A computerized labour-control system for Harmony Gold Mine

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SYNOPSIS

The Harmony Gold Mining Company Limited employs approximately 29 500 people, including 27 000 Black workers recruited from areas both within and beyond the boundaries of the Republic of South Africa. The problems arising from the control of this diverse and complex labour force have led to the need for a fully computerized labour control system.

This paper describes how, with the aid of an extensive interrelated network of satellite minicomputers, together with ancillary peripheral user terminals and printers, the management of Harmony Gold Mine intends to meet these problems.

SAMEVATTING

Die Harmony Gold Mining Company Limited het ongeveer 29 500 mense in diens waaronder 27 000 Swart werkers wat in gebiede binne en buite die grense van die Republiek van Suid-Afrika gewerf is. Die probleme wat ontstaan uit die beheer van hierdie uiteenlopende en ingewikkelde arbeidsmag het die behoefte aan 'n ten volle gerekenariseerde arbeidsbeheerstelsel geskep.

Hierdie referaat beskryf hoe die bestuur van die Harmony-goudmyn voornemens is om hierdie probleme die hoof te bied met behulp van 'n uitgebreide, onderling verbonde netwerk van satellietminirekenaars tesame met hulprandgebruikersterminale en -drukkers.

Introduction

The total lease area of the Harmony Gold Mine is 99,3 km², which is currently served by six surface and three underground service shafts, as well as three surface upcast ventilation shafts. A seventh twin-shaft system, Harmony Nos. 4 and 4A shafts, is now being sunk. Three metallurgical plants treat the 7800 kt of ore produced from 30 km of working stope face each year, and two workshop complexes maintain the equipment necessary for production.

To operate this vast undertaking requires a large work force, and Table I indicates how this has increased during the life of the mine. The increase in numbers has been accompanied by an enhancement in the sophistication of the Black workforce in terms of upgraded work categories, training, diversified pay scales, leave entitlements, unemployment, and death-benefit schemes, etc.

The effective management of this labour force has become more difficult with time, and it is the aim of this paper to outline how the management of Harmony intends addressing the problem of Black labour control by replacing the existing anachronistic manual system with a sophisticated computer-based system.

Diversification within Black Labour Force

Tables II and III give an indication of the magnitude of the labour-control problem.

TABLE I

NUMBER OF EMPLOYEES AT HARMONY GOLD MINE

Year		White employees	Black employees
1955		690	3 462
1965		1 212	10 734
1975		1 930	20 429
1983	Underground	1 248	22 000
	Surface	1 258	5 000
	Total	2 506	27 000

TABLE II

PLACES OF ORIGIN OF BLACK EMPLOYEES (JANUARY 1983)

Place of origin	Percentage of labour force
Lesotho	37
O.F.S./Lebowa, Qua Qua, Bophuthatswana/Botswana	18
Ciskei, Transkei, Cape	23
Mozambique	13
Malawi	8
Other	1
	100

Each of the 325 job categories shown in Table III has a fixed pay scale and leave entitlement, and variable fringe benefits. All the underground and many of the surface categories demand specific training requirements, dudec ratings, basic education standards, and specific physical-capacity ratings. Certain categories of labour qualify for membership of an unemployment insurance fund, while participation in death, sickness, accident, and convalescent benefit funds is compulsory. Certain senior underground categories qualify for acting allowances, special shift allowances are paid to 'cycle of shift' workers, and a few underground labour categories receive production bonuses.

The two training centres on the mine conduct seventeen courses for underground employees and six for artisan aides. Further, courses in elementary, intermediate, and advanced literacy and numeracy, as well as basic business economics, are available to selected senior personnel. When all the possible permutations are considered against the stark fact that the total labour force turns over once in every fifteen months, the magnitude of labour control at Harmony becomes apparent.

Motivation for a Computerized System

The efficient and effective management of this complex labour force requires dynamic data acquisition, processing, storage, and retrieval facilities, all of which are

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TABLE III

JOB CATEGORIES RELATED TO PAY CYCLES

Item	Underground			Surface				Totals
	Weekly		Monthly	Daily	Weekly		Monthly	
Shifts per fortnight	11	12			11	12		
Job categories (male)	84	7	11	—	58	73	61	294
Job categories (female)	—	—	—	23	—	—	8	31
	84	7	11	23	58	73	69	325

lacking in the existing manual system. The present system has not changed significantly since Harmony started production nearly thirty years ago. Paperwork overloads the system, and the compilation of accurate and meaningful reports and statistics is onerous and extremely time-consuming; in addition, unintentional, and often intentional, corruption of data is unfortunately prevalent. These factors have tended to relegate the function of the Personnel Officer at the shafts to that of a 'numbers man', leaving little time for personal contact with the labour force. This situation, which conflicts with the Group's code of employment practice, has resulted in a high turnover of personnel officials and a deterioration in the calibre of persons willing to embark on careers in this field.

It is expected that, once the projected computerized system has been introduced, most, if not all, of the shortcomings inherent in the manual system will be eliminated.

Advantages of the Projected System

Time and Attendance

The accurate recording of time and attendance so that the data can be analysed expeditiously will have the following benefits.

(1) The incidence of undetected absenteeism and fraudulent shifts will be reduced.
(2) The control of overtime, both paid and unpaid, will improve.
(3) The volume of paperflow that overloads the present data-collection system will be reduced.
(4) Information security in such areas as wage and overtime control, data on individual employees, and the submission of critical wage data to the payroll system will be enhanced.

Control of Labour

By virtue of its inherent capabilities to retrieve and manipulate data, it is envisaged that the proposed system will:

(a) improve the utilization and control of the company's labour force,
(b) provide more accurate and timeous information concerning mine labour strengths, gang control, manning control, and individual employees,
(c) improve facilities for the retrieval and reporting of labour information,
(d) provide much critical statistical information that is currently not available from the manual system,
(e) reduce current labour costs through the correct utilization of the four facilities discussed above.

Planning of Manpower

Because of the ability of the system to retrieve and collate statistical information accurately and expeditiously from the vast volume of stored data, it will enable management to

(i) predict all categories of labour leaving the mine at any time,
(ii) forecast all categories of labour due to return to the mine on specified dates,
(iii) extract up-to-date information pertaining to the current status of the labour force on the mine,
(iv) combine all three of the above facilities to plan the composition of the labour force,
(v) effectively recruit by skills needed rather than by bulk numbers.

Thus, in general the system will provide a powerful means by which management will be allowed to anticipate current and future situations while, at the same time releasing staff of the Personnel Department from the clerical duties inherent in the current manual system to concentrate their efforts in the field of personnel management.

Project Guidelines and Control

Following the publication in 1979 of a paper by Harrison[1], the Technical Services Department at Harmony Gold Mine established a project team to examine the feasibility of introducing a computerized labour-control system on the mine. Numerous existing and developing systems were examined and evaluated in terms of what were considered to be the requirements of the Harmony company. The systems examined ranged from basic time- and attendance-recording packages to the highly sophisticated Anglo American Corporation's HURIS[2] system. Following a lengthy investigation involving the project team, senior mine management, all the potential users, Head Office personnel consultants, managements of other gold mines in the group and computer personnel from Rand Mines Head Office and Barlow Rand Computer Services, the following guidelines were established.

(1) Initially, Harmony would introduce an extended time and attendance system to be known as EXTAS incorporating advanced manning control and limited manpower-planning facilities. Subsequent phases of the project would involve a direct payroll interface with the IBM 4341 series computer at present operating on the mine, and ultimately a total human-resources facility similarly linked to the IBM mainframe.
(2) The system would be structured in a modular format so that other mines in the Group could

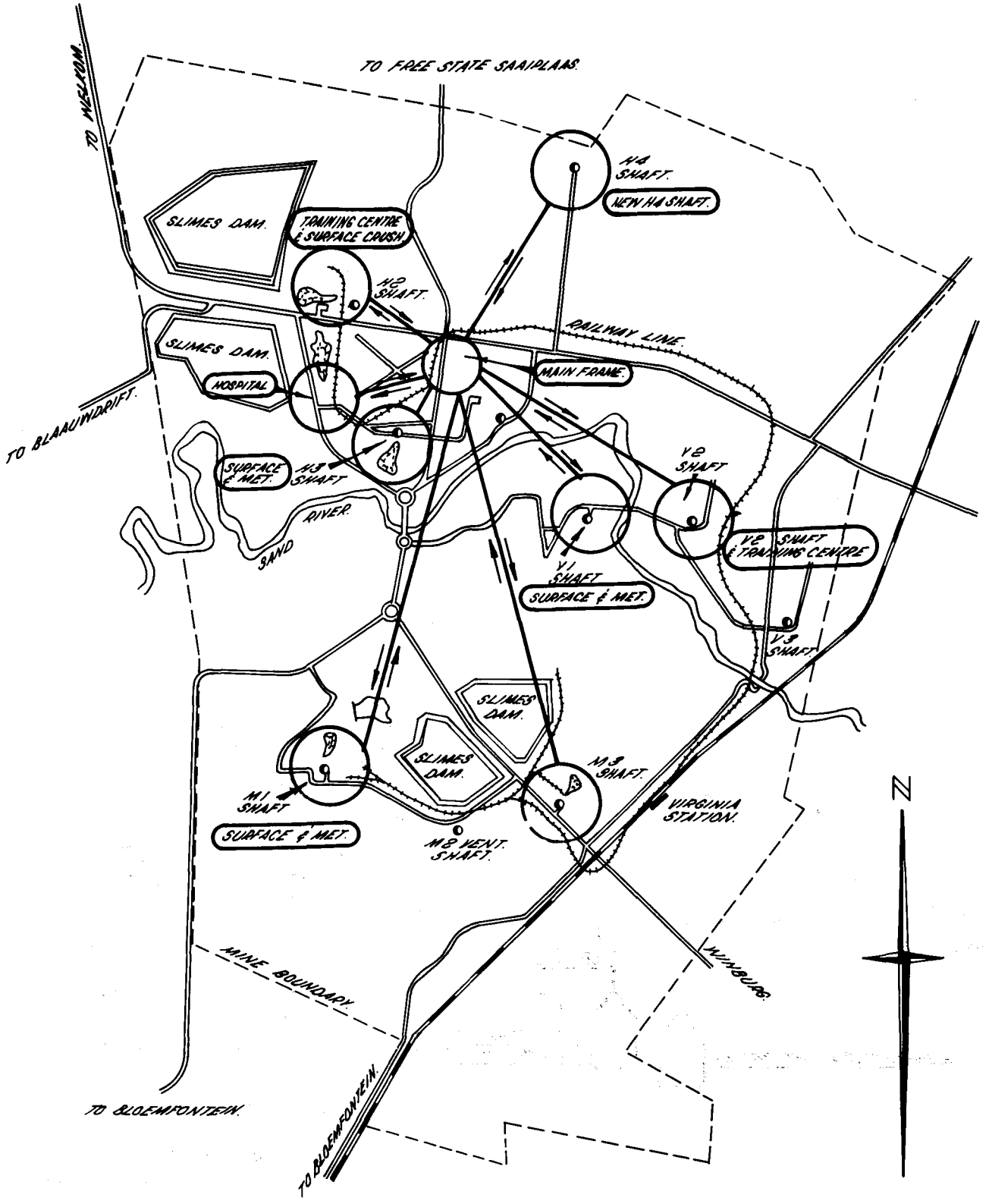

Fig. 1—EXTAS network at Harmony Gold Mine

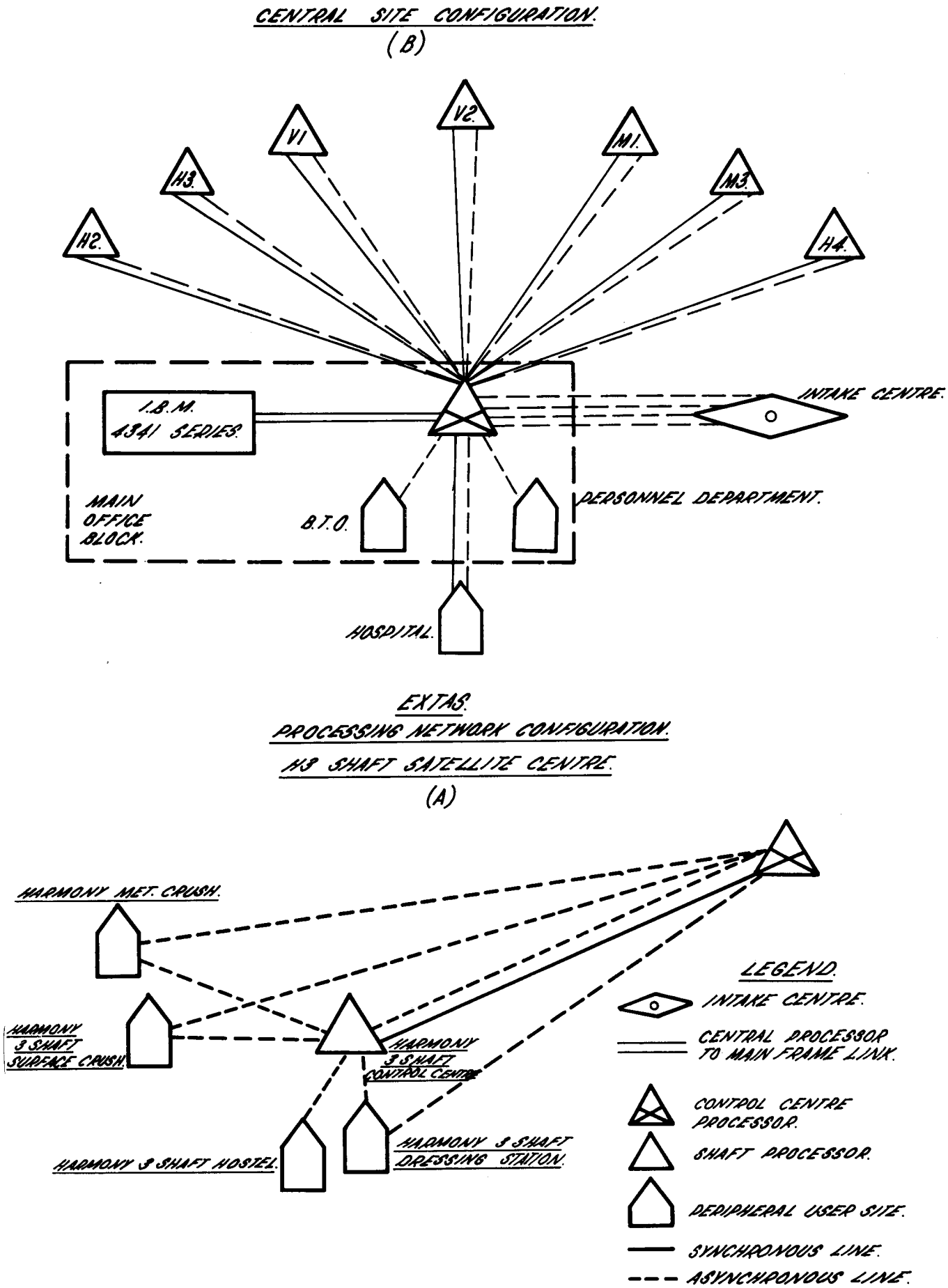

Fig. 2—Layouts for the control centre and for a satellite centre

implement some or all of the suite of programs in accordance with their own needs.

(3) The system would be designed, structured, and programmed from first principles, i.e. tailored for Harmony's needs without recourse to existing packages.

(4) A project management committee would be established consisting of senior personnel from Harmony, Rand Mines Head Office, Barlow Rand Computer Services, the project leader, and representatives from Perseus Computing and Automation (Pty) Ltd — the selected vendor. It would be the function of this committee to formulate policies and monitor progress.

(5) All phases of the project plan incorporating definition and compilation of the functional, technical, testing, and implementation specifications would be comprehensively discussed with all user centres, and would have to be accepted by them in writing before the next phase of the plan was initiated.

By the adoption of the above approach, it was envisaged that all technical and administrative aspects of the complex project would be examined rigorously, thus ensuring an orderly introduction of the system into the highly sensitive fields of labour control and personnel management.

Configuration of the Network

The planned configuration conforms to a typical distributed processing network involving a control processing centre and six satellite processing centres, one at each of the service shafts on the property. When the Harmony No. 4 shaft system has been commissioned, an additional satellite centre will augment the network. Each of the satellite centres will communicate with the control centre, as well as with one another, via the control processor.

Fig. 1 illustrates the planned geographical distribution of the proposed network, and Fig. 2(A) depicts a more detailed layout for a typical satellite centre, namely that envisaged for Harmony No. 3 shaft. Similarly, Fig. 2(B) illustrates the layout for the control centre. Here, the processor will be housed in the same building as the present IBM 4341 series mainframe computer, into which data will be transmitted once the payroll and human-resources components of the project are implemented (Fig. 3).

As shown in Fig. 2, each of the processing centres incorporates an array of peripheral user sites for communicating data to the network and retrieving information from it. The satellite centre illustrated will be equipped as indicated in Table IV.

The Virginia No. 2 and Merriespruit No. 1 shafts will be equipped similarly, but those at Harmony No. 2, Virginia No. 1, and Merriespruit No. 2 shaft will differ because these three centres do not have workshops and metallurgical plants and there are training establishments at two of them.

The transmission of data between the satellite and the control processors will be via synchronous lines, and asynchronous lines will link the peripheral user sites to the satellite as well as to the control processors. The

Fig. 3—The processor at the control centre with the IBM 4341 mainframe in the background

object of this arrangement is to obviate any disruption to data capture should the satellite processor shut down for any reason. For example, if this were to occur while employees were clocking on or off shift, the data would automatically be channelled to the control centre and later retrieved once the faulty processor was operating again.

All the satellite centres will operate on an uninterrupted power supply provided by a bank of batteries that will be continuously on charge from the mains. The reasons for this are twofold: firstly, should a total power failure occur, the system can continue to run for approximately two hours by which time, except under very unusual circumstances, the power supply will have been restored; secondly, the arrangement of batteries will act as a power conditioner by eliminating peaks and troughs in the direct mains supply to which the processors have proved to be extremely sensitive.

The peripheral user sites at the Hospital and the Intake Centre will be linked directly to the control centre, independently of any satellite centre, via asynchronous lines as are the Time Office and the Personnel Department, which are situated in the main office block.

The estimated hardware required to equip the entire network is listed in Table V.

The processors installed at the satellite centres will be Data General NOVA 4 computers with a processing

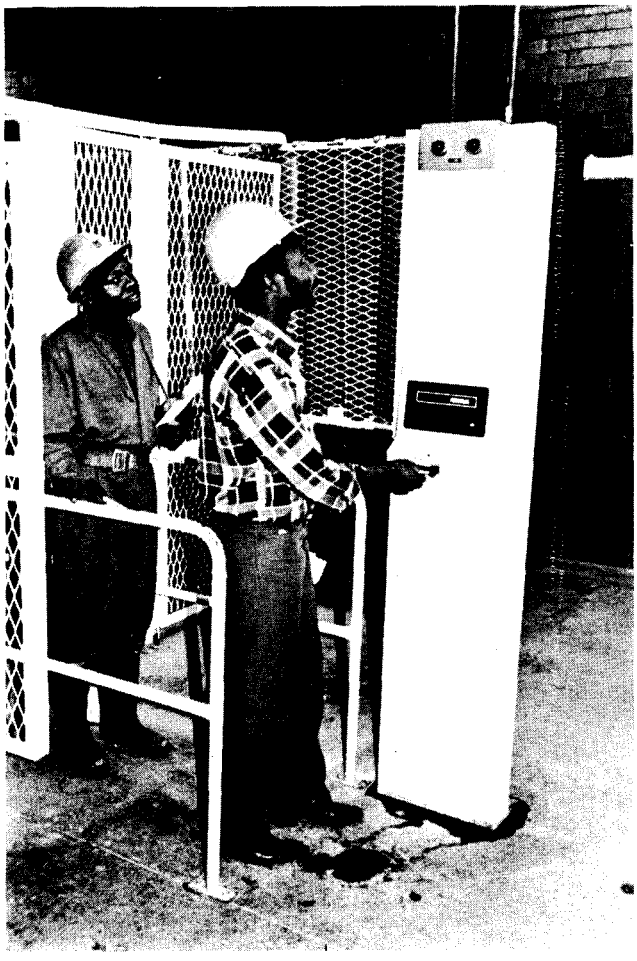

Fig. 4—An employee clocking off shift at a badge reader

power of 256 kilobytes and a storage capacity of 12,5 megabytes capable of being enhanced to 25 megabytes. Additional storage is provided in the form of a 1,26-megabyte diskette. A similar computer is installed at the control centre with identical processing power but with the storage capacity increased to 96 megabytes and additional storage provided by a 46-megabyte tape unit.

At the Intake Centre, where all new and returning employees will report on arrival at the mine, a microprocessor will be installed. No decision has yet been made as to the precise specifications for this unit.

Recording of Time and Attendance

All Black employees are to be issued with a 'badge' in the form of a plastic laminated card measuring 82 mm by 70 mm that displays a photograph of the person concerned, his name, and employee number, both in normal print and punched according to the Hollerith coding format.

On arriving at the Crush *en route* to the place of work, the underground employee removes his work ticket from the appropriate section rack and proceeds to one of the badge readers allocated to his particular shift type, where the badge is inserted (Fig. 4). If the green light is displayed above the badge reader, the employee proceeds to the lamp rack, removes his lamp, and hangs the badge on the hook above the lamp position and proceeds to the shaft. On arrival at the underground working place, he hands his work ticket to the Team Leader for checking against the gang sheet later during the shift.

Should a red light be displayed on insertion of the badge, the employee proceeds to the enquiries office, where his master file is interrogated on the visual display unit to ascertain what special instructions must be given for one reason or another. Should these instructions still permit the employee to go underground, his file is amended accordingly and he returns to the badge reader, which will now accept the badge and display a green light.

At the end of the shift, the process is simply reversed. The employee collects the work ticket, proceeds to surface, replaces his lamp, removes the badge, and clocks out, and replaces the work ticket in the card rack. Again, should a red light be displayed when the employee inserts the badge, he must report to the enquiries office before leaving the Crush.

For a surface employee, the procedure is very similar except that a lamp is not drawn and the employee merely retains his badge during the shift.

In general, the supervisor goes on shift after the workforce has clocked through the Crush, by which time the computer has printed the gang sheet depicting the current attendance status of the gang. The supervisor takes this sheet to the place of work, where he checks it against the work tickets handed in by the employees as described above. Any anomalies detected during this cross-check are investigated at the end of the shift.

Retrieval and Reporting of Data

Data are retrieved from the system either in the form of structured reports or via a facility known as EASY, which is described later.

To demonstrate the power of the EXTAS system and to illustrate how effective the system will be in replacing its manual predecessor, a comprehensive list is given

TABLE IV

HARDWARE FOR THE H3 SATELLITE CENTRE

Location	Processor	30 c.p.m. printer	300 l.p.m. printer	V.D.U.'s	Badge readers
Crush (underground)	1		1	3	10
Hostel		1		2	1
Workshops		1		1	2
Metallurgical Plant		1		1	2
Totals	1	3	1	7	15

TABLE V

HARDWARE INVENTORY FOR THE TOTAL NETWORK

Site	Processor	30 c.p.m. printer	300 l.p.m. printer	V.D.U.'s	Badge readers
D. P. Centre	1		1	2	
Time Office		1		1	
Personnel Department		1		1	
On-site Spares	1	1	1	8	8
H2 Shaft	1	2	1	6	17
H3 Shaft	1	3	1	7	15
H4 Shaft	1	1	1	5	12
V1 Shaft	1	3	1	7	13
V2 Shaft	1	2	1	7	12
M1 Shaft	1	2	1	6	13
M3 Shaft	1	1	1	5	12
Hospital		1		1	
Intake Centre	1	1		3	
Totals	10	19	9	59	102

below of the structured reports that can be compiled and printed on request. It must be realized that, when assembled manually, many of these reports require days, and even weeks of examining records etc., by which time the information derived is often out of date. Further, among these reports are several that cannot be compiled on the existing system.

The words 'by section' in the following list imply that the report will be compiled in response to a section code that is fed into the computer, e.g. N2 section manager (N), N2B underground manager (B), N2BA mine overseer (A), N2BAA shift boss (A), N2BAϕ1 gang (ϕ1) etc.

1. Employee master files. These can be accessed either by means of the employee's company number or lamp number.
2. Absentee reports – three variations:
   - 2.1 Current absentees.
   - 2.2 Consecutively absent employees.
   - 2.3 Consistently absent employees.
3. Abnormal-shift reports – three variations:
   - 3.1 Long shifts worked.
   - 3.2 Short shifts worked.
   - 3.3 Incorrect shifts worked.
4. Report on miscellaneous persons clocked in.
5. Overtime-discrepancy reports – two variations:
   - 5.1 By shift type, i.e. morning, afternoon, night, etc.
   - 5.2 By section.
6. Report on all outstanding gang sheets.
7. Overtime-audit report.
8. Shift-clear reports – three variations:
   - 8.1 By individual gangs
   - 8.2 By sections.
   - 8.3 Clear-of-blast employees, i.e. those persons who have not clocked out from underground but are working in areas not affected by blasting.
9. Lamp file reports – three variations:
   - 9.1 Lamp number versus employee's company number.
   - 9.2 Employee's company number versus lamp number.
   - 9.3 New allocations and re-allocations register.
10. Gang/section labour-summary reports – three variations:
    - 10.1 Gang-status report, i.e. details of any individual gang.
    - 10.2 Section labour-status report.
    - 10.3 Section labour-summary report.
11. Labour-situation report, i.e. strengths versus complements per job category.
12. Misplaced labour-qualifications reports – five variations:
    - 12.1 Misplaced labour per section.
    - 12.2 Over-complement labour per section.
    - 12.3 Misplaced qualifications per section.
    - 12.4 Incorrect eleven- or twelve-shift fortnight categories.
    - 12.5 Incorrect education, physical-capacity rating, or dudec rating for work being performed.
13. Acting-in-an-alternative-capacity report.
14. Contract expiry and extension reports – two variations:
    - 14.1 Actual contract-expiry information.
    - 14.2 Volunteered contract-expiry information.
15. Expected-return labour report.
16. Returnee statistical reports – two variations:
    - 16.1 Historical statistics.
    - 16.2 Returnee statistics, i.e. by job code or section.
17. Anticipated-return labour report – two variations:
    - 17.1 Summary of persons at home and date returning.
    - 17.2 Individual employee enquiry report.
18. All labour-in-training report.
19. Employee's training-centre progress and results report.
20. Payroll reports – altogether twenty-four of these reports are available covering all payroll returns, audits, etc.
21. Drilling-bonus report.
22. Maximum-pay-discrepancy report.
23. Hostel-register reports – three variations:
    - 23.1 Room lists per hostel section.
    - 23.2 Individual room lists.
    - 23.3 Absent without permission/leave/sick/in-training-room list per room per hostel.
24. Hospital reports – three variations:
    - 24.1 Current admissions.

24.2 Bed/ward/illness register.
24.3 International code/illness register.

25. Convalescent-register report.
26. Program-usage log report – there are several variations of this report giving information concerning details involving program usage, reports issued, etc.

EASY (English, Afrikaans SYmbolic language) is a high-level, user-oriented on-line language that can be used to access, create, or modify information in the database. In general, it is used as an *ad hoc* reporting facility in instances where a structured program does not exist. Since it can also be used to amend data on file, it is possible to access the database only once the user has been identified by means of a unique password, as is the case with all programs on the EXTAS system. This ensures security against any wilful corruption of data since any one password will permit access only to specified areas of the database.

Conclusions

At the time this paper was compiled, the control centre and the Harmony No. 2 shaft satellite centre, together with its associated peripheral user sites, were up and running. Although many problems have been encountered, management is confident that, once the system has been implemented throughout the mine, the term 'labour control' will have a totally different connotation from that at present, and that the objectives defined for the project will be fully realized, so justifying the considerable expense involved.

Acknowledgements

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War on Wear

The Institution of Mechanical Engineers is to hold an international conference on 'Tribology in Mineral Extraction: War on Wear' in Nottingham from 17th to 19th September, 1984.

Mineral extraction, whether coal or ores, and the machinery employed are subjected to very hostile conditions of operation. These conditions cause great damage to interacting surfaces in relative motion. Much valuable time is lost because of abrasion and wear, and further, often unnecessary, costs are incurred through avoidable maintenance and repair. Yet tribological solutions to this pointless waste of resources, energy, and production are often already well-known in universities, in research laboratories, and in pockets within the industry. The purpose of this Conference will be to identify the problems and to demonstrate solutions, or methods leading to solutions of these problems.

The Conference will consider the application of tribology to mining, mineral extraction, and primary processing.

Papers are invited on the following topics:

Mineral removal — methods, equipment, materials
Mineral transport and preparation — conveyors, chutes, bunkers, washing plant
Machinery design — pumps, motors, gear transmissions, seals, bearings, lubricants, fire-resistant lubricants and hydraulic fluids
Health and safety aspects — incendive sparking, manriding, etc.
Machine reliability — problems, failures, condition monitoring
Case studies — solution of problems by application of tribological principles
Plant operation — environmental factors.

Synopses of papers, comprising up to 250 words, should be sent to Trevor Hebden at The Institution of Mechanical Engineers. Papers are expected to be in the region of 4000 words, but shorter papers on particular case studies will be most welcome. The address is as follows: Conference Department, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW1H9JJ, England.