The planning of mining-equipment trials

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SYNOPSIS

This paper describes a procedure that has been found successful in the planning and execution of practical trials of mechanized-mining equipment. The procedure is illustrated by reference to development trials of a rockslotting machine with pneumatic or hydraulic drills that were conducted on South African gold mines.

SAMEVATTING

Hierdie referaat beskryf 'n prosedure wat geblyk het suksesvol te wees vir die beplanning en uitvoering van praktiese proewe met gemeganiseerde mynboutoerusting. Die prosedure word geïllustreer deur verwysing na ontwikkelingsproewe met 'n rotsboormasjien met druklug- of hidrouliese bore wat in Suid-Afrikaanse goudmyne uitgevoer is.

Introduction

The successful development of any product, mechanized-mining equipment in particular, involves a large number of people. The best ideas cannot succeed without properly planned and executed practical trials, and there are many examples that can illustrate this point.

The intention of this paper is to describe a procedure that has been found to assist in the achievement of satisfactory results in the planning and execution of such trials. The points made are illustrated by reference to the rockslotter that is at present being developed by Boart Research Laboratory (Fig. 1). Although this is a fairly small piece of equipment, its testing requires attention to all the elements found in a very much larger piece. Indeed, with large, expensive equipment, the margin for error is very much smaller and the problem likely to be very much greater, and careful planning is therefore all the more important.

The points mentioned here are not the only factors to be considered, but together they provide an excellent basis for the testing of equipment, regardless of its size or application.

Initial Appraisal

The various procedures that determine the specification of a piece of equipment or its intended application are not discussed here. These are initially the concern of the marketing and engineering personnel of the manufacturer. However, the decisions made at that stage are inevitably examined in detail during a practical trial, and some aspects should be highlighted from this point of view.

Application

The job for which the machine is intended should be clearly defined. For this to be possible, the need for the machine and the benefits it has to offer should be clear, not only to the manufacturer but, more important, to the potential customer, the mine.

With the rockslotter, the manufacturer's approach has been to concentrate on the benefits of selective mining, in this case the elimination or reduction of the blasting requirement, together with an improvement in the recovery of high-grade material mined. The machine is not a tool for high production rates, but rather a continuous means of obtaining high-grade ores.

It is not uncommon for a machine to be judged in an application for which it was not intended, and this should obviously be avoided.

Performance

If the application is correct, the expected performance should be identified. This will enable the user to judge for himself whether the machine is able to offer him an advantage or not. In some cases, it will be difficult for the supplier to anticipate the user's detailed requirements, particularly with financing and versatility for example. Only thorough preparation will determine these needs at the specification and design stage. The user should have sufficient information to permit him to make his own appraisal.

Manufacturers, as well as miners, can often be accused of being too optimistic with regard to performance and reliability. This may be due to not knowing some aspect of the application or underestimating the operational problems underground, which are often not associated with the equipment being tested. The assumptions made in the application study should be clear to all concerned.

The performance of the slotter was estimated from known cutting speeds, allowances being made for delays and breakdowns. A realistic figure for the utilization of this equipment was taken as 65 per cent. From this it was possible to estimate the number of machines, and hence the capital and revenue costs, of a typical full-scale installation. The benefits of improved recovery and continuous working could then be estimated.

Specification

The mechanical specification is determined from a knowledge of the application and performance required for economic results. During the design and manufacturing stage, any changes found to be necessary should be related to the application to ensure that the new specification is still relevant. By the same token, any changes in the mine's requirement should be examined to see if

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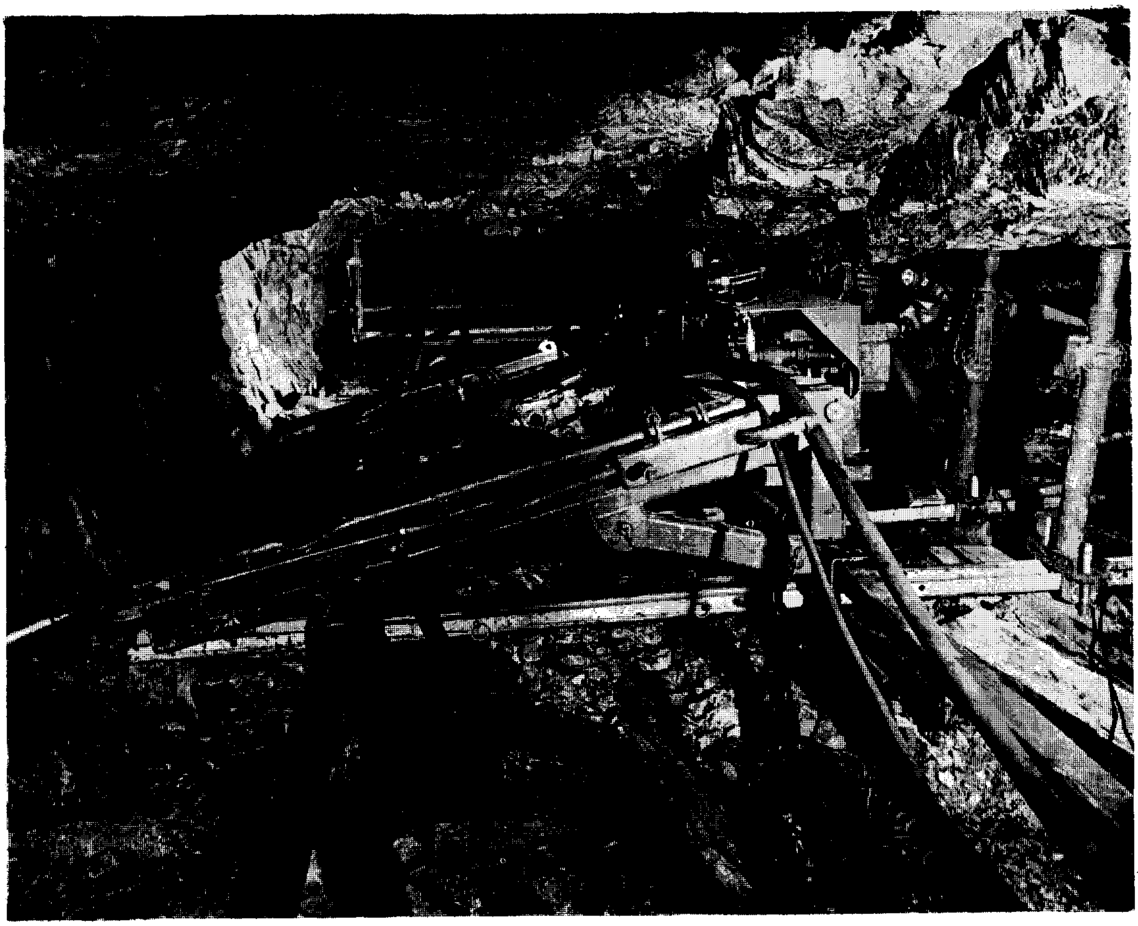

Fig. 1—The rockslotter used in illustration of the procedure proposed for equipment trials

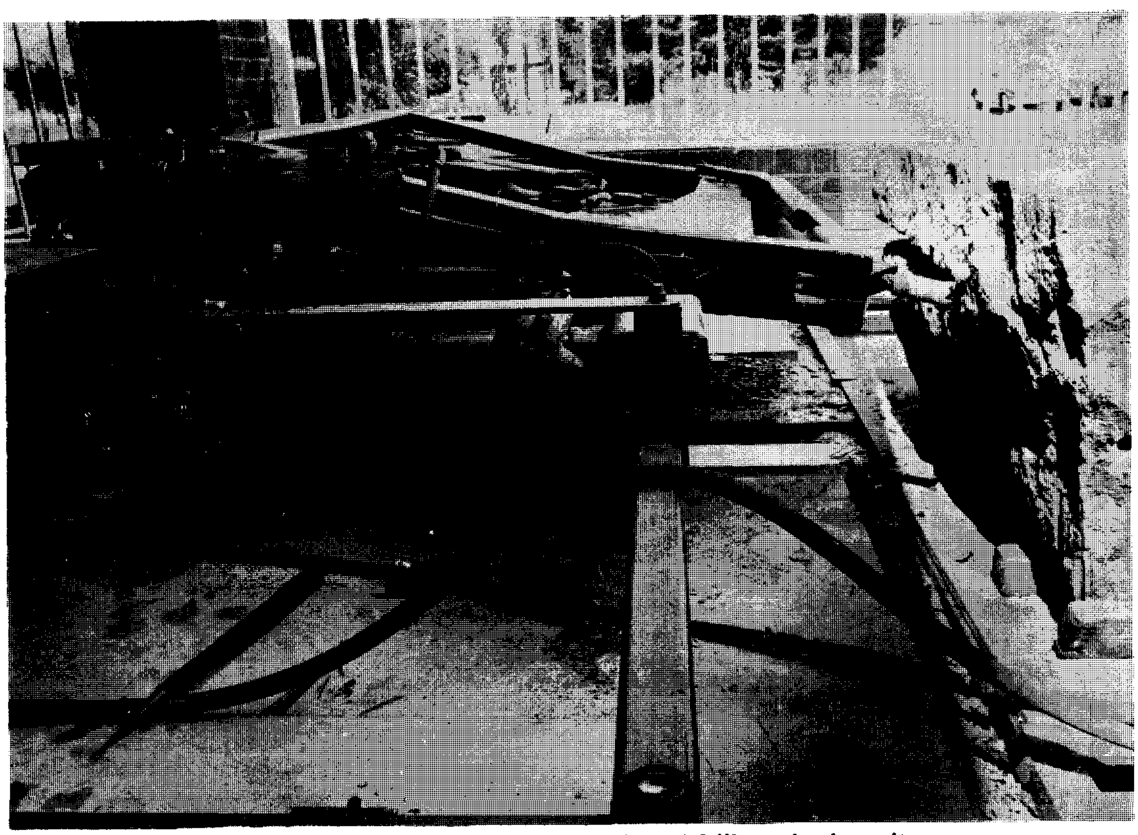

Fig. 2—The rockslotter, with a hydraulic rockdrill, cutting in norite

the specification will meet it; if not, changes must be made. It is only by this continuous monitoring that the production of an unsuitable piece of equipment can be avoided.

Because of the problems experienced in obtaining adequate supplies of compressed air for the pneumatic rockdrills of the rockslotter, these drills were replaced with hydraulic drills. The higher performance of the hydraulic units provided a specification with a better prospect of successful application. The improvement in performance was substantial — from approximately 0,7 centares to 1,6 centares per hour — and has a considerable impact on the overall economics of the stope operation.

Testing of the Prototype

After completion, the machine should be tested on the surface as thoroughly as possible, the underground application being simulated as closely as possible. In some cases this is not practical, but it is usually worth while spending a good deal of time and trouble in examining every aspect of the application in as much detail as possible. The detailed specification should be checked, and all the components in the machine should be run under full load and, if possible, in likely overload situations. Problems identified at this stage can be dealt with very much more easily than at a later date. A sound attitude to adopt at this stage is that 'If it can happen, it will'. Many of the problems in underground development are encountered because this maxim was not observed, often because some known limitation in the machine was being subconsciously protected.

In the surface trials on the rockslotter, which involved cutting in norite, an instantaneous cutting rate of 1,6 centares per hour was obtained with a hydraulic rock-drill (Fig. 2). This rate was related to the rate used in the original performance estimates, together with the utilization factors expected to ensure that the acceptable levels of underground performance were possible.

Time spent at this stage is often recovered many times over when underground work starts.

Planning of Field Trials

The initial field trial of a piece of equipment is the most critical phase it has to pass through. Thorough and detailed planning is necessary to remove as many risks as possible from this stage. Open and frank communication is the most important single theme throughout this work: it cannot be expected that a piece of equipment will be operated correctly or judged correctly if the people concerned do not understand the part they have to play in the trial. This planning stage is concerned with establishing the objectives of the test, the role of all the people involved and the extent of their responsibility, and the arrangements for recording progress so that an objective assessment of the machine will be possible on a continuous basis.

Site

This is one of the most critical steps in the whole trial. The mine concerned should see a need and application for the equipment so that the mine personnel have some interest in a successful outcome. This will require discussions with the most senior people at the mine, sometimes Consulting Engineers as well, because only they can determine how the equipment will fit into their plans.

The site within the mine should be selected with great care so that the conditions meet the specification requirements of the equipment as closely as possible. If possible, the equipment should be used where the normal pressure for production can be avoided. In the initial stages, it is often necessary to prove aspects of the machine's performance in a systematic way, and this cannot be done correctly if production is required. Some mines are establishing test areas where this can be done without the usual calls for production, and this is an ideal arrangement.

The mine should be informed of the site details in advance so that unnecessary delays can be avoided later. Some points to be considered here are

the physical layout of the test area,
support details,
the power required: what kind, what quantity, and where.

For the rockslotter installation, a dimensional drawing showing the required layout was supplied, together with details of the support recommendations. A typical slotter installation is shown in Fig. 3.

Physical inspections of the site should be made to ensure that all the requirements will be met before the equipment is installed.

Test Procedure and Reporting

This is the heart of the development programme, and all those concerned should be clear about what is expected of them. Briefings should be held to discuss the detailed programme with everyone concerned. In this way, the chances of overlooking some vital point can be minimized.

The points to be established include the following.

Test Objective

What is the purpose of the test, what is the machine expected to do, and how will it do it? How will its performance be judged (this, of course, relates to the initial appraisal of performance)? Fairly often of similar importance — what is the machine *not* expected to do?

Manning

How will the machine be operated, by whom, and following whose instructions? Who will collect the operational data? Who is responsible for servicing, repairs, reporting, and so on?

It has been found that replacement of one operator with another can cause considerable delays. Whilst the mine's problems of labour turnover are understood, it is important to retain a regular work force on specialized equipment if the operation is to proceed with the minimum of interruptions.

Reporting

The practical development of the machine's application requires accurate reporting. Many expensive tests become worthless because the information obtained

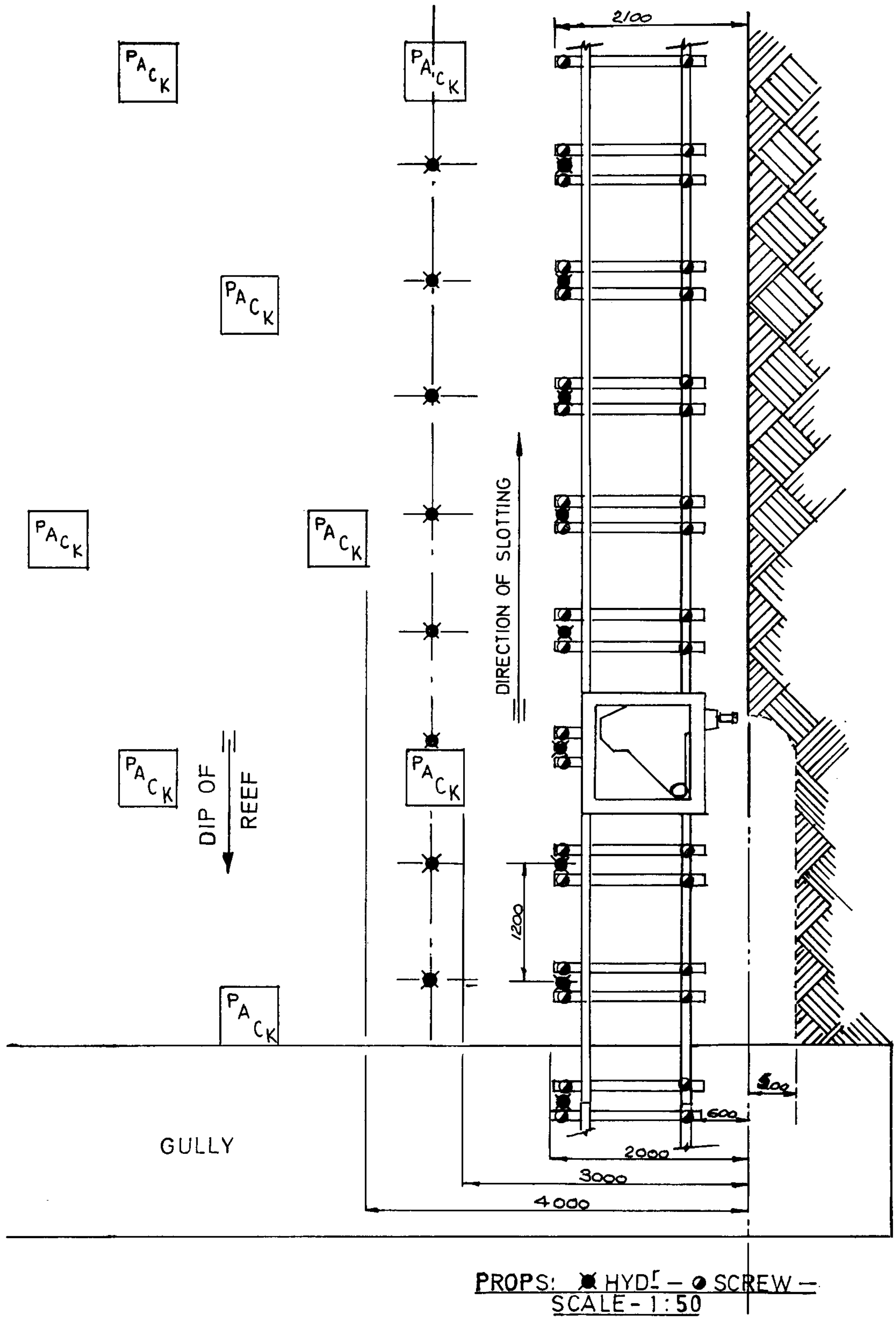

Fig. 3—The rockslotter installation

ROCK SLOTTING AT : "X" MINE

DAILY SHIFT ROCKSLOTTER REPORT

DATE : 21/5/77

SHIFT | 1 | 2 | 3 |

MACHINE	TOP	MIDDLE	BOTTOM	
INDEX SETTING			25	
ADVANCE	500			
SLOT DEPTH	500			
DIST SLOTTED IN SHIFT	5 MTRS.			

SLOTTER PERFORMANCE :

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BITS

BIT Nº	2/2	1/2	
NEW		X	
USED	X		
DIST. SLOTTED	3	2	
REASON FOR DISCARD			
THREAD WEAR			
BLUNT	X		
BROKEN INSERT			
OTHER (SPECIFY)			

RODS

ROD Nº	T3		
NEW			
USED	X		
DIST. SLOTTED	5		
REASON FOR DISCARD			
THREAD WEAR			
LOOSE COLLAR			
FRONT END BREAK			
SHANK BREAK			
OTHER (SPECIFY)			

DOWN TIME	START	STOP	TIME	WATER-PRESS	AIR-PRESS
WENT TO FACE	6,00	6,45	45		
CUTTING – STICKING BADLY	6,45	8,45	120	350	450
CHANGED BIT AND BARRING	8,45	9,00	15	"	"
CUTTING	9,00	10,30	90	"	"
POWER PACK CUT OUT	—	—			
OVERHEAT, LOW OIL DUE TO OIL LEAK	10,30	11,00	30	"	"
CIRCUIT BREAKER ON/OFF SWITCH BROKEN					
STRIPPED FAULTY HAMMER AND FOUND PISTON	11,00	—			
MARKED AT BACK OF PISTON	—	12,00	60	"	"
EARTH LEAKAGE TRIPPED	12,00	1,30	90	"	"

Fig. 4—The standard daily report form used

cannot be used to assist development or assess performance.

The data to be reported and the reporting format should be established. Standard report forms can often simplify this, and standard methods of failure analysis can be used when appropriate.

Fig. 4 shows the standard daily report form used in the rockslotter trials. As well as the output for the period, full details of the performance of the accessories (bits and steels) are recorded, as well as details of all the down-time. This down-time analysis has been found to be one of the most useful outputs from this report because the elimination of down-time can result in significant increases in output.

All this information is summarized on a daily basis to produce a simple visual report based on the actual time of operation (Fig. 5) and an analysis of activity (Fig. 6). A weekly summary is produced from these for reporting to senior management on the general progress (Fig. 7).

The mine personnel concerned with the trial should agree to this reporting procedure, and be part of it, because they are required to act upon it when necessary.

The person responsible for providing the data should understand what is required and why. The channel for communicating the data should be established, and regular meetings should be held with the mine personnel to confirm the actions required as a consequence of the results achieved.

Trial Support

The means of providing continuous support for the equipment should be established. The requirements and manning for regular servicing and the arrangements for breakdown repairs should be clear. The provision of services from the mine should be arranged, particularly if the machine changes its working place as a development drilling rig might.

Financial Arrangements

Arrangements should be made in advance for the financial aspects of the trial.

(a) Who owns the equipment, or what is the basis for payment or hire?
(b) Is a cost to be recovered to repay the manufacturer's expenses if it is his equipment, and if so at what rate?
(c) What is the basis for charging for mine services and the supply of mine manpower?
(d) Who pays for servicing and breakdown repairs?
(e) How are the consumables used to be charged?
(f) Are any special insurance arrangements necessary?

Detailed attention to every aspect at this stage can save may problems, often embarrassing ones, at later stages.

Execution of Field Trials

Installation

If the site is correctly prepared and the services available, the installation should present few problems. Adequate time and manpower should be available to erect the unit as quickly as necessary. If alterations to the site are found to be necessary after the equipment is in place, these can often be extremely difficult to complete, particularly if additional excavation is necessary.

Commissioning

In some cases it is not possible to run a complete machine on load anywhere but in its working place. If this is the case, then some time must be allowed for a complete and thorough test of all the elements of the unit to ensure that they are performing satisfactorily.

A planned programme of checks should be followed to ensure that nothing is overlooked. At this stage, there is a natural tendency for all concerned to want to get on with the trial, but this preliminary checking should be complete and accurate.

Where the complete machine has been checked on surface, it is still advisable to carry out a brief check to ensure that no damage has been suffered in the move to the underground site.

Trial Procedure

The planning and preparation having been completed satisfactorily, everyone concerned will be clear about what is to be done and how it is to be done. At this stage the work can be divided into two broad divisions: the first is an analysis of the machine performance in its various aspects so that the various parameters can be optimized; the second, and sometimes more important, is an analysis of the reasons for poor performance and delays. Often these are not due to the machine at all but to some quite separate problem. In one case, a drop in performance was noted with a particular supervisor. When the reasons for this were checked, it was discovered that he was having difficulties in communicating with the operators. It showed that his Fanakalo was not really up to the requirements of the job; a session in the Language Laboratory solved that problem!

To achieve the objectives, an accurate record of what is actually happening is essential. The daily reports (Fig. 4) should identify the problems, and manpower should be provided with the specific purpose of sorting out the problems reported whether they are associated with the machine itself (hence the manufacturer) or with the test site and services (hence the mine). Close co-operation between the machine manufacturer and the mine personnel is the only way to ensure that delays are overcome as rapidly as possible.

In Figs. 5 and 6, it can be seen that a considerable delay was caused by the mine on 23rd May, and it was essential to resolve this problem with the mine personnel to prevent a recurrence. Typical problems of this type include delays while awaiting blasting or cleaning, and those due to a shortage of water. Some re-organization of the mine services may be necessary in extreme cases.

When the mine is required to provide information on performance, this should be determined on a regular basis where possible. This is an essential part of the overall trial but outside the immediate control of the manufacturer. Where the information is confidential to the mine, some special arrangements may be necessary before the success of the equipment can be measured.

Reporting

The detailed reports should identify the actions required to improve the machine performance. These should be acted upon as quickly as possible, and regular meetings with all interested personnel are necessary.

As shown in Figs. 4 and 5, the machine stopped for over one hour on 21st May owing to rockdrill problems. Steps were taken to solve the problem, and the success achieved can easily be detected in the weekly summary (Fig. 7).

The manufacturer's objective is to minimize delays due to equipment problems and to maximize the cutting time. Mine delays outside the manufacturer's control can only detract from the total output.

The weekly and monthly summary of progress is needed to inform senior personnel of progress, problems, and actions. At each stage, the progress summary should relate progress and performance to the original test objectives to indicate the degree of success of the test. In addition, the utilization factor allowed for in the initial performance appraisal can be related to the actual utilization. At some stage it is necessary to decide when the best practical utilization has been achieved, and when no further improvements can be expected. Without a test objective and plan, this essential feedback and comparison are not possible, and tests can take far longer than is necessary; in extreme cases, they never end because there is no end in sight!

Completion

At some agreed stage, decided either by time or performance, the test should be terminated. An example of this requirement is afforded by a rockslotter test to

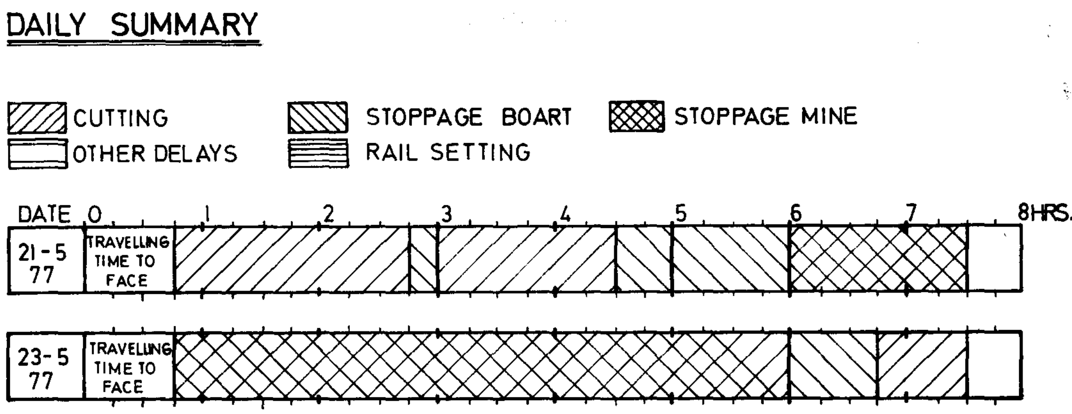

Fig. 5—The standard daily summary

DAILY ANALYSIS

DATE	CUT	TIMELOST-MINE		TIMELOST-BOART		CUTTING-TIME		WAITING-TIME		RAILSETTING TIME		HOURS PER SHIFT
		HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	
21.5.77	CENTRE	1,5	22	1,75	26	3,5	52	NIL	0	NIL	0	6,75
23.5.77	CENTRE	5,25	78	0,75	11	0,75	11	NIL	0	NIL	0	6,75

Fig. 6—The standard daily analysis

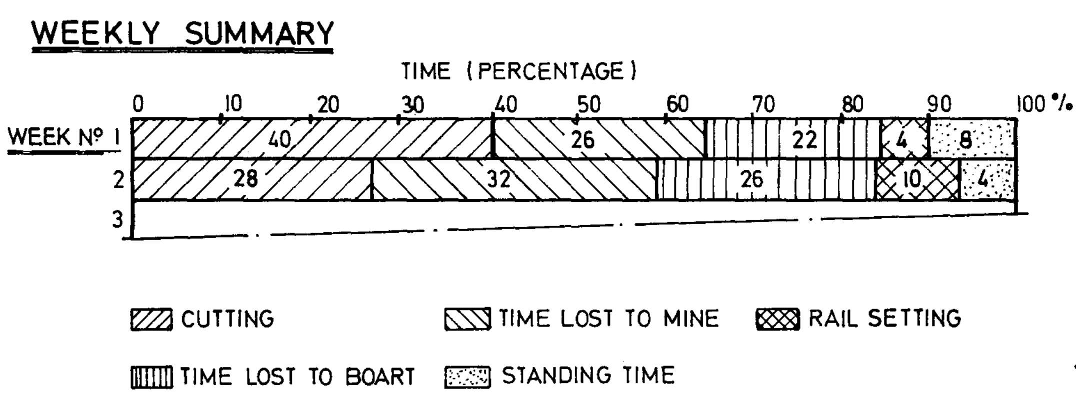

Fig. 7—The standard weekly summary

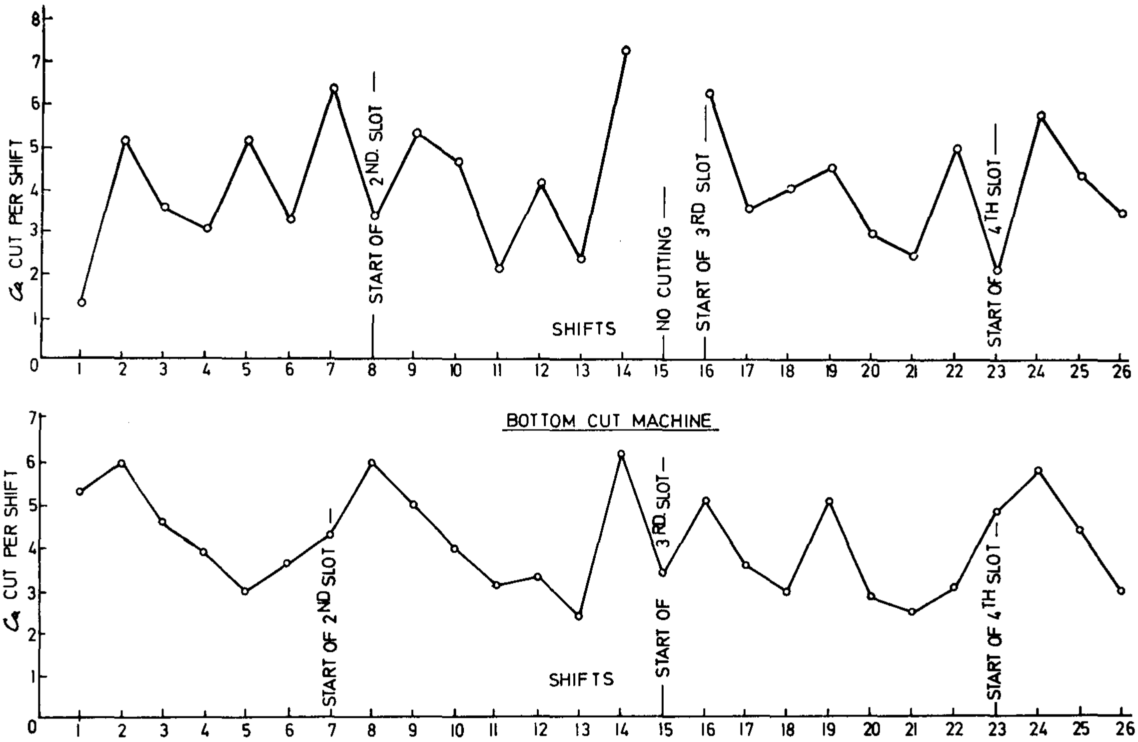

Fig. 8—Performance, in centares cut per shift, during pneumatic rockslotter trials

determine the mining rate possible in a gold mine during a measured month. Fig. 8 shows the daily performance obtained. At the end of the month, when 108 centares had been mined by a pair of pneumatic slotters, the test was terminated. The equipment should then have been handed over for normal mine operation if the performance was acceptable, or removed. However, there was no prior arrangement for the mine to take the equipment. The setting of the original objectives would make this point clear from the beginning.

If the equipment is to be left in the mine, then part of the performance appraisal should relate to the adequacy of the mine manpower and services to operate and support the equipment satisfactorily. It is clearly in no-one's interests, when good results have been obtained with expert outside help, for the mine to be left to train operators and so on. This training and manpower evaluation should be part of the original trial plan if the objective is for the machine to be left in the mine.

Conclusion

Careful and thorough planning of field trials is an essential prerequisite to success. The failure of many new ideas can be attributed to this simple fault, even if the mechanical aspects of the equipment are basically sound.

In summary, the essential steps are as follows.

(1) The establishment of the test objectives with a clear statement of completion targets.

(2) A thorough knowledge of the application by all concerned.

(3) Careful and detailed preparation.

(4) Accurate reporting to give information on which the development can be based.

(5) The establishment of a clear organizational structure to handle problems as they arise.

It has been found the hard way that progress and success can be influenced to a very great degree by these steps. All our trials are now planned through this route, and the results obtained have been most encouraging.

While these procedures may seem obvious, simple, and perhaps pedantic, observations of trial failures show that they are rarely followed. It is suggested that they are worth very serious consideration and application.

NIM reports

The following reports are available free of charge from the National Institute for Metallurgy, Private Bag X3015, Randburg, 2125 South Africa.

Report no. 1885

A data-logging system for a submerged-arc ferro-alloy furnace. (21st Nov., 1977).

The report describes a device that was constructed to monitor the inputs of real and reactive power to a submerged-arc furnace, together with the composite resistance of the furnace burden, the three electrode currents, and one electrode-to-electrode voltage.

The accuracy of measurement (analogue techniques were used) was within 3 per cent, and on repetition it was well within 1 per cent.

The device was housed in a stainless-steel refrigeration unit to maintain a constant internal ambient temperature and to protect the circuits from the corrosive and conductive atmosphere usually experienced in smelting shops.

Data recording was by a multi-point chart recorder, and details of the circuit realization are included.

Report no. 1939

An industrial microprocessor system. (12th Jan., 1978).

This report describes work done in 1974 to 1976 on the design and construction of an industrial microprocessor system capable of testing the limits and capabilities of microprocessors in the industrial process-control world. The system had to be capable of operating in a data-logging or in a control or supervisory capacity. It was intended to provide a low-cost reliable alternative to expensive process-control and data-logging systems based on minicomputers, which are under-utilized in many applications.

The system consists of a robust, electrically isolated unit designed on the 'black-box' principle with the minimum of operator controls. It is housed in a sealed crate with internal access by way of rows of input and output plugs and connectors. The system is modular so that it can easily be expanded. It can be operated as a small dedicated controller or expanded to its full capacity by the addition of memory or industrial input–output modules.

The system is based on the Intel 8080 microprocessor. The industrial interface consists of electrically isolated analogue and digital input and output modules, which can be selected under programme control. There are also up to 64 asynchronous priority-encoded alarm channels that can interrupt the control sequence at any time should an alarm condition arise. A plug-in front-panel unit is provided for the debugging of hardware and software.