CONTROLLED ENGINEERING MAINTENANCE

By H. E. HASTINGS

Introduction

With increasing mechanization in industry and mining the emphasis for supervision begins to swing toward the problem of maintaining the machines at fullest utilization. The expert "organization" of direct productive labour has but limited value if machines are not in running order.

Down time on machines results in production losses, which in turn cause profit losses.

Breakdowns of machines mean that some components have been run to destruction. The effect of allowing this to occur is likely to shorten the lives of other components.

It has been shown in the United States that the combined costs of the labour that maintains the machines, and of the parts consumed in running are not uncommonly, greater than total nett profits earned.

If these statements are accepted it will be recognised that in maintenance, management is faced with a problem of major proportions.

It cannot be denied that speaking generally, management has not accepted the challenge. It has not applied the concentrated thinking to the organization of maintenance that it has to "Direct Production." One reason for this may be the relative unfamiliarity of the average senior executive with the maintenance trades. It happens in general that senior executives work their way upward through "production" departments. "Maintenance" remains to them an unexplored mystery. The manager is usually a layman in this field, leaning heavily on his staff. If the amount of down time does not seem too great the manager is apt to conclude that he has a good maintenance staff and happily let it go at that. He has no real measure of how good the maintenance work is or how much better it might be made, because there is no yardstick with which to assess the position. It is not too much to say that frequently insofar as the maintenance department is concerned, the manager figuratively drives a vehicle with neither brakes nor steering.

Without providing a means of measuring the work of maintenance it is unreasonable of management to expect a skilful job of supervision from maintenance foremen.

In the case of supervisors on direct production, there is always a target to shoot at; the productive capacity of men and machines are fairly well known; management is acutely aware, day by day, if not hour by hour, whether the production target is being met and if not, why not. The atmosphere of a production department is permeated with a consciousness of output and of the urgency of time. In maintenance work prodigies of achievement may be performed in emergencies when men work round the clock to repair breakdowns. But these instances represent or should represent a small fraction only of the working year. Between emergencies the maintenance staff, with no recognisable goal to attain and no measure of accomplishment, inevitably develop an outlook which is unaware of time and its proper use. This is not necessarily laziness nor even indifference. It is lack of direction. Time between breakdowns tends to be spent ineffectively or in unrecorded idleness.

The result of these circumstances is the condition in which many plants are found today. Maintenance labour costs are excessive, production is lost through avoidable breakdowns, money is spent unnecessarily on spares which have been run to destruction, spares inventories are too high through lack of standardization and knowledge of usage rates, and machinery deteriorates too rapidly, requiring replacement too soon.

None of these things is inevitable. They can be prevented by the use of a scheduled maintenance programme which foresees the failure of components and ensures correct action in time to avoid such failures.

A proved, practical plan, applied in more than fifty mines and plants, will now be described by means of which management is able to systematize and control maintenance work, to determine an equitable work loading for maintenance men, to minimise overtime and to reduce plant breakdowns to a minimum.

Preventive Maintenance

The phrase "preventive maintenance" is self-explanatory. It means in effect that maintenance artisans are chiefly employed in preventing breakdowns and only to a minor degree in repairing them. Common practice is the reverse of this.

In theory if a machine is correctly lubricated, if all nuts are kept tight and if worn components are repaired before failure, the machine can only break down through an accident. Accidents are comparatively rare. The airlines carry their maintenance fairly close to the theoretical potential because lives and property depend on the fact that machinery must not come apart in the air. The relatively insignificant number of technical failures in all the millions of air-miles flown yearly are ample proof that machine stoppages can be almost eliminated. It remains then to industry merely to measure the economics of intensive preventive maintenance before deciding to employ it. Clearly if better maintenance can be achieved at little or no increased expenditure it must be attractive to management. Indeed, it must be recognized as an essential in *good* management.

Maintenance must be considered in two categories, i.e. work done on site, and work done in the shop. The two are to a considerable degree independent, but it is essential to develop suitable shop controls, if the entire maintenance organization is to be considered satisfactory.

Initiation of Preventive Maintenance

It will be held by some that preventive maintenance is a fine ideal and should be adopted in all new plants, but that it is impracticable in old plants in bad condition, more particularly if stand-by units are not available. The theory is that such plants cannot be put onto a preventive schedule without shutting down and reconditioning all bad equipment. Since production must go on, this is impracticable and so the plant must stagger on, accepting as inevitable all the grief that follows faltering machinery. This is simply not true and its unreality has been demonstrated many times. The fact is that the majority of breakdowns originate in one of three things: first, faulty lubrication; second, loosening of connections through vibration; and thirdly, dirt and uncleanliness.

These faults can be remedied without shutting down plant. Actual experience shows that within six to eight weeks of systematically and determinedly attacking these points, breakdowns begin to drop measureably. Once breakdowns come even partially under control and lost time declines, opportunities arise to stop machines with less effect on production than arose from a previous high incidence of breakdowns.

Making Preventive Maintenance Work

It can be accepted as a first principle that in so far as is possible, the extent to which agreed maintenance schedules are in fact carried out should be an open book. By this is meant it should be easy for the resident engineer and the general manager to see, at a glance, whether or not schedules are being maintained. If, to do this, requires digging details out of reports and log books, the maintenance system cannot be considered satisfactory.

The solution to the problem has been found in visual controls. These are designed so that everyone from the artisan to top management at any time, can see what work lies ahead, what work is behind the programme and how much it is behind, what each individual has to do and when it must be done. From every standpoint of team work, mutual confidence, clarity of thinking and decision making, these controls have proven beneficial. The effect on labour relations and on the relations between production departments and service departments is notably good. All men like to know in advance what is expected of them and they like to know that the division of work is reasonably equitable. Much of the friction between service staff and production is eliminated if shutdowns are jointly planned, well in advance. A good deal of unnecessary discussion and even loss of confidence between top management and the engineers can be avoided if the current standing of maintenance programmes and the work load on personnel is factual and not merely a matter of opinion.

The necessity for extra men or extra overtime or more machines becomes self-apparent and the making of decisions in such matters is thereby greatly simplified. To achieve these ends a number of visaul controls have been devised and two of these will be described.

Visual Controls

The Running Time Control Board (Fig. 1) is the most important type of visual control. The purpose of this device is to highlight at once the immediate jobs due and those overdue. Each horizontal line is devoted to a particular unit or machine and each space between vertical lines represents a day. On each horizontal line is a movable cursor which is slid along toward the "dead line" as running time progresses. All cursors to the right of this line represent units overdue and the number of spaces they have been moved beyond the dead line indicates the number of days they are overdue.

The great virtue of this board is the fact that units overdue stand out in the most glaring manner. Neither men nor foremen relish the necessity to explain why an individual cursor has passed to the right of the dead line. This becomes a powerful stimulus in keeping schedules up to date.

An essential of planned and loaded work is, of course, so to stagger the schedules that the work load is as nearly uniform as possible on every day throughout the year. If this is not done it is obvious

RUNNING TIME CONTROL BOARD

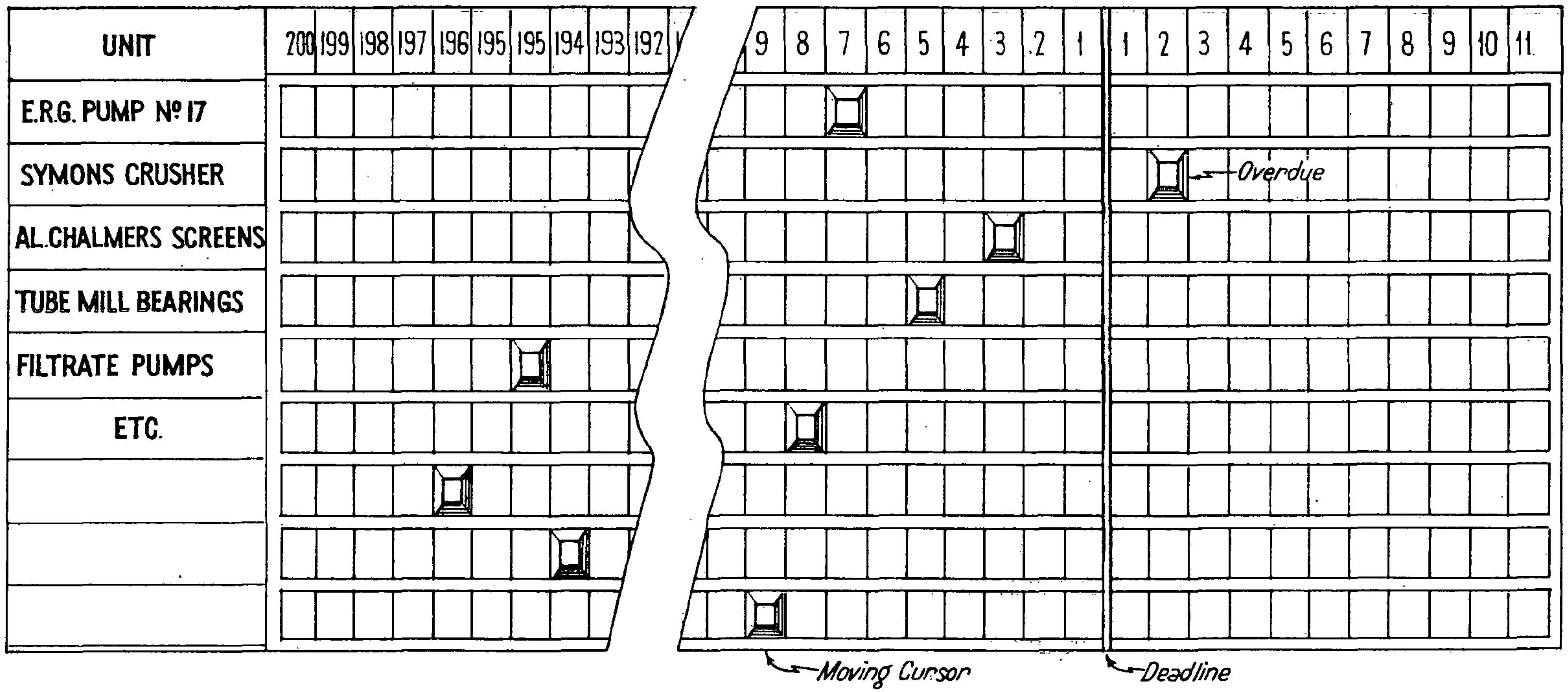


Fig. 1

that a number of units can fall due for service on the same day. In such an event either serious loss of production must ensue and/or an excessive labour force must be carried constantly, merely to meet peak demands. The Running Time Control Board makes it possible to see at a glance whether or not the schedule has succeeded in staggering inspections in a logical and satisfactory manner.

Work Loading Board

The Running Time Control Board shows the extent to which the work is up to date and evenly staggered. There is required in addition a visual indication of each individual's programme of work. This is done by the use of the Allocation Board (Fig. 2).

This board carries the name and trade of every man under a foreman's direction. One is supplied to each foreman for his own use and to be operated by himself. The foreman loads separate job cards in priority order on the board under each man's name. It is his duty to see that each job card is loaded only after he has written on it any necessary instructions and has made available a sketch, sample, material and machine, where required. The artisan removes his job card from the board in priority order and proceeds with his task without the necessity to find and consult with his foreman.

Since a foreman may, of necessity, often require to be out of his office, this mechanism enables him to keep in constant touch with the state of work-loading merely by periodically glancing at the board on returning to the office.

Preventive Maintenance on Site

This is comprised of two major parts:

1. Common sense everyday precautions (lubrication, cleanliness and tightening).
2. The forecasting of times at which trouble will begin to develop, if parts are not replaced.

Effective preventive maintenance must establish procedures and create enthusiasms which will ensure that the elements named above are strictly carried out. It is quite futile merely to issue general instructions on maintenance and expect they will be performed. As a general guide to the maintenance of plant, such instructions are useful but they do not provide an adequate system of preventive maintenance because they lack certain vital features. For example:

They do not indicate sufficiently in detail what precisely is to be done.

They do not specify who is to do it.

They do not say how long the job should take.

They do not provide any specific check that the job was actually done.

There is no provision for any incentive to encourage the carrying out of the job.

They do not provide a penalty for failing to carry it out.

To be effective a Preventive Maintenance Plan must spell out every step required.

All steps required in each service must be defined so clearly that a minimum of knowledge, thought or memory is required of the maintenance man. The criticism that this kills initiative in men and creates a force of robots is simply unrealistic. What it does do is to ensure that the same kind of attention is given to every machine at every service period, that this is neither too much nor too little and that men are properly trained in correct procedures.

The next step is to determine the time that will be required to carry out these instructions. Time studies are employed for this purpose supplemented by method study, ratio delay observations, analytical estimating and other recognised techniques commonly employed to establish work standards. Measured allowances must, of course, be made for walking, which in some plants may sometimes exceed actual working time. Since routes are pre-determined the calculation of travelling time does not entail serious difficulty.

Method study should not be passed over lightly in this discussion. As can be imagined it is a fruitful field for achieving reduction of the work content in maintenance jobs. The mere fact that attention is focussed on standard times for standard jobs serves as a challenge to men and foremen to exercise ingenuity which previously lay dormant for lack of inspiration.

Frequency of Inspections

As has been said, standard time allowances for all features of maintenance work can be established through orthodox methods of time study or allied procedures. An equally important feature however, is the frequency with which inspections must be made to forestall component failures.

Frequencies must initially be determined largely on the basis of experience. Makers' specifications are not always available and even when they are can seldom be considered as more than a rough guide. Local conditions vary so much it is usually necessary to consider each case on its own merits. Since much of the success of a maintenance plan depends on the enthusiastic support of the human

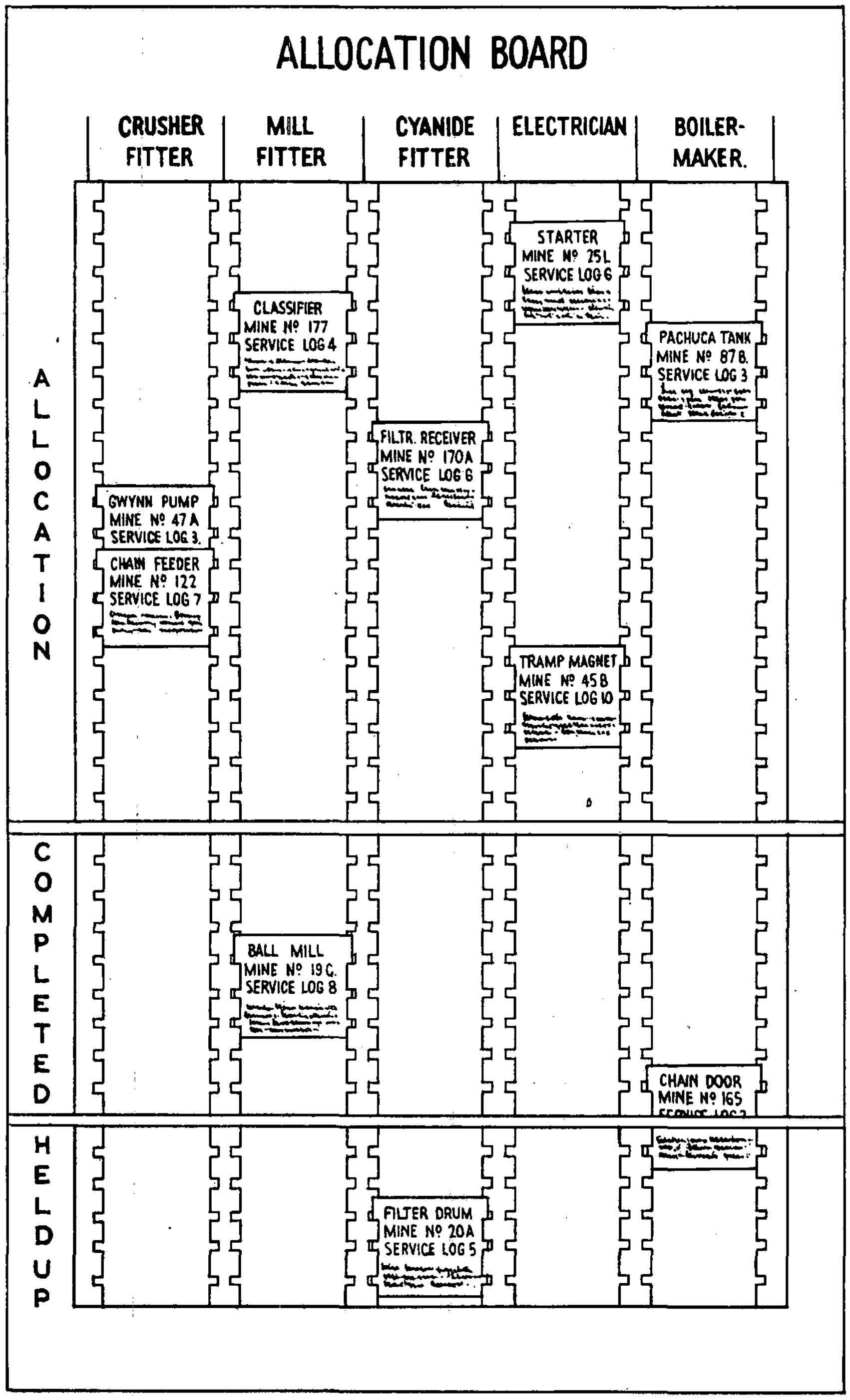

ALLOCATION BOARD
CRUSHER FITTER
MILL FITTER
CYANIDE FITTER
ELECTRICIAN
BOILER-MAKER.
ALLOCATION
COMPLETED
HELD UP
STARTER MINE Nº 25L SERVICE LOG 6
CLASSIFIER MINE Nº 177 SERVICE LOG 4
PACHUCA TANK MINE Nº 87B. SERVICE LOG 3
FILTR. RECEIVER MINE Nº 170A SERVICE LOG 6
GWYNN PUMP MINE Nº 47A SERVICE LOG 3.
CHAIN FEEDER MINE Nº 122 SERVICE LOG 7
TRAMP MAGNET MINE Nº 45B SERVICE LOG 10
BALL MILL MINE Nº 19C. SERVICE LOG 8
CHAIN DOOR MINE Nº 165
FILTER DRUM MINE Nº 20A SERVICE LOG 5

Fig. 2

beings involved, it is wise to give very careful consideration to all opinions expressed. To ride rough shod over the views of mechanics or foremen in matters which, after all, are usually considered to be questions of opinion, is to create resentment and frequently to court failure. At the same time experience has shown that in very many cases the estimates of suitable frequencies for inspection are wildly inaccurate and almost universally on the high side. It is quite understandable that this should be so where no accurate records have been kept of breakdowns. Human memories are fallible and it is not unnatural for a man to exaggerate in his mind the frequency with which he has had trouble with a machine. Since the frequency of inspections has a major bearing on the work load which will be assigned to the maintenance staff, it is unlikely that either men or foremen will voice opinions calculated to minimise that load. Preventive maintenance is specifically designed to improve progressively the condition of machines, and as this result is achieved the frequency of necessary inspections should materially decrease. It is not to be expected that the maintenance personnel will be in a position initially to estimate the extent to which frequencies will ultimately be extended through improved machine conditions.

With continuous auditing and comparisons between plants it is expected that very substantial reductions in maintenance staff will be made concurrently with improving condition of plant.

The operation of the Preventive Maintenance Plan should be a dynamic thing. It should not be looked upon as a cut-and-dried system which once installed can be expected to perpetuate itself. With the accumulation of data continuously and intelligently analysed, improvements and economies can be expected to flow perpetually from this source.

Checking Work

It is obvious that merely laying down a scheduled routine without a positive method of checking to ensure it is carried out can be a waste of time. Experience has shown that merely to instruct foremen to check the work of mechanics is not adequate. The foremen, themselves, must be provided with a definite programme of work. Theoretically, of course, a major function of a foreman is to assure himself that the work of his men is correctly carried out. In practice it is more the exception than the rule to find this being done. It is considered a reasonable thing to demand the foreman shall devote a percentage of each week to making spot checks of the condition of equipment through the use of approved sampling techniques.

Incentive Pay

The use of incentive pay in connection with maintenance work is highly desirable since it sustains the interest of all concerned in carrying out the planned schedules. It also operates to reduce unnecessary overtime and makes it possible to apply penalties in cases where schedules are not being carried out.

The most suitable type of incentive is that based on time studies which establish accurate standard times, including appropriate allowances for rest and personal needs. Methods have been devised for establishing standards for non-repetitive work during recent years which are proving entirely satisfactory to management and to men. In the case of scheduled maintenance, a great deal of the work done is in fact repetitive.

In cases where it is not practicable to employ meticulous time study methods, recourse may be had to the "Maintenance Allowance Plan." A great deal of basic time study data has been accumulated under a wide range of mine and factory conditions. This information in experienced hands, combined with local knowledge, can be utilised to set up workable standard times for all operations likely to be encountered. After inspection and lubrication frequences have been laid down and standard times established it becomes a comparatively simple matter to lay out equal work sections for all men.

Incentive is calculated on the generally accepted basis that a man who performs at 100 per cent. effectiveness is entitled to incentive pay of $33\frac{1}{3}$ per cent. more than his basic rate. Having regard for the fact that in practice emergencies are inevitable, no attempt is made to load all men fully with "bonus" work. To simplify calculations and make it easy for men to understand the basis of payment, a price is set on each unit of equipment. The price, of course, varies for the different types of service. The daily service will be relatively quick and the "overhaul" service will be lengthy and thorough. Each has an appropriate price. There is, therefore, an ever-present incentive for men to ask for larger sections.

For each breakdown exceeding one hour in lost time which can be traced to failure to carry out a schedule for which a man has signed, an appropriate penalty is levied against his weekly premium. Similar penalties are assessed for sub-standard work, and it is understood that a man cannot earn both premium and overtime in his own section unless the overtime is necessary for some reason outside the man's control.

Case History Card

This is a card on which to record the entire life history of every item of equipment. Once a week the planning clerk enters on the case history sheets details of work done during the week and inspection schedules carried out. Done weekly this consumes very little time, but it provides an invaluable record for a new man or a relieving man in a section. He can see at a glance the life history in detail of every piece of equipment which is his responsibility. In case of accident the full story of the treatment accorded each machine in the past is available, including the names of the individuals involved. For comparing various types or makes of equipment in similar or different conditions the case history has obvious value, and for carrying out the perpetual comparative audit to determine whether frequencies are being suitably revised, it is indispensable. The case history, in fact, is one of the most useful adjuncts of the preventive maintenance plan.

Shop Control

The establishment of preventive maintenance procedures may throw a heavier work load on the shops for a time and it is accordingly important to introduce steps to increase their productivity by suitable means.

The most desirable form of shop control is, of course, an incentive plan based on work study from which synthetic times can be built up. This can be done quite satisfactorily on non-repetitive repair work and no other method can be considered nearly so satisfactory. However, in cases where insufficient time is available to take time studies, very good relative improvements can be obtained by other means.

Some recent results from a group of ten mines show a saving of 5,054 man-hours per week. The work output per man has increased by 80 per cent. The saving in equivalent mechanics amounts to about 120 men. The time required to achive this result was about two years and considerable further economies are expected. The saving in wages is, of course, considerable, but the more important economy stems from the fact that an apparently impossible backlog of work is now about caught up, construction has moved ahead and advantage can now be taken of subsequent natural wastage of men to reduce the permanent maintenance staff.

In the case of these mines, it was not practical to make use of time study methods. The alternative adopted is an interesting one. A major difficulty in shop control, where time study standards are not in operation, is the lack of a yard-stick to measure performance. It has been established after lengthy trials that the "workshop order" may involve thirty minutes of work or it may take three days. Nevertheless, a graph plotted on the basis of a three-monthly moving average, will be based on thousands of orders and the irregularities will average out sufficiently to indicate significant trends.

The most tangible evidence of increased work through the shops is the decrease in the backlog of work. On one mine orders which are over two weeks in process have decreased from an average of 180 odd to 25 or 30.

Since good maintenance cannot be achieved if shop capacity becomes a bottleneck the control of shop work is a necessary corollary to the development of an effective preventive maintenance programme.

Results Achieved

The techniques which have been described were first introduced in 1950 and are now in use in more than fifty mines and plants covering a wide range of industries. Some of the results which have been achieved are shown graphically in the charts which follow:

Fig. 3 shows the relationship between man-hours spent on the repair of breakdowns and man-hours spent on maintenance at a large gold mine. Whereas in August 90 per cent. of all the available hours were spent on repairing breakdowns, and only 10 per cent. on maintenance, five months later this had decreased to 20 per cent. on breakdowns and increased to 80 per cent. on maintenance. This took place despite a considerable reduction in total hours worked, amounting to 25 per cent.

The costliness of breakdowns is demonstrated by the experience in a gold reduction plant processing 75,000 tons of ore per month. The lost time on key units was reduced from 7.1 hours per day to 4.0 hours, making it possible to mill a further 4,000 tons. This is a four pennyweight mine and since variable costs of production amount to 20s. per ton, the extra tonnage obtained produced £5,000 additional net profit.

At a new mine, where the scheme has been in operation for a year, twice the amount of plant is being maintained by the original number of men. Breakdowns underground have decreased from eighteen per month to one.

Fig. 4 illustrates the effects of applying preventive maintenance to Diesel locomotives. Prior to adopting the scheme, 2,150 man-hours were spent on the repair of the locomotives. This was reduced to 860

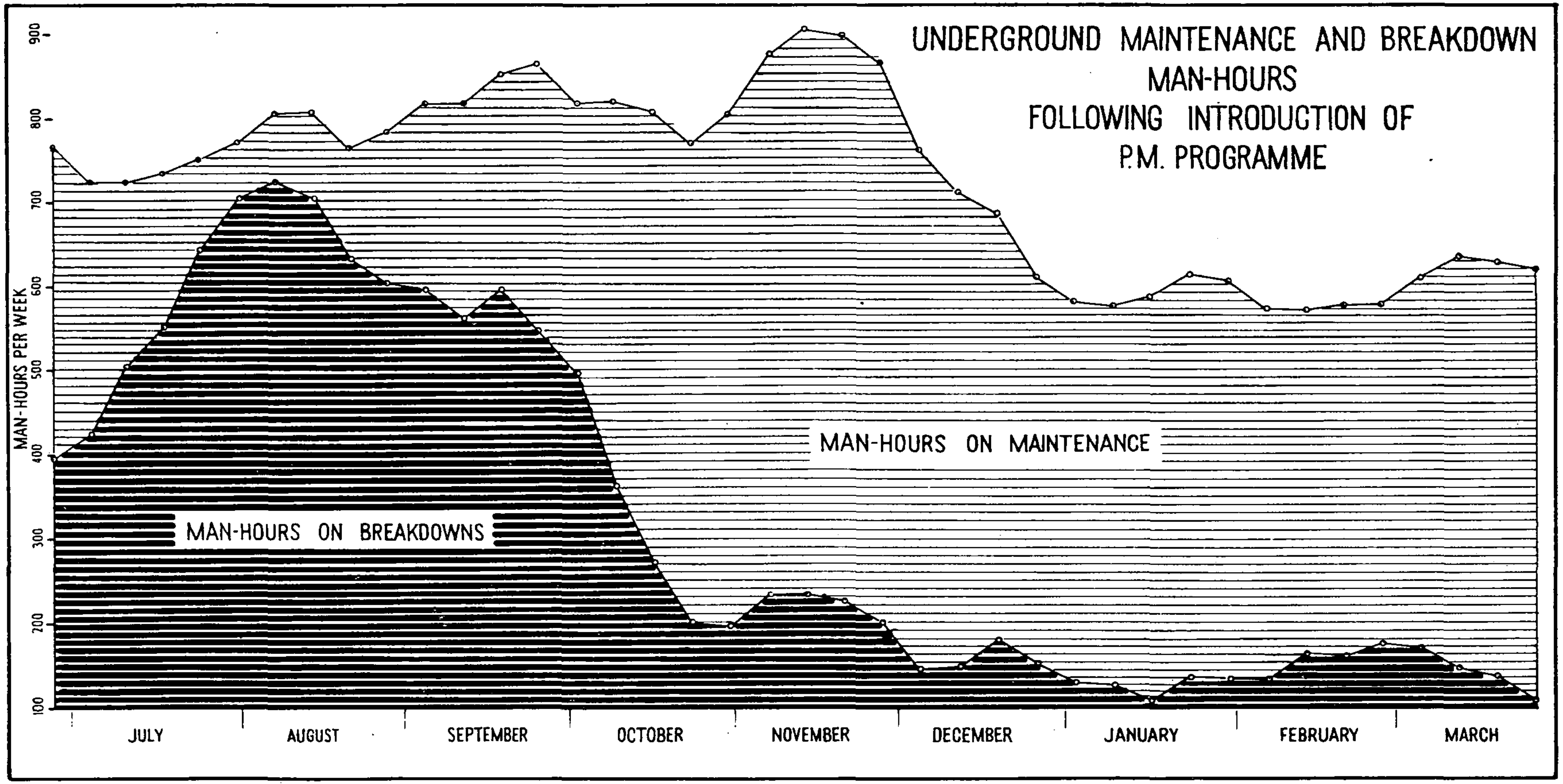
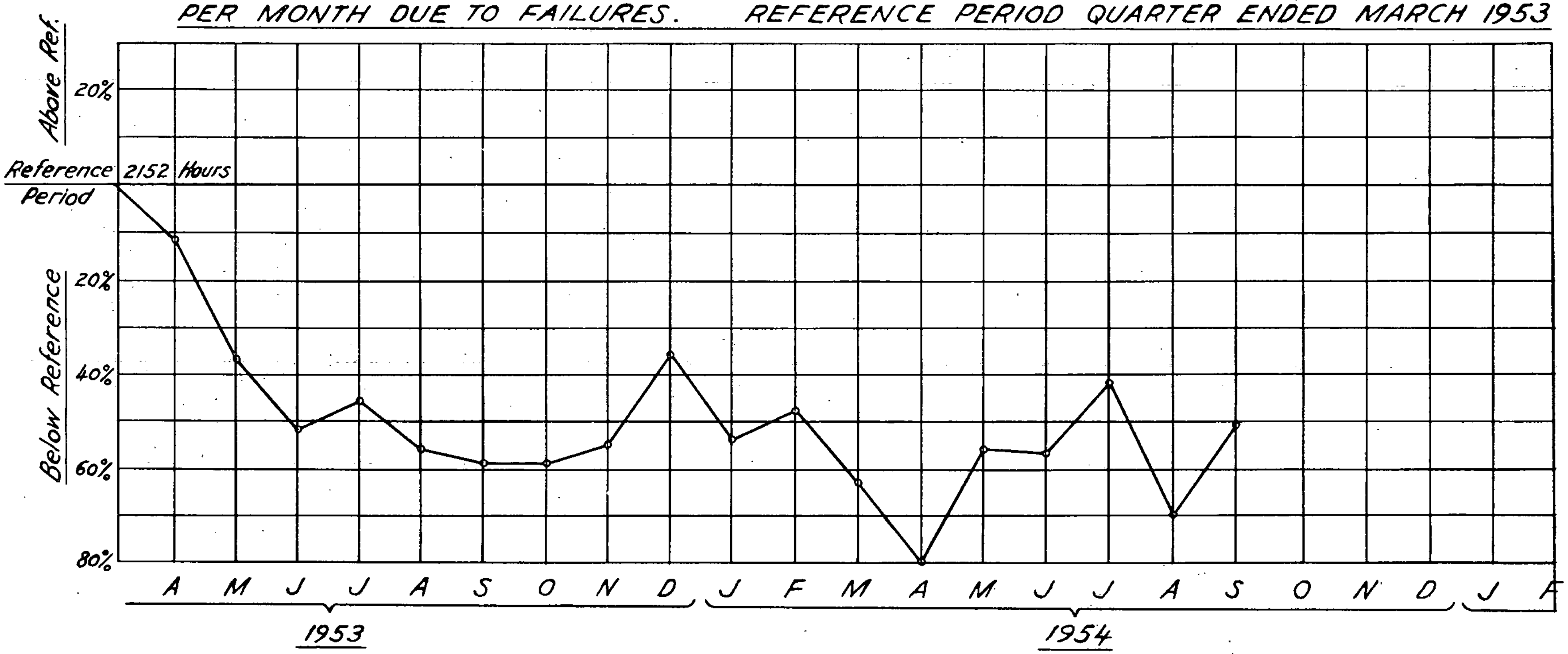

UNDERGROUND MAINTENANCE AND BREAKDOWN MAN-HOURS FOLLOWING INTRODUCTION OF P.M. PROGRAMME
MAN-HOURS PER WEEK
900
800
700
600
500
400
300
200
100
MAN-HOURS ON MAINTENANCE
MAN-HOURS ON BREAKDOWNS
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH

Fig. 3

RECORD OF HOURS SPENT ON THE REPAIR OF MAIN LINE LOCOMOTIVES PER MONTH DUE TO FAILURES. REFERENCE PERIOD QUARTER ENDED MARCH 1953



November, 1954

Fig. 4

hours, with an increase in utilization in terms of mileage operated amounting to 25 per cent.

At this same property, maintenance standards for trucks and the application of incentives to the track gangs were responsible for a drop in derailments from an average of fifty per month to five.

A large power station which has recently adopted preventive maintenance techniques reports the following features:

(*a*) Labour hours spent on repair of defects which were 2,200 hours in the first month of record fell to 800 hours after full implementation of the scheme.

(*b*) Week-end work which used to be as high as 2,000 hours per month, is now as little as 600.

(*c*) 60 men (as opposed to the normal establishment of 70) are capable of performing all work requirements.

The re-deployment of 47 men at a colliery in the United States and the introduction of controlled maintenance effected a reduction in overtime of 238 hours per week. At $3.65 per overtime hour, this mine is saving $44,000 per annum. What is more important however is that production has increased by 10 per cent.

Overtime has become a decided evil in many parts of South Africa and almost impossible to control by normal means. Planned maintenance coupled with incentive has been especially effective in accomplishing the required control. Fig. 5 shows how overtime was reduced in the case of twelve fitters and electricians employed underground. This control took on added importance in November, 1955, when the cost of an overtime hour rose by 25 per cent., through the incorporation of a portion of c.o.l.a. into basic wage.

Conclusion

I will close this discussion on preventive maintenance by recapitulating its purposes. These are:

1. To eliminate avoidable breakdowns as far as possible.
2. To improve the standard of maintenance.
3. To act as basis for training maintenance men.
4. To provide continuity of maintenance when there is a turnover of manpower.
5. To ensure that no unit is neglected, while other equipment may be over-maintained.
6. To standardize maintenance.
7. To act as a basis for assessing a suitable size of section for a maintenance man.
8. To provide a current list of all maintenance work overdue, so that special arrangements can be made if necessary for carrying it out.
9. To allow maintenance work to be pre-planned so as to fit in with production requirements.
10. To provide a basis of comparison between plants and types of equipment, thus indicating possible improvements.
11. To act as a basis for applying an incentive bonus based on individual performances.
12. To obtain an increase in productivity.
13. To assure the completion of jobs in their correct order of priority.
14. To gear the shops to maintenance requirements.
15. To improve safety.
16. To achieve a reduction in costs.

Experience in many mines and factories has proven that the adoption of controlled maintenance involves no possibility of loss, but every opportunity for substantial gains.

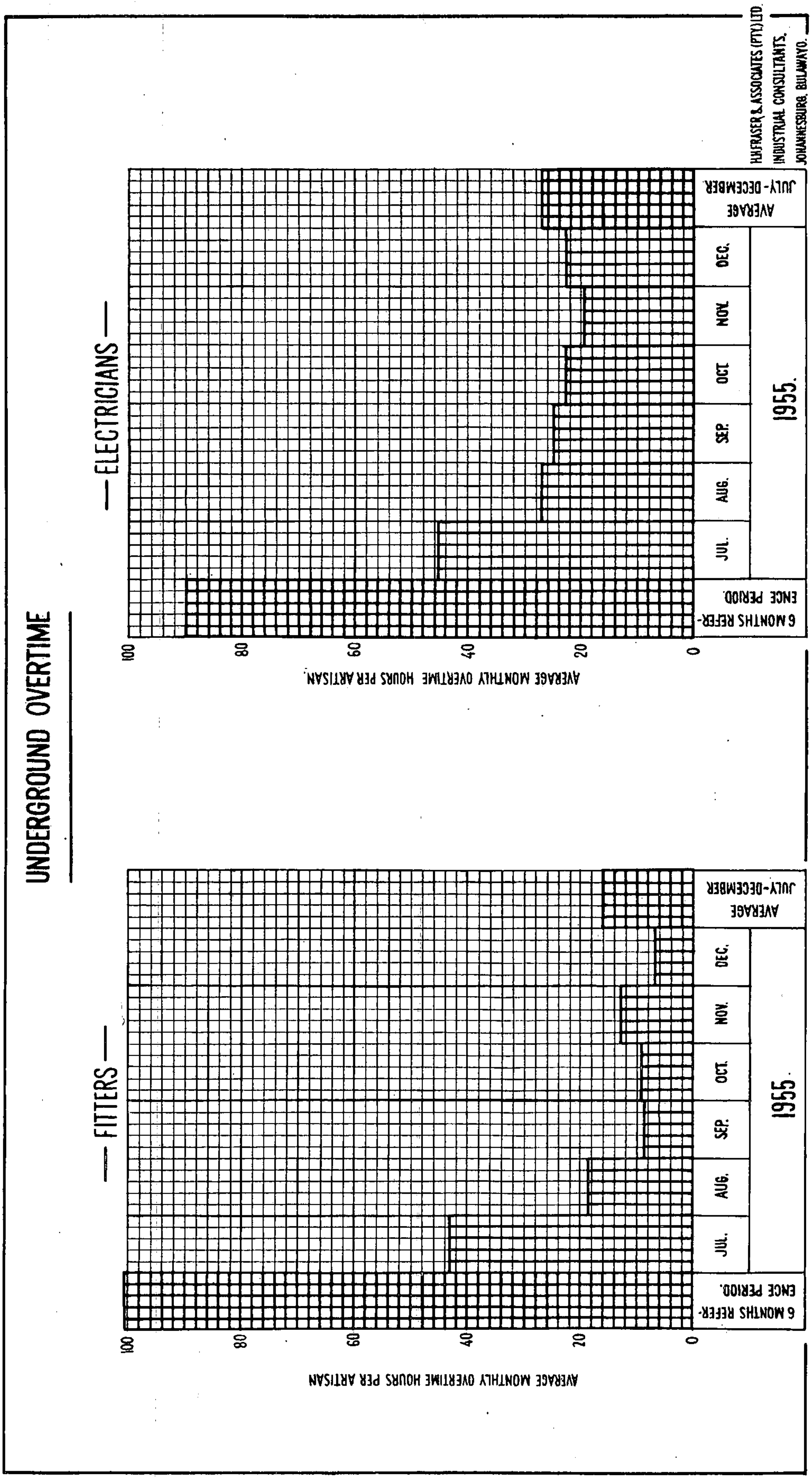

UNDERGROUND OVERTIME
FITTERS
ELECTRICIANS
AVERAGE MONTHLY OVERTIME HOURS PER ARTISAN
0
20
40
60
80
100
6 MONTHS REFER-ENCE PERIOD.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
AVERAGE JULY-DECEMBER
1955.
H.H.FRASER & ASSOCIATES (PTY) LTD.
INDUSTRIAL CONSULTANTS,
JOHANNESBURG, BULAWAYO.

Fig. 5

The President stated that this paper was something new in our annals and should provoke much thought in the industry.

Mr. Scott said that stress was laid in this paper on the reduction of artisans and similar staff, but it was not mentioned how many extra higher operators and executives would be required. He wished to know what extra amount of paper work would be involved in carrying out this system of Preventive Maintenance.

Mr. Hastings replied that it was planned that in one large unit in the sugar industry, the assistant resident engineer would be responsible for overseeing this system and he would be assisted by a single planning clerk, who would analyse the figures that came forward, weekly or monthly, and hand them on to the executive whose responsibility it was to see that the work was carried out. It was not estimated that the assistant engineer would have to spend all his time on this work, and he would be merely performing the work which he was supposed to be doing in any case. There would be an extra cost in installing this system, because consulting engineers with experience of it would have to be called in, but this was in the nature of a capital cost.

On large gold mining properties, only a planning engineer, a clerk, and a typiste, are required to operate the scheme.

The President stated that sugar mills were not normally supplied with spare major units so that during week-ends maintenance work had to be carried out. It might be to some extent haphazard, but even so, and in spite of the spare units, the bigger companies budgeted only for a loss of about 3 per cent of available time which allowed for stops such as mill chokes, lack of steam, trip-outs and the like, as well as mechanical breakdowns.

Mr. Hastings would find conditions in sugar factories rather different from what he had experienced up until now.

The President wished to know if the system of incentive bonuses was accepted by labour unions and industrial councils.

Mr. Hastings replied that there was sometimes objection by the unions to piece work in shops and factories but they raised no objection to incentive bonuses for maintenance work. This system was vastly different from conventional systems of incentive.

He said he had had experience in large power stations, cement works, and chemical plants. What these various plants got out of the system depended upon their particular circumstances and problems.

Mr. Gunn asked if this preventive maintenance scheme had ever been applied successfully without an incentive bonus.

Mr. Hastings replied that it had been. One important thing about the scheme was the incentive bonus did give one an opportunity of applying penalties for overtime, breakdowns and poor work. Such penalties however could only be applied after earnings had been increased by incentive bonuses.

Mr. Munro pointed out that in the sugar industry there was a considerable off-crop, during which the staff must be employed, and that gave an opportunity of doing additional overhauling and maintenance work. As the work has to be done in any case, the question arises as to whether it would be economical to employ the extra control staff to carry out this system of preventive maintenance.

Mr. Hastings replied that it was all a question of economics and he was unable to say whether it would pay or not, but he pointed out that in one large plant where it was the custom to close down for one month each year, this was no longer necessary.

In the sugar mills, he realised the off-crop was forced upon them, but he could not state dogmatically whether it would be an economical proposition in the sugar industry to save the work done during the off-crop by carrying it out during the crushing season.

The President pointed out that there was a tendency to leave things to the off-crop which should be maintained during the season.

Mr. Scott said that in the case of gold mines, time study departments were established, and to begin with they saved a lot of money, until it eventually reached a point where savings completely nullified the extra cost of applying the time study method. He asked if the same thing could not occur with the system described by Mr. Hastings.

Mr. Hastings replied that while it was true that on the reef some mines had discontinued their study departments, some of them on the other hand were still expanding them.

He realised that this system would always mean a certain amount of extra paper work, but it was hoped to keep this to a bare minimum.