pro-Productivity

Britain's new Labour Government has plans to grant monetary inducement to firms showing vigour in stepping up exports. It wants to reshape its fiscal policies on the basis of maximum productivity, particularly in the export industries. Prime Minister Harold Wilson, soon after assuming office, made it clear to his party associates that "leisurely weekends were out, for the time being at least." Mr James Callaghan, the new Chancellor of Exchequer, declared: "I am going to do a bit more work..."

British firms in recent months have evolved a number of techniques designed to speed up production in the printing industry, improve quality control, check corrosion, and lift and convey a weight of several tons through a mechanised hoist by voice command (the last one should be of interest to India in obviating difficulties in unloading food cargoes at ports). Brief details of these and other innovations are given below.

Setting Type by Computer

Setting type with the aid of a computer is the latest and most revolutionary development in the printing world. An organisation, which will offer this service to newspapers, and to periodical and book-publishing houses, is now being set up in London. It will be the first of its kind in Europe.

Use of the computer eliminates two of the main tasks in type-setting—"justifying" and

hyphenating. This means the accurate spacing of words in a column and logical breaks in words at the end of lines. With the new system a typesetter simply produces a punched tape on a machine like an electric typewriter. This tape then goes into the computer which produces another, adjusted and hyphenated to the required column widths. The risk of error is one in five million. Human errors in the making of the original tape can be corrected at computer speeds. The final tape from the computer can be used in a number of ways with conventional printing techniques.

Highly Versatile Rotary Press

A multi-purpose rotary press, which has been designed by the UK printing engineers for large quantity output, will produce book sections, magazine sections, or folded business forms and brochures in a range of sizes which, it is claimed, have never previously been possible from one machine.

Used for either letterpress or dry offset printing, this machine incorporates a number of innovations, including an entirely new type of adjustable jaw and tuck folder, the flexibility of which permits an exhaustive range of cross folds. This folder has an additional advantage in that it allows maximum use of paper. Pin-collecting cylinders, a traditional feature of cross folders, are not used, and there are, therefore, no holed page edges to be trimmed.

Machine to Straighten Bars

A machine, now under production in Britain, is capable of high speed straightening of extruded or drawn bars up to 28 tons per sq. in. tensile strength, as well as steel or non-ferrous thick or thin-walled tubes, without marking or blemishing them.

Automatic Tube-cutting Feeder

An automatic feeder, developed in Britain, when linked to a cutting-off machine, makes the cutting of metal tube a fully automated process. Several feeder/cutter assemblies can be looked after by one man, since all that is required is that the magazines of the feeders should be kept filled with tube.

A new tube is drawn from the magazine before cutting on the previous tube has been completed. This allows the new tube to follow immediately behind the previous tube, so that feeding is continuous and no time is lost.

Improved Quality Control

An automatic device which cuts the time needed to measure the magnetic properties of steel samples from two hours to a few minutes has been developed by a British steel-making firm, to improve quality control and speed up production. Known as an automatic compensated permeameter, steel samples are fed into the front of the machine and their magnetic characteristics are then automatically charted on a graph machine alongside.

One characteristic measured—the magnetisation curve—is related to the torque output of a motor, and the other—the static hysteresis loop—is linked with the efficiency of a motor or transformer.

Bonding Glass with Rubber

Esso Research & Engineering Company, Linden, NJ, USA, have recently discovered in their laboratories a method for chemically bonding glass with rubber. Esso Research proposes to apply this invention, under a US Air Force contract signed by them, towards the development of aircraft tyres featuring glass fibre cord. Other possible applications for the improved fibrous glass bonding technique include truck and passenger car tyres, drive belting, conveyor belting, hoses and rubber storage bins.

Hoist Works by Voice Control

A mechanised hoist which can lift and convey a weight of several tons by voice command has been shown in London. It is an ordinary electric motor system running on a channel rail, but equipped with radio control. A man with an aircraft type microphone tells

the hoist when to lift, drop, move right or left, and consequently has precision control of a weight conveying system.

It is designed to give a factory worker complete command of a weight-lifting system, leaving his hands free to load and unload. The system can be arranged for half-a-ton to 250-ton loads.

Vacuum Metallising Plant for Coating Light Bulbs

A vacuum metallising plant, designed to put a reflective film of aluminium on the interior surfaces of electric light bulbs, has also been developed in Britain. The semi-automatic plant treats eight lamps every 75-second cycle, and is said to have a *faster output than the conventional method* of treating the inside surfaces of bulbs with silver nitrate.

The manufacturers state that it can be adapted to treat other articles, including sealed headlight reflectors, front and rear lamp automobile bezels, radio and automobile trimming fixtures, and other metal, glass or plastics products which have to be metallised on one surface only.

New Powder Coatings are Flexible

A new range of powder coatings for metal finishing, claimed to have a number of advantages over similar products, is now being produced in UK. The coatings, manufactured from epoxy powder, contain a curing agent which reacts on stoving to produce a film which is exceptionally resistant to chemicals and the effects of corrosion and abrasion. This resistance is claimed to be far superior to that associated with more conventional finishes. The only surface preparation necessary on new metal is a thorough degreasing and the powder is then applied in one operation. There is hardly any wastage during application.

One advantage of the new powder coating is its degree of flexibility. An object can be roughly treated, or in the case of thin sheet, bent or twisted, without cracking or flaking the finish. The powder can be applied by electro-static spray gun or by the conventional fluidised bed technique.

Cement to Resist Chemical Attack

Britain has developed a new type of special-purpose cement with exceptional strength, adhesion, and resistance to chemical attack for on-site use. It is based on polyester resins used in conjunction with a specially prepared cement and can be mixed with water on site. The cement has been specifically developed for such applications as industrial flooring as well as for road and airfield patching where it should prove an economic proposition.

Khrushchev and Post-Khrushchev Productivity

"...Khrushchev destroyed the system of police restraint and religious fanaticism on which Stalin based his power, but he did not know how to replace it with a system which allowed Soviet citizens to participate in political and economic decisions. We gave the Russians the principle of *habeas corpus*, but not its logical consequence—representative government. His Government remained a pyramid with all power concentrated at the apex. Under him, therefore, Russia became increasingly a political and sceptical about the

future. This public mood has proved a source of great weakness...

In a collective society, where the profit motive is absent and the stimulus to individual cupidity feeble, only political purpose can supply the driving force to individual effort and so make society dynamic. And political purpose, in turn, depends upon the public clash and interplay of ideas.

Khrushchev was not an armchair dictator —as *Pravda* now asserts. On the contrary, he spent most of his time haranguing the Russian people in an attempt to drag them out of their apathy and get them to work better. He did most of this against the instincts of the party apparatus, which, since Stalin's day, has always disliked anything which tended to stimulate the people. This bureaucratic machine was willing to follow Khrushchev when he dismantled the Stalinist terror, which threatened them along with everyone else, but it was too rigidly schooled in the thought processes of the old dictatorship to produce any original ideas. Hence Khrushchev's innovations, which were insufficient in themselves, were further watered down by the unimaginative way in which the bureaucrats executed them...

The Russian political and economic system remains a warning rather than an example. There is absolutely no evidence that they have any more plausible ideas than Khrushchev for solving the problems of Soviet agriculture or getting consumer goods into the shops...The hybrid system which Khrushchev created cannot endure much longer, because it inhibits economic development."

"Russia", says a writer in the *New Statesman*, "is still the only major world power which cannot provide an adequate supply of fresh milk, eggs, fresh fruit, and vegetables for its population..." Here is an assessment of Khrushchev and post-Khrushchev productivity.

Now that he has departed (writes a Moscow correspondent), how did life in Russia change under Khrushchev? "The Russians have more personal freedom than they have ever had before; since 1957 blocks of flats have sprung up at an incredible rate; great strides have been made in the production of consumer goods. In 1961, Russians always used to joke about radio sets made at the end of the month. They used to look at the production date carefully—always tucked away somewhere on a little disc—and did not buy anything dated near the end of the month. This was when the Russians worked badly trying to fulfil their norms, and electrical goods produced then often simply did not work.

Now things are much better. I have a Russian iron and a Russian coffee-grinder which both work quite normally, though Russians still prefer electrical equipment from the Baltic States. Clothes have improved in design and quality, but a decent winter-coat still costs about £70. The food situation has deteriorated terribly this year. There were shocking shortages of milk, eggs, flour, and rice. Khrushchev himself revealed this a few months ago when he promised the Russians *an egg a day by 1970*. Many Russians even say that food supplies were better under Stalin, though this is not true. Maize bread—often all that has been available during the last year—did not make Khrushchev popular. He was responsible for the maize mistake, and for the failure of the Virgin Lands Development Scheme which was undertaken against expert advice. The Russian feeling about this can be summed up best by this joke attributed to the non-existent Radio Armenia: "It was Stalin's fault really. He only laid in wheat reserves for 10 years."

The arts have made considerable progress under Khrushchev; although *Dr Zhivago* has never been published, the curtain of silence has been lifted on the purges and World

War II. Glazunov had a heretical exhibition of paintings, by courtesy of Madame Furtseva, then Minister for Culture, which lasted a day and a half before it was closed by the powerful, conservative Union of Painters.

"Lot to Do"

But Brezhnev and Kosygin have a lot to do. Russia is still the only major world power which cannot provide an adequate supply of fresh milk, eggs, fresh fruit, and vegetables for its population. Distribution is still shocking. The quality of the meat makes it fit usually only for stewing. *The waiting time for a telephone is from three to five years, depending where you live.* Switchboards seem to be virtually unknown. This means dialling six different numbers to find the person concerned. Buses, trains, and the underground are hopelessly overcrowded at most times of day, making travelling to work and back much more of a nightmare than the rush-hour in London. Window-cleaning does not seem to exist. Laundries and shoe-repair shops perpetually ruin or lose things and the consumer has little redress. (Not that this is unknown in the West.) The housewife has fewer labour-saving devices than anywhere else in the rest of Europe, although a great number of women go out to work.

...The Russian public are not content with all this and say quite openly that, *if it were not for all the foreign aid that Russia gives, their housing would be much better.* Khrushchev's successors will face the same problem. The Soviet budget is no more elastic than any other country's. *What will be the new priorities?* Kosygin was responsible for light industry at one stage in his career, so should know the problems. He is very popular with the younger generation and will want to keep his popularity. Khrushchev's fall, in fact, was not entirely unexpected: there has been a wide popular feeling that the time has come to break with the veterans of the Revolution and turn to a younger generation."

Chinese Scene

'Great Leap' Image Being Restored

IN the last 12 months, there have been significant advances in China both on the industrial and agricultural fronts, and there has been a consolidation of the recovery from the disasters of 1959-61, according to a report in the *Financial Express*. The report says: There is more food in the shops, more raw materials are flowing to the factories, and the danger of the national economy being affected by natural calamities has been reduced to a considerable extent.

Although the Chinese still fight shy of giving concrete production figures to illustrate the progress in industrial and agricultural production, they take great care to lay emphasis on the continuity of progress since the start of the Great Leap Forward.

So far, Peking had attributed its successes to the policies of retrenchment and consolidation adopted in 1961, implying that the over-ambitious Great Leap Forward campaign had been replaced by a realistic approach. But the current series of reports have laid definite emphasis on the Great Leap and the year 1957 as the "eve of China's great upsurge in national reconstruction."

Thus, it is claimed, the annual output of the machine-building industry is now 25 %

more than the average of the First Five-year Plan (1953-57), with the introduction of new branches producing chemical fertilisers and oil-refining equipment. The present power capacity of China's irrigation equipment is given as 10 times that of 1957.

Attention has also been drawn to the several thousand new products turned out by the machine-building industry in the six years following the Great Leap, including a 12,000-ton hydraulic forging press, 350-ton gantry cranes and machinery for producing railway wheels, rims and rolls for cold rolling machines.

By considering the years since the beginning of the Great Leap as one stage of economic growth, Peking is trying to re-instil the spirit of confidence, optimism, and intense industriousness amongst the people which inspired them then, but which has since fallen off. At the same time, Chinese leaders are also trying to play down changes in policies since 1961 which as good as admitted the failure of the Great Leap Forward. The articles and reports published on the occasion have laid definite stress on the necessity of self-reliance and inter-regional co-operation. It is also pointed out that, while the practical implementation of the vision of a perfect and developed industrial society may well take decades and even centuries to attain, the vision itself and the revolutionary fervour it inspired must remain unimpaired.

CHINESE PRODUCTIVITY

Communist China, which exploded an Atom Bomb in October last, claims that the "success of this test was due to the hard work and the great co-ordinated effort of China's workers, engineers and technical personnel, scientific personnel, and all working personnel engaged in building up China's defences, as well as various regions and departments throughout the country under the leadership of the party..."

Incentives in Czechoslovakia

CT Gould, Chairman of the Institute of Incorporated Work Study Technologists Ltd., London, recalls some impressions gained during his recent visit to Czechoslovakia in an interview with DS Garnier.

...In Czechoslovakia, innovation groups are organised geographically by types of industry into groups under the direction of a technologist of the local House of Technique. In practice, a technologist of the House of Technique gathers together a group of people from the industries or firms concerned with his particular branch of technology. These may be operatives, management, technicians or technologists from the various factories who either evince some interest in innovations or have shown some aptitude for creativity.

Problems for solution are either found from experience in the factory, or arise from need or are handed down from above. On an average, five problems are put up per annum for each group who are expected to meet periodically to review progress and exchange ideas. It is at these meetings that

...A free house or a holiday on the Black Sea...These are among the prizes awarded by the Czech Government for productivity...

suggestions are put forward and discussed, and the group decides on a programme of work to follow up the suggestion.

Prizes are offered by the State for solution of the problems, and where these lead to patentable inventions, the individual concerned is paid on the basis of the economic return to the business which exploits the invention. There is a scale of reward laid down, and although no figures were produced to substantiate claims, a case was noted where the equivalent of £4,000 was paid to an individual for a single patented invention.

The innovation competitions are advertised in the factories, as was seen during a visit to the Institute of Research Mechanisation and Automation, where a poster, 6 ft. × 8 ft., was displayed at the entrance to the factory. The prizes range from a house to a holiday at a resort on the Black Sea. These prizes are in addition to money prizes based on the economic value of an invention or innovation to the factory.

"Throughout our travels I had no reason to suspect that we (Mr Gould and Mr SJ Noel-Brown, another Institute Council member) were in any way being guided, because, particularly in Prague, we had the whole Sunday to wander about any part of the city we liked, and we did, and saw no signs of poverty anywhere. On the other hand, and particularly in Prague, there were signs of opulence and wealth. There are high-class restaurants comparable with anything but the very highest in any other capitals of Europe, and, judging by the opulence of some of the cars and the houses, there are a number of wealthy people in fact. There are apparently a number of millionaires in Czechoslovakia, although I did not at the time inquire whether they are dollar, pound or Czech crown millionaires. But even at Czech crown level they are still people in the £100,000 class. This I could well imagine, and apparently this class is made up mainly by writers and artists, musicians, and so on. These people are allowed to retain anything that they make free of any burdens of tax in any form. All people, of course, have to pay the equivalent of our local rates, but apart from this there is apparently no income-tax.

There is nothing to prevent anybody from selling his services outside the hours of his State employment commitments, and this is apparently done. The painter will work for a neighbour in his spare time and the carpenter

Productivity of Nuclear Power

In July, Soviet scientists visited Washington to discuss cooperation in research on the use of huge nuclear plants to take the salt out of sea water. While the initiative for the talks is said to have come from Russia—it may have been inspired several months ago—a team of US experts from the Government's scientific agencies foresaw that by 1975 it should be possible to build a dual-purpose nuclear plant, turning out at least 500 million gallons of fresh water a day along with at least one million kilowatts of electric energy. The predicted prices are about 25 cents a thousand gallons of water, and about 2.5 mills (a tenth of a cent) for a kilowatt hour of electricity, which works out to less than ½ Paisa. These low costs, feasible because of the enormous size of the plant—in nuclear plants, costs tend to go down as capacity increases—would be competitive with those of power and water obtained from conventional sources.

Now it seems that atomic fuel elements are lasting much longer than expected, and the price of fabricating the elements has gone down, to less than £100 a kilogram from about £150.

Commercial nuclear power industry in the USA now generates more than a million kW. Another 3.5 million are

will make furniture for his private clients. There are other signs that the Communist system is not so rigid and controlled as is popularly understood.

Mr Gould found a curious method of job grade structure which provided a measure of reward and sanction for individuals in that if they are good at their job they will be promoted, but if they are not effective in a particular grade they could be demoted. The case was quoted of a woman who, due to persistent bad work and non-cooperation, was progressively demoted from a technologist appointment to dishwasher in a canteen. An endeavour was made to press the point still further of what might have happened to this person had she, as it were, fallen out of the bottom grade of the labour structure. Apparently the party members try their best to persuade the person to see the error of his or her ways, and if this is not effective then corrective treatment is resorted to. It was not possible to obtain any very definite information as to what corrective treatment means.

Another visit was to the Institute of Research in Mechanisation and Automation at Nevo Mesto (New Town). This establishment designs and manufactures special purpose machinery, employing some 800 operatives; and is reminiscent of Royal Ordnance Factories in Britain, with about the same level of productivity.

We were not of course taken all over the factory, as some areas were on secret work. We were taken through a well-equipped machine shop with very modern all-purpose machine-tools of various kinds, and this adjoined an assembly area where a number of automatic machines were being put together. The general impression was of low manning, and the sort of productivity that you would find in an equivalent government or civil service establishment in this country. We were given demonstrations of latest techniques of metal cutting, using ceramic tools, and some ingenious tooling was displayed with justifiable pride. The machines being designed, however, tended to be somewhat heavy by our standards, though in the model section which we saw later there was evidence of advanced thinking in industrial design application."

Under the system operating in the country, all means of production are accrued by the State, which means that all persons are

being planned or built. As a further stepping commercialisation, the Atomic Energy Commission itself has suggested that the nuclear power industry may be allowed to own its own nuclear fuel instead of realising it from the Commission. Very obviously, we are at the threshold of another phenomenal increase in the productive powers at the disposal of mankind.

As is well known, one of the major elements in industrial cost is the hazard to which workmen have been exposed on account of the use of mechanical contrivances and power. At the recent nuclear conference held at Geneva, both Soviet and American scientists went in agreement that the nuclear industry was characterised by the least hazards. In the USA, the nuclear industry ranked among the least hazardous industries, and plants were designed to be "inherently safe". The Soviet spokesman said that accidents in nuclear plants in the Soviet Union had been far less than in other long-established industries, like chemicals, metallurgy, and even textiles. Indeed, the accident rate in the nuclear field was so low that a special sanatorium built in the Soviet Union for the exclusive use of patients of nuclear accidents was finally given over for the general use of non-nuclear convalescents.

employed by the State. There is a structure of payment for grades of operatives, technicians, technologists and scientists to laid-down scales. Promotions are based on three factors—training, ability, and personal factors. On entering employment, a person is placed in a grade according to his education and training, and moves up the grading structure according to the development of his ability and his personal qualities. The latter two are assessed by his superiors. The system provides a comprehensive health and medical service for all the people, and pensions on retirement which are stated to be up to 90 per cent of the terminal salary of the employee. The State guarantees a minimum payment to everybody which is assessed at about £2 10s per week in equivalent English purchasing power.

The collective farms presented an interesting situation. These are, in effect, groups of people who have banded themselves together on the basis of a village to carry out cooperative operations. The State supplies machinery which of course they have to pay for over a period of time out of their earnings, and the State also provides a quota of produce and fixes prices. Members of the cooperative join at will, or can carry on farming their own bits of land if they so wish. In fact many of them apparently do. Having supplied the Government's quota at the Government price, then the collective is quite free to sell any surplus produce on the local market. The same principle is applied to individual farmers.

"A visit of this sort does make one realise how badly informed one is about the conditions in other countries. This is no less true of the people I met in many walks of life and different intellectual levels in Slovakia and Prague..."

Productivity even in Telephone Directory

Apart from its very obvious use of contact with the outside world, people have discovered that the Delhi Telephone Directory has many other uses—for example, research into the caste system: how many Chaudhrys, Mukherjees, Banerjees, Aiyangars, Aiyars, Subramaniams, Sharmas, Vermas, Goels, Aggarwals, Anands, Aroras, Bhatias, Chopras, Kapoors, Khannas, Sehgals, Singhs and Zutshis there are (available on telephone); and how differently they spell their names. The Telephone Directory also gives a peep into the nature of foreign elements in the Indian social economy. America and Britain figure more prominently in the directory than any other country. There are American or British lock companies, furnishing houses, tin stores and dealers in paints, plastic and stationery goods. There are German chemical works, French radio companies and even a Chinese art palace and dining room, but—and this is against our spirit of co-existence—no firm or shop which styles itself Russian.

recent literature on productivity

GUIDANCE ON FOREMANSHIP

FOREMANSHIP: A Deb, Asia Publishing House, Bombay, 1964, pp. 150, Rs. 6.00.

WITH industrialisation, Foremanship in industry is of vital importance to increase productivity. This book, a welcome addition to the literature on the subject, attempts to provide guidance to technicians who rise to the positions of foremen. The author has a rich and varied experience, having worked for about 30 years in various supervisory capacities in Indian Railways.

Though elementary, the book could be used for supplementary reading. It is divided into four parts: Part I deals with Foremanship, the topics covered including organisation, different types of controls such as financial control, waste control, inventory control, and production control, and human relations and foremanship in practice; Part II is a compilation of various Acts such as the Factories Act, the Industrial Disputes Act, and the Workmen's Compensation Act; Part III contains a glossary of terms; and Part IV contains questions set for the various technical examinations of universities and State councils.

The first part forms the core of the book. Since many topics are covered in a limited space of 73 pages, their treatment naturally is sketchy and elementary. Also, the author has not been able to present in clear perspective the problems involved in Foremanship, and hence the reader is left with a feeling of vagueness about the industrial organisation and its activities. Though the author says he had referred to a large number of books, no mention of them is made anywhere in the book. Very little space has been devoted to subjects like work study, methods improvement, communication, scheduling, and safety. The topics dealt with, however, are in general terms,

and could be of interest to almost all industrial personnel at the middle management level.

There is useful reference material in the second part which contains a compilation of the Acts. But the value of the compilation would have been enhanced if common problems faced by the foreman had been discussed along with the application of the Acts. In the glossary of terms (Part III) one comes across such terms as 'ability' and 'dexterity', and their meanings as explained by the author reveal his lack of precise and analytical approach in dealing with the subject. It would have been better if the explanations of the terms had been borrowed from any standard work which provides uniformity of connotations of the terms. The fourth part will be useful to students appearing for the AMIE and other examinations on the subject of Foremanship. —**DL Amin**

Work Study

WORK STUDY IN JUTE AND TEXTILES: SN Kar and SK Lahiri, Book Society of India Ltd., Calcutta, 1964, pp. 184, Rs. 15.00.

THIS book, with a foreword by Prof RF Bruckart, until recently Industrial Management Adviser to the National Productivity Council, makes valuable contribution to the subject of work study in its application to the textile industry. It starts with a brief, but clear presentation of the concept of productivity, the increase of which is being so much sought for, the world over, and a pressing need for survival in the developing economies of today. The subject of work study in general has been discussed both to include method study and work measurement, outlining techniques of recording, methods improvement approach, materials handling, time study, performance rating, time study allowances, work sampling, etc. These chapters, although basic in character, have been presented in a lucid manner which can be directly appealing even to a new reader who may be a novice to the subject. The book has a number of charts and diagrams making the presentation effective and easily understandable.

Two chapters on random servicing and cyclic servicing have been discussed in detail which are of special use in the application of work study techniques and methodologies in the textile industry, be it either jute or cotton textiles. The concept of machine interference has been discussed which is a contributing factor to the problem of work-load standards and evaluation of standard strength of work force. The chapter on random servicing develops a systematic approach to determining the work-load of spinner for a particular figure of optimum assignment. The chapter on cyclic servicing deals with machine efficiency, cycle time, stops per cycle, and open and closed circuit situations in spinning which are discussed quite lucidly. There is a useful chapter on ratio-delay study which includes the approach to measure machine utilisation and evaluation of operator productivity. The last chapter is on wage and incentive which outlines a few historical schemes, including some which have been applied in practice with effectiveness.

The book, which is probably the first of its kind published in India by Indian authors, can make very useful and interesting study as it introduces the subject quite effectively to the new reader and is of practical value to the industry.—**MR Ramsay**

Organisational Problems

STRUCTURE AND PROCESSES OF ORGANISATION: HC Ganguli, Asia Publishing House, Bombay, 1964, pp. xii+184, Rs. 22.00.

WITH the public sector undertakings assuming progressively increasing importance in the country, the need to pay attention to organisational and management aspects of these industries is assuming a special significance. Industry studies relating to employees have usually been those dealing with the aspects in which the industrialists

are interested or those from the labour union point of view. It is only in recent years that the problems of the employee at work and of the management in relation to these have become the subject-matter of study on systematic and scientific lines. The result has been an extraordinarily interesting insight into matters whose existence was suspected only indirectly from their repercussions. The problems relate to management, organisation, industrial psychology, leadership, sense of fulfilment, morals, *esprit de corps*, etc.—problems of a live active entity.

Dr Ganguli has attempted in this book an interesting study of these aspects. He examines in Part I the nature and processes of organisation as developed in recent thinking on the subject. He takes up, in successive sections, organisation, its nature, its formal and informal aspects; the role of communication; decision-making; organisational control, climate and effectiveness; and the significance of decentralisation, improved communication, of size and specialisation in integrated organisation, and participation. Before concluding this part, Dr Ganguli emphasises that the most pressing problem of India is the development of managerial skill for the proper integration of persons and functions in the organisation.

Part II presents the results of a comprehensive study of the organisational problems in a large railway mechanical engineering workshop engaged in the manufacture and repairs of locomotives, carriages and wagons from the point of view of the consideration and methods of analyses discussed in Part I. The findings of this study deserve the most careful attention of those connected with large organisations in the country under both Government and private management. The Railways will find something of special interest to them in the analyses and comments in Part II.—**LA Natesan**

Books Received

INDUSTRIAL RELATIONS IN UTTAR PRADESH: JL Rastogi, published by the Author, Lucknow, 1964, pages 266, Rs. 15.00

PLANNING OF BUSINESS EDUCATION AND RESEARCH IN INDIA: AN Agarwala, Asia Publishing House, Bombay, 1964, pages 87, Rs. 5.50

LABOUR PRODUCTIVITY: Attar Singh Talabgar, Amritsar Productivity Council, Amritsar, 1964, pages 20, Price not mentioned.

MATERIALS HANDLING IN WEST GERMANY, BRITAIN, AND USA: NPC Report No. 38, 1964, pages 92, Rs. 3.00; TECHNIQUES OF INTERNATIONAL TRADE IN WEST GERMANY, USA AND JAPAN: NPC Report No. 39, 1964, pages 77, Rs. 2.50; CEMENT INDUSTRY: Report of Productivity Study Group, 1964, pages 58, Rs. 2.50. National Productivity Council, 38, Golf Links, New Delhi-3.

Rural Economy

***Khadi Gramodyog:* Eleventh Anniversary Number, October 1964, Khadi Village Industries Commission, Bombay-56, Rs. 2.00.**

THE Khadi and Village Industries Commission deserves to be congratulated on the publication of the 11th anniversary number of its journal of rural economy, *Khadi Gramodyog*. It is a special issue dealing with rural industrialisation, and a number of distinguished persons have contributed towards its enrichment—UN Dhebar, (the late) VL Mehta, NK Bose, Arun Chandra Guha, Ajit Prasad Jain, Nirod Mukerji, and others. It also contains a number of case studies and factual presentations. What probably is more striking is that *a new wind has begun to blow among the Gandhian economists.* Though Sri Dhebar has faithfully expatiated on the Gandhian philosophy of birth control, yet the warning sounded by him is significant in the modern context:

> "Immediate steps have nevertheless to be taken to prevent the population explosion

which threatens to destroy our economic fabric" (page 9).

What is more significant is almost an open and frank acceptance of modern technology. Sri Mehta is still his old modest self, but nevertheless the change in his approach is significant:

> "Provided this displacement is avoided and alternative forms of employment are found either in some operations in the same or allied industry and in or near the existing places of work, the proposals visualise the adoption of improved tools and techniques by these industries. The adoption of a new technology may accordingly be by gradual stages, but the aim all the time should be a high level of efficiency" (page 17).

Sri Guha is more forthright:

> "...Rural industries must be based on uptodate technological equipment and skills, and they will have to ensure proper standardisation...the Government and the organisers should disabuse their minds of certain ideological biases against uptodate mechanical devices, instruments, tools, electrification, etc., being introduced in rural industries..." (page 27).

The Editor's gibe on borrowed technology is a good one. The only historical fact, however, is that practically all countries—including Germany, the USA, France, the Soviet Union, and Japan—all have developed very largely by frantically borrowing the latest technologies, one from the other. Countries have become great nuclear powers by borrowing the latest technology, by hook or crook. This apart, the growth rate has been determined very largely by continuous borrowing of new technologies and techniques. One of the reasons why the British growth rate has lagged behind is their traditional reluctance to borrow. Probably the lesson of Soviet development is the most significant: since the time of Lenin, through Stalin and Khrushchev, they have borrowed, left and right, from the technologies and even the advanced managerial practices of capitalist countries.

The consequence of the exhortation of Sri Nirmal Kumar Bose, that "...We apply our shoulders to the yoke of the bullock-cart which has got stuck in the mud...," will be that we too shall get stuck up in the mud! This is not to decry Sri Bose's suggestion that the way out of the present rut can only be found through education and organisation, plus modern technology (borrowed as also indigenous), as other distinguished writers to this special issue have urged, plus productivity as we would ourselves urge in the interest of the maximum development of the economy. Through these methods alone can the objectives, as stated by the Editor on page 8, be realised.

Besides its rich content, the Editor deserves to be congratulated on the attractive cover, and the beautifully set up photographs of the prize-winning ceremony for the Hindi edition of *Khadi Gramodyog*.—**DHB**

Silence, the only Productivity Device

"Corruption, it must be remembered, is very much a matter of noise; everybody talks about it and it is universally believed that everything is rotten. Then follows silence; and most people seem reasonably content... —From THE DITCHER'S DIARY in **Capital.**

NPC Question-Answer Service

Q You ask... We answer... A

1. EFFICIENCY IN SUGAR INDUSTRY

RATIO analysis is very valuable for inter-firm comparison. Ratios greatly help to shape and formulate managerial policies. Attention on this aspect was focussed in *Productivity* (Vol. V, No. 3), and below are printed two questions from Sri RD Kulkarni, Chief Accountant, Kopargaon Sahkari Sakhar Karkhana Ltd., P.O. Kolpewadi, Dist. Ahmednagar, relating to management efficiency with reference to sugar industry.

(1) What are the standardised financial ratios that can be utilised for evaluation of management efficiency in the sugar industry?

(2) What should be the value of normal investment in stores inventory in case of a sugar mill of a daily crushing capacity of 1,000 tons and manufacturing only sugar?

Readers of *Productivity* are welcome to offer their comments.

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2. WORK-LOAD FOR ACCOUNTS STAFF

Sri RD Kulkarni, Chief Accountant, Kopargaon Sahkari Sakhar Karkhana Ltd., Ahmednagar, raised four questions relating to fixation of work-loads for Accounts staff, etc., which were published in *Productivity* (Vol. V, No. 1, page 177). Replies sent by Mr KC Jasper, Senior Management Consultant, George Fry Team attached to NPC (Vol. V, No. 1, page 178), and by Sri MM Karnik of the Indian Aluminium Co. Ltd., Kalwa, Maharashtra (Vol. V, No.3, pp. 564-566), have since been published. Below is the reply of Sri Krishan Lal, Cost Accountant, Indo-German Prototype Production and Training Centre, Okhla Industrial Estate, New Delhi, to Sri Kulkarni's Questions which are also reprinted here for the convenience of readers.

Question 1: *What are the preliminary stages for fixation of work-load, in case of Accounts staff which performs different types of work, and which is absolutely new to work study methods?* (RD KULKARNI)

Answer: The work done by the Accounts staff is more or less of a repetitive nature and the fixation of work-loads should not cause much difficulty. Given below is a simple outline of the steps to be taken to fix work-loads.

1. The total work being done in the Accounts Section should be grouped under major heads—Pay Group,

Maintenance of Purchases and Creditor Account and Payment to Suppliers, Sales and Debtors Accounts, Cash and Bank Accounts, and Miscellaneous Accounts.

2. Man of minimum qualifications and experience recruited for appointment in the Accounts Section should be asked to do work in the different groups. The time taken by him should be recorded, and the work done assessed by a qualified and experienced Accountant.

3. Work-loads can then be fixed after taking into consideration the following factors in addition to normal idle time:

   (a) Allowance should be given for periodical statements to be submitted by the Accounts staff in addition to routine work.

   (b) Efficiency acquired by the member of the staff in performing the same duties continuously for a considerable period.

   (c) Time required to reconcile the differences which normally creep into the accounts.

   (d) Work-loads should be revised at suitable intervals to minimise the practical difficulties.

Jobs of different nature can be shown as a fraction of the common denominator and the work-load thus arrived at will remain suitable for all types of work done in the Accounts Section.

Question 2: *It is said in respect of the sugar industry that its unit of production being only one (viz., sugar) and its process of manufacture being one continuous whole, there arises no question of cost control. Is this statement true? If not, what type of cost control measures can be adopted in the sugar industry?* (RD KULKARNI)

Answer: The statement contained in the question that there is no need of cost control in sugar industry is not true. The real position is the reverse of this contention. A system of cost control can be introduced and implemented as detailed below, though unlike cost reduction, a programme of cost control has a limited range of operations:

(i) On the basis of past workings of the industry concerned, and on the basis of statistical reports of the neighbouring sugar mills, norms or standards can be fixed for each process.

(ii) Actuals can be watched and recorded precisely. These figures can be compared with the standards, and deviations or variations recorded.

(iii) Reasons for variances can be investigated to prevent the recurrence of undesirable happenings. Standards can be reviewed periodically in the light of such variance-analysis and revised, if necessary.

It appears from the question that there is more concern in regard to cost reduction than in regard to cost control. Cost reduction can be effected thus:

(i) Cost of materials forms a major part of the total cost in sugar industry. The causes for waste and loss of materials in process can be inves tigated, and efforts made to minimise such losses.

(ii) It is necessary to investigate if the time taken in each process can be reduced, because the labour cost and overhead expenses are dependent on this factor.

Question 3: *Are there any standardised work-loads for Managerial or Supervisory Personnel working in industrial concerns? If not, what is the yardstick to measure their efficiency?* (RD KULKARNI)

Answer: A scientific method is not available to fix work-loads in the case of supervisory personnel. Their efficiency can, however, be judged from information arising from—(a) Whether the quantity of production had increased, and (b) Whether the unit cost of production had decreased. If due to their efforts waste of materials had been reduced or rejections minimised, or idle time or idle capacity reduced, the unit cost of production is bound to decrease, and this will reveal the efficiency of the supervisory personnel.

Question 4: *What are the accepted methods of merit-rating that can be adopted in the case of clerical employees?* (RD KULKARNI)

Answer: A common method for merit-rating for clerical employees will work thus:

(i) Quantity of work done will be measured in terms of the numbers of letters replied or written, typed or despatched, amount and number of transactions for cash received and paid, number and nature of accounting entries recorded, and cases processed.

(ii) Quality of work done is judged from the numbers of reminders received due to non-reply or partial reply of letters, non-reconciliation of accounts and audit objections, penalties and fines incurred due to late submission or non-submission of statutory returns—to mention only a few examples.

When the diary of daily work done, which is countersigned by the next supervisor, on a day-to-day basis, is compared with work-loads fixed (as detailed in the answer to Question 1), it will help the person in position to make a periodical report regarding the efficiency of members of the clerical staff.

Some Productivity Tips for Indian Exporters

Speaking of productivity, India is keen to increase her earnings from exports. But "many of the Indian products are entirely unknown," according to a despatch from Brussels (The Belgian standard of living is among the highest in Europe) published in the *Economic Times*. The quality of the goods alone would not be enough to satisfy a foreign buyer.

Sample what the correspondent, Malcolm Subhan, says: "...Most of the trade inquiries at the Brussels Food Fair (India is participating in the fair)" ...have been for tinned foods, of which a larger selection is on display...The Indian exporter must study the European market. Greater attention will have to be paid to packaging, for instance... labels are often printed on an inferior grade of paper in unattractive colours (the combination of poor paper and printing inks results in muddy colours). The labels on some of the jars of pickles, for instance, were oily in patches, as if the contents had leaked. Some of the fruits tins had torn labels, indicating poor packing. Labelling should also be informative. This means the weight must be clearly indicated in grams, and the contents described in some detail in the local language...Many of the Indian products are entirely unknown...Most of the bottles are poorly designed and of inferior quality glass. Their shapes are dull, and except for differences in size, they somehow look as if they came from the same mould.

Indian exporters could well experiment with other than glass containers. Clay or pottery containers may prove feasible, especially if decorated with Indian motifs. Though this will add to the price, it must be remembered that many Indian products will be bought by housewives seeking to add an exotic note to their table. With many of them price will be a secondary consideration—within limits, of course.

Editor's Correspondence

Work Simplification on Farms

...The application of work simplification techniques to farm tasks will not increase the yield per acre to any significant degree, if at all. As you know the germination of seeds is essentially a chemical reaction. If one is to increase the yield per acre, an improvement in the chemicals involved and their use must be effected.

It is true that the principles of work simplification could be applied to such tasks as harnessing a team of bullocks; they could be applied to the cleaning of farm implements, the lay-out of buildings, the loading of grain, and similar other tasks. My concern...was that the publicity NPC had thus far received or generated was of a type that could be construed as increasing agricultural yields by way of improving seeds, irrigation, fertilisers, crop rotation, and the like. It is in these areas that we lack expertise.

I have no doubt that we could be successful in teaching work simplification to farmers. But the question still remains: How significant an improvement would these training efforts bring to the problem of low yield per acre?

It would seem to me that the same training efforts would be more fruitful if we concentrated them in the agricultural processing industries to reduce waste, and improve the handling of the agricultural products *after* they have been produced...There is a great deal more scope on American farms for the use of work simplification due to the large amount of machinery and machine accessories which are commonplace on these farms.
—JR KENNEDY, George Fry & Associates Inc.
New Delhi, Sept. 8, 1964.

Editor's Reply

...It is obvious we are in agreement over a large part of the ground...We do very obviously lack expertise in improved seeds, irrigation, fertilisers, crop rotation, etc., but there are plenty of people in this country who do have the expertise and we just propose to help them, as we helped, for example, the Naval Dockyards...The germination of seeds is, of course, a chemical reaction, but so are

many processes in many factories which the George Fry Team itself must have ably assisted over a long period of time, without feeling the necessity of knowing the nature of the chemical reaction.

A productivity technique, if it is genuine, must be of universal application... Need I say that I love the manner you argue and it is going to be of great help to us.—DH BUTANI.

New Delhi, Sept. 9, 1964.

Labour Productivity

...Some of the colleagues of mine at SIET and I have read with some interest the recent July-September 1964 issue of *Productivity*.

We are left with the impression that there is over-emphasis on labour productivity, and on cutting labour costs. It is thought that in a situation of abundance of labour and scarcity of capital resources, an emphasis on higher productivity through better utilisation of capital equipment and scarce raw materials would be a better overall approach.

And now a specific point. It is the concluding para on page 476 of the article on "Twelve Ways to Improve Productivity" which reads thus:

> "It may be mentioned here that productivity in terms of production per man-hour, or man-hour required per unit of output, is not labour productivity as is commonly understood, but total productivity expressed in terms of man-hours."

We wonder whether the statement made therein can be readily accepted.—RN JAI, Principal Director, Small Industries Extension Training Institute.

Hyderabad, Oct. 19, 1964.

Editor's Reply

...I am in entire agreement with para 2 of your letter, except, of course, the first sentence: I do not know how you got that impression. In the Appendix*, I have quoted at length from the leading articles published since the inception of *Productivity:* these passages show conclusively that our approach is exactly the one spelt out in para 2 of your letter.

I have carefully looked through the latest issue of the journal to which you have made a particular reference. So far as I can see, the emphasis is on cutting all costs, not only labour costs. It is a special issue dealing with Inter-firm Comparison as a management technique; yet, the labour point of view is very well taken care of. I have just opened at random the article on *NPC Xray of Cement Industry* where the following passage occurs (pages 509-510):

> "It is apparent that any steps taken to increase productivity will always interest the industrialists, because higher productivity means more goods produced at the same cost, or the same amount of goods produced at lower cost. In either case only the industrialists seem to benefit. Under such conditions why should the worker take part in raising productivity?' "

I can say with confidence that NPC is fully conscious of the labour point of view, and the importance of the maximum utilisation of labour in the context of the current social situation.

Incidentally, this is a professional journal, patterned on the academic model. We are duty bound to present various points of view. Within the broad limitation that NPC is a tripartite organisation on the ILO pattern, our distinguished contributors enjoy the utmost intellectual freedom in the discussion of problems. I am sure that you, as the Principal of the Small Industry Extension

*The Appendix to this letter, which contained copious extracts from leading articles in *Productivity*, to show that there was no "over-emphasis on labour productivity and on cutting labour costs," is not reproduced here owing to pressure on space. In fact the emphasis has been quite the other way round. *Productivity* has unequivocally advocated a full employment fair wage policy as an essential prerequisite to the success of the productivity drive.

Training Institute at Hyderabad, will be in agreement with this point of view.

Regarding the specific point made by you in the last two paragraphs of your letter under reference, this, of course, is a study done by the Department of Business Management, University of Delhi. If you like, I can refer it either to Prof Dasgupta, with whose courtesy this was published, or to Sri Paresh Nath Chatterjee who did the job. It occurs to me, however, that the particular statement quoted by you is a formally correct one. As will be clear from the papers published in our special issue on *Measurement of Productivity*, this position has been accepted by all international experts. It is just commonsense when, for example (see page 466 of *Productivity*, Vol. V, No. 3), the Banmore Cement Plant takes over 20 man-hours to produce a ton of cement, and the Rohtas Industries less than six man-hours, the differences in productivity are accounted for not by labour alone, but also by the capital equipment and other factors with which labour is associated. The productivity of a train, for example, cannot be attributed entirely to the engine driver or the guard, but to the entire paraphernalia of the train—the engine, the railway line, in fact the whole railway system.

I am sorry the letter has become rather long. As Editor of *Productivity*, I am anxious that we keep strictly to the correct path. We must also satisfy men of your goodwill and knowledge that we are following correct policies.— DH BUTANI.

New Delhi, Oct. 30, 1964.

Modern Work Study

...Those were golden words you wrote... Particularly, I refer to your very kindly letter which now graces the "Great Book." As you may know, this magnificent volume was presented to me at my official retirement ceremony. Being a well-kept secret, it was a sudden but very pleasant surprise.

Now that I have read what you have written, so personally and so generously, I feel not only very indebted to you, but very humble also. Solace comes in knowing that what the book stands for must be shared by so many. Most particularly is this true of all those who contributed to it.

The development of modern work study over the last 15 years, with its analytical and yet humanitarian approach, has been a combined operation of a high order by many. Therefore, I thank you, not only for your most generous letter, but for all the understanding help you have given me without which any contribution I may have made would not be.

I must also express real appreciation to ICI for their altruistic policies over the years, and to its work study staff, past and present, who have contributed so greatly with so many others, to see that work study served national interest and international understanding, as well as domestic advantage.

I am deeply grateful to you and your well-beloved country—now rising against fearful odds, to be a power for good in the world of all mankind.—RUSSELL M CURRIE.

PS: I have made special mention of your magnificent work to Lord Mountbatten.

London, Aug. 20, 1964.

Human Relations

...Thank you very much for your letter of Aug. 13 which has been forwarded to me by Courtaulds through the Commonwealth Relations Office! Actually I work with a Dutch Company A.K.U., and am the personnel Manager of their UK plant, British Enkalon Ltd., which I had the unique experience...of starting up from scratch...This involved selection..., training in groups in Holland, the establishment of policy, salary and wage-scales, preparation of pamphlet on conditions of employment and TU negotiations throughout. By far the biggest task was establishing team-spirit, converting a collection of individuals into a collective entity, and by far the hardest part of this was my own group—the seniors, as you may well imagine! I have, of course, got quite a lot

to say about this, if you are interested! It took one year to start, and now after a further two years we will be doubling the staff (700 strong) of the company which I hope to achieve by this time next year in order to stay ahead of Courtaulds, our main competitors!

By starting up without any ties, I have been able to avoid all the horrors of the past—wage differentials, individual or even group incentive bonuses, overdone 'paternalism', and so on. We have only four categories of workmen—labourers, semi-skilled, process operators and tradesmen—and we expect to cut out the semi-skilled category soon. We pay a high day-rate, and of the four shifts, three are continuous. In paying wages we aim not to lead the field, but to be up amongst the best payers. I am sure that as automation takes over, this is the way of the future. At start up we have leaned over backwards to establish good human relations, and in the three years I have allowed only one to be sacked, and three to be given one-day suspension each. This has paid off not only within the plant, but also in recruitment.

...I was very sorry to leave India (which I love), but supertax crippled me!—LT. COL. LD GATES.

N. Ireland, Oct. 18, 1964.

Trained Manpower

...The idea of converting the deluge of population explosion from a liability into an asset by increasing trained manpower in all the fields of human activities is fully convincing. When this idea is put into practice on a large scale, there will be an enormous saving in time due to an acceleration of development activities, saving in material resources and labour because of improved techniques, improvement in morale and confidence of the people as a result of their efforts meeting with success, and material benefits. The idea, when assessed in this way, is valued at several hundred crores of rupees. However, it can be implemented only when there is "management's support from the top and workers' cooperation from the bottom." Those who are to impart training should not be overloaded with physically impossible conditions.—RM AGARWALA, Water Chemist, Bhilai Steel Project.

Bhilai, July 29, 1964.

A Problem in Incentives

...Regarding the incentive/production bonus scheme referred to by Sri SB Chakraborty (Vol. V, No. 3, pp. 554-555), I wish to state that whenever an incentive scheme is to be put into operation in an industry for the indirect personnel, an assessment of the effect of the incentive scheme on the earnings of the indirect personnel should be made in detail. For this assessment, the productivity figures of direct labour prior to the introduction of the incentive scheme can be used. A graph should be drawn to represent the productivity percentage of direct labour, the incentive earnings of the indirect personnel, and the proposed scheme. It will be a guide to know the incentive earnings of the indirect personnel at different productivity levels of the direct personnel. At the time of introduction of an incentive scheme for indirect personnel, it is necessary to see that the incentive earnings of indirect personnel is fairly low at the current productivity level of direct labour. Otherwise, the incentive amount to be paid to indirect personnel at the performance level corresponding to the period prior to the introduction of the incentive will be just a burden on the management.

Referring to the case of the small tile-manufacturing industry, the incentive scheme introduced for indirect labour must be such that the incentive earnings of indirect workers at the productivity level at which direct workers earn Rs. 35 to Rs. 50 per month, should be Rs. 12 to Rs. 20 per month. This means that, with the introduction of this incentive scheme, the indirect personnel have just got an increment of Rs. 12 to Rs. 20 per month without any need to put in extra efforts.

In this case, the higher earnings of these indirect men cannot mean higher productivity. Thus the management has got to be careful before taking any decision to introduce an incentive scheme for indirect personnel.

The remedy in this case can be the launching of a productivity drive to increase the productivity of direct workers. In the case of indirect workers, on the plea of having increased their wages, they should be asked to put in their best efforts to help increase the productivity of the direct workers. —P PANDE, Industrial Engineer, Hindustan National Glass Mfg. Co. Ltd.

Calcutta, Oct. 15, 1964.

Industrial Training

...We are manufacturers of the Parmar Brand Lathes (Grade I)...We understand the necessity of raising the productivity level, but we seek your guidance on the following problems: (1) Introduction of a thorough scheme to impart training to employees and apprentices; (2) Setting up of standards in respect of production, job efficiency, raw materials, tools and costs.

We wish to ensure present production, and plan ahead, and this requires selection of the right employee for the right job, maintenance of uptodate and easy records of production, efficiency, consumption of raw materials, and of the total cost, everything per machine basis, and test of the efficiency. Under the circumstances, we need copies of training and apprenticeship schemes, or information about systems successfully employed in well-developed units of the machine-tool industry...—MS MEHTA, Manager, Parmar Mechanic Works.

Surendranagar (Gujarat), Aug. 16, 1964.

Standardisation in Gauges

...I am a student of the Production Engineering course conducted by the Department of Technical Education, Maharashtra, at VJTI, Bombay. I am undergoing in-plant training at Kirloskar Oil Engines Ltd., Poona, for a period of six months. I have been assigned the project—"Methods and modes of inspection procedures and design and selection of inspection equipment for 'A' and 'B' Items (ABC Analysis) of the diesel engine." I am interested to know (1) Details of, or literature available on, standardisation in gauges (plug and snap); and (2) How the gauges should be confirmed to its specific dimensions, before issue to workshop, within the available short time and by suitable procedure. After receiving the gauge from the worker, there is no time—it is not even possible—to check all gauges at the end of the day's shift. On the next day, it is complained that the same gauge is undersized. This happens many a time.

Further, I am interested to know the various techniques to be adopted in the selection of inspection equipment—such as value analysis to save money, and standardisation...—LN GURJAL.

Poona 3, Aug. 23, 1964.

IFC Centres

...May I express my sincere congratulations to you on the publication of the special issue of *Productivity* on Inter-firm Comparison? The articles and other material contained in it are highly valuable for persons interested in the productivity movement. It will certainly be in the interest of advancement of better techniques of productivity and management in Indian industries, if industrywise centres of inter-firm comparison, on the lines of the British Centre for Inter-firm Comparison, depicted by Mr H Ingham in his article, are sponsored by the National Productivity Council.—RD KULKARNI, Chief Accountant, Kopargaon Sahkari Sakhar Karkhana Ltd.

Ahmednagar, Oct. 11, 1964.

"..So far. thinking in the Government had been mainly in terms of reducing inequalities between the rich and the moderately rich, whereas there are millions who lack incomes even for a minimum level of food consumption..."—PS LOKANATHAN (presenting a New Strategy for the Fourth Plan).

"...There is a growing tendency among Ministers to consult astrologers...There might as well be a Minister for Astrology..."—SN MISHRA (at AICC meeting in September).

"...The people of UP villages find it easier to speak to Ministers and the Prime Minister than to the District Magistrate and other officials..."—LAL BAHADUR SHASTRI (after a visit to villages around Delhi).

"...It is courtesy alone which will ensure progress of the Indian Oil Company..."—Chairman, Indian Oil Company.

"...Capitalism is using its money; we socialists are throwing it away. We should study capitalism to learn how to avoid waste..."—FIDEL CASTRO, Premier of Cuba.

"...In the next 30 years, the world will change beyond recognition. Man will go to the moon and come back. Nuclear power will be used for everything big...unchanged will remain the Calcutta Corporation..."—A Columnist.

"...African farmers in the Embu district of Kenya have been using Government loans to buy wives, instead of improving their land .."—JULIUS OSOGO, Assistant Minister of Agriculture.

"...The State cannot introduce legislation to limit the number of children in each family; it is an intimate private sector activity in which only education will help..."—ZAKIR HUSSAIN.

"...In one of the stores in the heart of a new colony in Moscow I found on display Indian shaving blades which certainly gladdened my heart..."—SP CHOPRA in *Eastern Economist.*

"...We intend to grow up with our projects, for only then can we hope one day to do everything on our own..." —ROMESH THAPAR in *The Economic Weekly.*

"...We need to think more about earning money and less about making it..."—HAROLD WILSON, Premier of Britain.

"...Decent people were among book-lifters and they seemed to think that book-lifting was not an offence like theft..." — SAVARIRAYAN in Madras University Senate.

"...Prices, food and unity; oh! I'm bored and yet, what else is there?..." —From A Ditcher's Diary in *Capital.*

"Fifteen years of hard work, national unity, homely frugality, self-denying devotion, and robust commonsense, have got the Chinese economy just off the mud..."—JOAN ROBINSON in *The Economic Weekly.*

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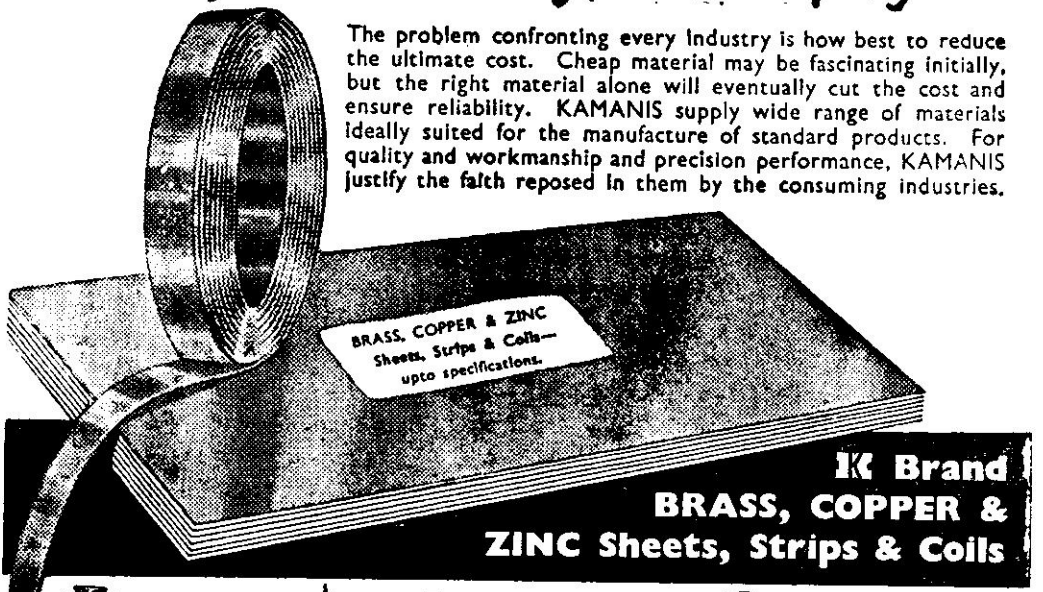

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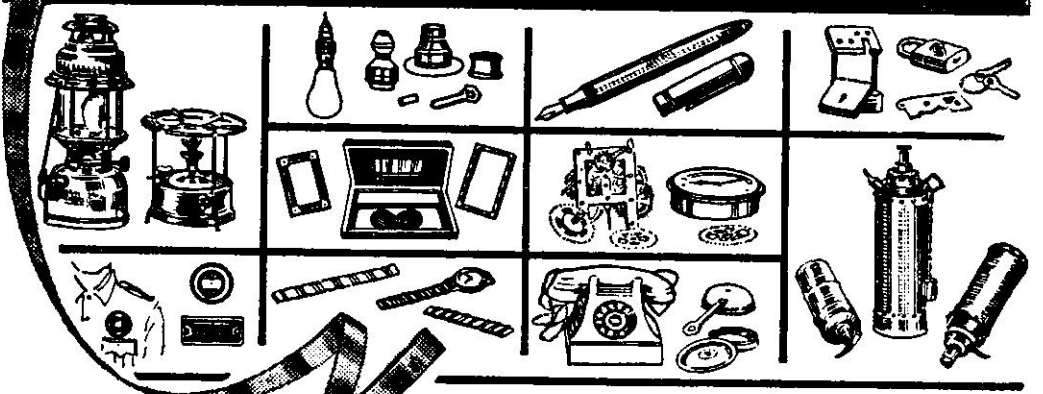

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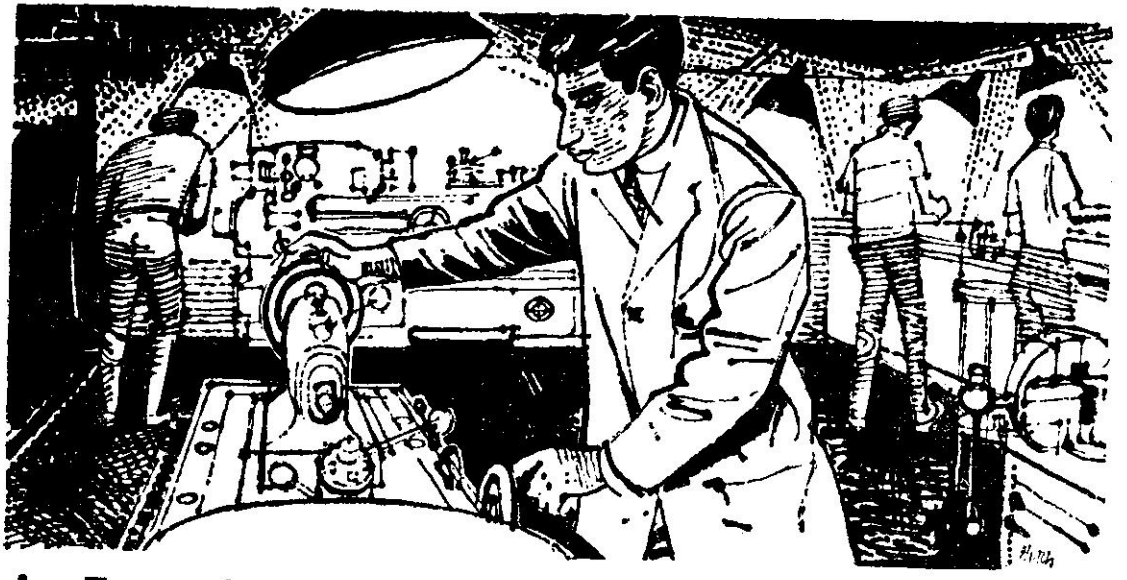

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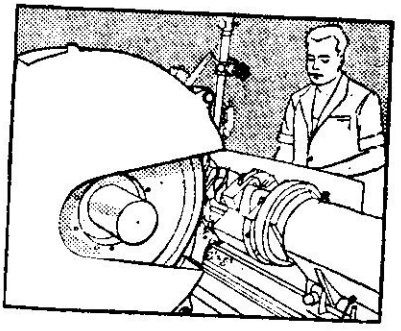

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Printed and published by DH Butani for the National Productivity Council, 38 Golf Links, New Delhi-3, at The Caxton Press Private Limited, New Delhi.