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Modifications to the coal-preparation circuit at the Grootegeluk Coal Mine to improve its efficiency*

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SYNOPSIS

A strong incentive exists for the coal-preparation engineer to improve plant efficiency by modifying circuits and upgrading process equipment, since these result in lower production costs and more valuable plant products.

At the Grootegeluk Coal Mine, it was found that the overall plant efficiency could be improved by modifications to the dense-medium circuits, the installation of additional process equipment for the recovery of fine coal, and improvement of the fine-material processing circuit.

Apart from these modifications, there is still potential to increase the plant efficiency, particularly in the utilization of plant waste, the recovery of slimes, and even the improvement of cycloning performance as a result of new cyclone design.

This paper points to the potential wealth locked up in existing coal-preparation plants, and shows how the coal-preparation engineer, with new technology at his disposal, can unlock this wealth.

SAMEVATTING

Daar bestaan 'n sterk aansporing vir die steenkoolvoorbereidingsingenieur om aanlegdoeltreffendhede te verhoog deur 'n wysiging van vloeilyne en opgradering van prosestoerusting aangesien dit kan lei tot laer produksie kostes en meer kompeterende steenkoolprodukte.

Daar is by die Grootegeluk-steenkoolmyn gevind dat die doeltreffendheid van die hele aanleg verbeter kon word deur wysigings van die digtemediumkringe, die installering van bykomende prosestoerusting vir die herwinning van fynsteenkool en die verbetering van die verwerkingskring vir die fynmateriaal.

Afgesien van hierdie wysigings is daar nog die moontlikheid vir die verhoging van aanlegdoeltreffendheid, veral wat die benutting van aanlegafval, die herwinning van slik, en selfs die verbetering van digte medium siklone se werkverrigting deur die toepasssing van nuwe sikloon ontwerpe.

Hierdie referaat wys op die moontlike rykdom wat in die bestaande steenkoolvoorbereidings aanlegte opgesluit is en toon hoe die steenkoolvoorbereidingsingenieur, met die nuwe tegnologie tot sy beskikking, hierdie rykdom kan ontsluit.

INTRODUCTION

Background

The Grootegeluk Coal Mine is situated on the Waterberg coalfield and started production in 1980, primarily to produce coking coal for Iscor's steelworks. A middlings product arising from the two-stage washing process is also produced. The availability of this product, which is suitable for the generation of steam, led to an Iscor tender for the supply of coal to an Eskom power station. Eskom accepted Iscor's tender and established the Matimba power station. This power station was planned to generate some 3600 MW at full production (towards the end of 1991).

The establishment of the Matimba power station required additional production facilities, since the production from the existing plant was 4 Mt of steam coal per annum, while 12 Mt per annum would be required towards the end of 1991. This tonnage would be supplied from three separate sources with the installed capacities as shown in Table I.

As a result of the positive results obtained with Grootegeluk's blend coking coal in Iscor's blast furnaces, the Mine's production of that coal was increased from the design tonnage of 35 kt per week to a current level of 38 kt per week. The production was increased further to 40 kt per week from 1990 following the installation of a spiral plant to beneficiate the fine-coal fraction (larger than 300 μm).

TABLE I
Facilities for coal production

Plant	Run-of-mine production t/h	Annual production of coking coal Mt	Annual production of steam coal Mt	Description
Grootegeluk 1	3300	1,98	4,0	2-stage washing
Grootegeluk Eskom	2200	–	3,5	1-stage washing
Pit bottom	1100	–	4,5	Crushing and screening
Total	6600	1,98	12,0	

To utilize the Waterberg coalfield to its full potential, it was necessary to continuously explore the potential of the existing Grootegeluk 1 plant in order to obtain increased efficiencies, a higher throughput, and lower costs for the final products. This paper describes how process modifications contributed to the above-mentioned needs.

Grootegeluk 1 Plant

The Grootegeluk 1 Plant is a two-stage washing plant that produces 1,98 Mt of coking coal and 4,0 Mt of steam

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coal annually. The plant, designed to handle 3300 t of run-of-mine coal per hour, consists of various modular sections to ensure high overall maintenance availability and utilization. The major elements of the plant in 1989 were as follows:

- three primary breaking and screening modules, each having a design capacity of 1100 t of run-of-mine coal per hour
- five primary cyclone modules with a rated capacity of 270 t/h each, the average cutpoint in this section being 1,8 g/cm³
- five primary Teska modules with a rated capacity of 480 t/h each, the average cutpoint in this section being 1,8 g/cm³
- five secondary cyclone modules with a rated capacity of 240 t/h each, the cutpoint in this section varying between 1,30 and 1,38 g/cm³
- five flotation modules with a rated capacity of 95 t/h each
- two 70 m diameter thickeners feeding the flotation section of the plant
- two 50 m diameter tailings thickeners
- five screen-bowl centrifuges for the dewatering of fine coking coal
- two 81 m² horizontal-belt filters for the dewatering of fine steam coal.

A schematic flowsheet of the Grootegeluk 1 Plant at that time is shown in Fig. 1.

MODIFICATIONS TO THE DENSE-MEDIUM CIRCUIT

Drum Plant

The original dense-medium circuit made use of the well-known overdense system, which allowed operating personnel to control the density in the circulating cone by adding either dilution water or overdense medium directly into the circulating cone. This layout is shown in Fig. 2.

The problems encountered with this design were as follows:

- fluctuating bleed-off from the circulating circuit to the dilute circuit (a bleed-off is required to obtain dense medium)
- slow reaction to the adjustment of density setpoints as a result of the large volumes treated in the circulating cone
- unreliable automatic control valves, resulting in plant downtime
- sporadic overloading of the dilute circuit, leading to a high consumption of magnetite
- high wear rates and energy consumption to keep the overdense medium suspended in the overdense tanks.

As a result of these problems, the overdense system was removed and the circulating cone was operated as an overdense unit while dilution water was added in the suction line of the circulating cone. Furthermore, provision was made for a constant bleed-off from the circulating

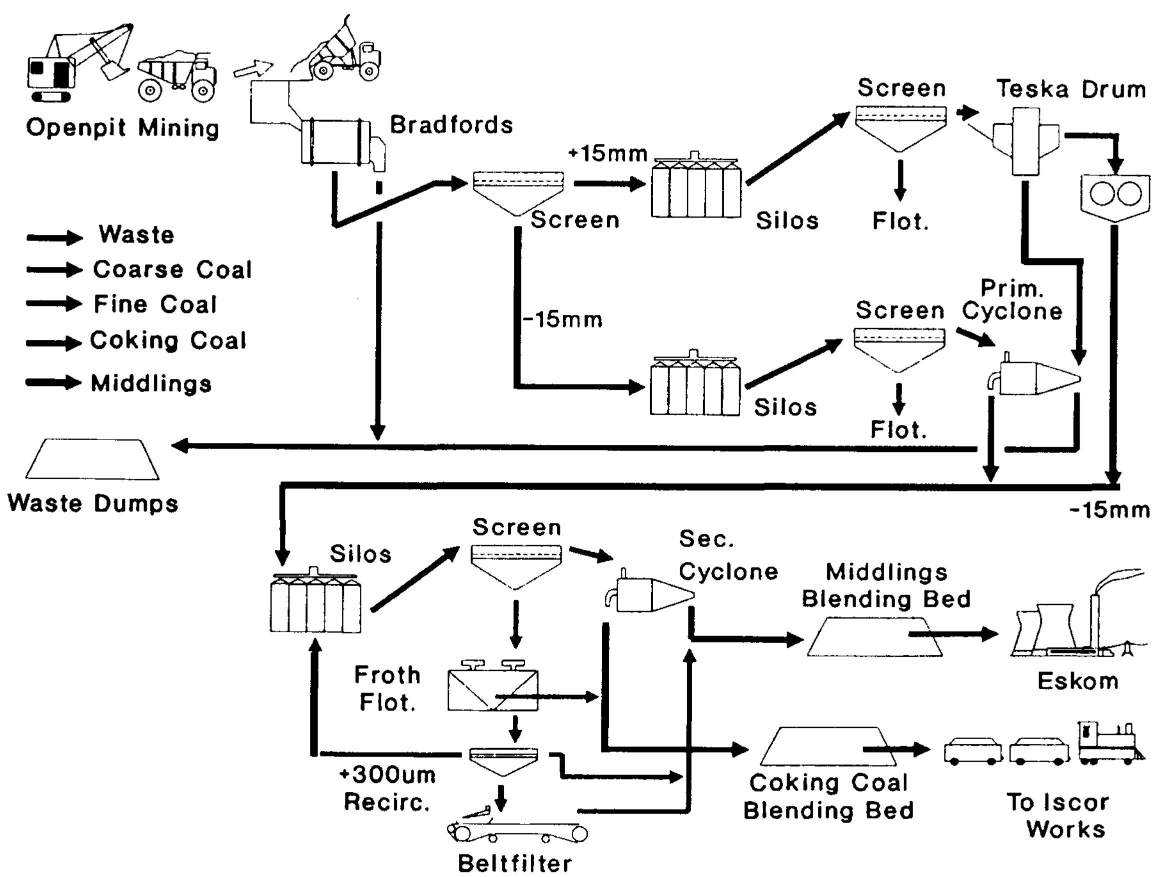

Fig. 1—Flowsheet of the coal-preparation plant at Grootegeluk 1

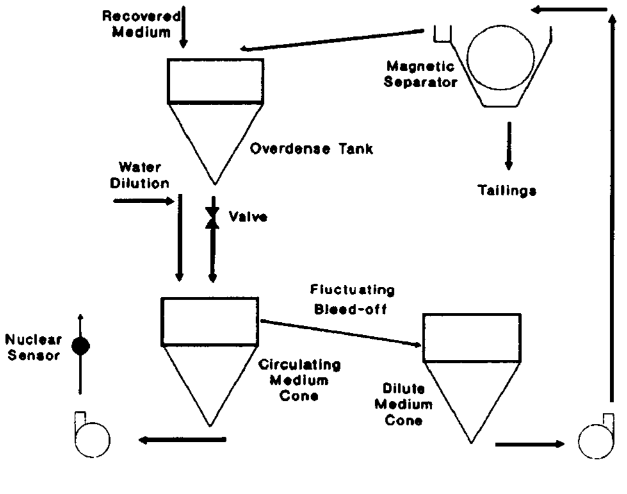

Fig. 2—Original circulating-medium circuit

circuit to the dilute system, thereby ensuring constant magnetite loading of the dilute circuit. This also ensured sufficient overdense medium for the plant operators to control the circulating density at a minimum relative density of 1,8.

A typical flowline illustrating the above-mentioned changes is shown in Fig. 3.

The following were the main advantages resulting from these changes:

- removal of the automated valves on the overdense tanks, thus resulting in a saving on maintenance costs while decreasing the plant downtime
- decreased consumption of magnetite
- stable operating conditions
- improved reaction time to adjustments of density setpoints
- increased plant efficiency as a result of stable operating conditions.

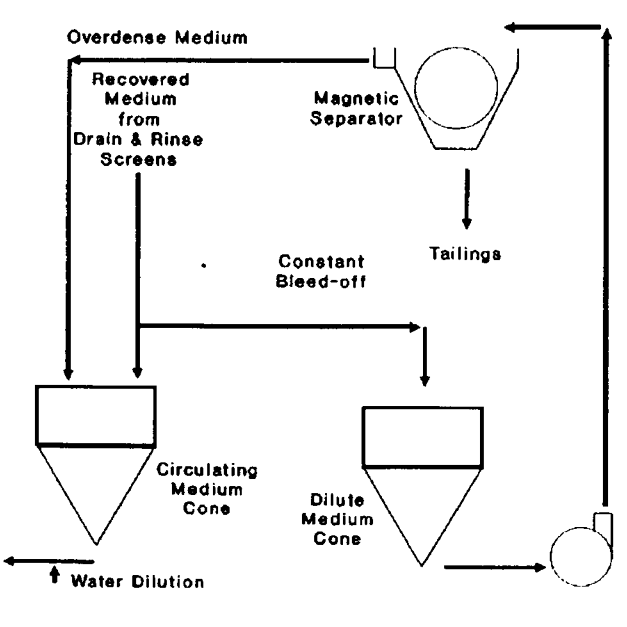

Fig. 3—Modified circulating-medium circuit

Cyclone Plant

A relative density of 1,8 had been envisaged for the circulating medium in the original cyclone-plant design. Owing to insufficient capacity of the magnetic separators and increased production demands on the cyclone plant, this circulating density was difficult to maintain. Apart from these problems, suitable steam coal could be recovered by washing at higher densities, thus also improving the Mine's problem with the spontaneous combustion of plant waste. Two possible solutions to this problem were investigated: to improve the performance of the magnetic separation, and to use centrifugal densifiers.

The conventional type of magnetic separator was found to recover magnetite concentrate at a relative density between 2,05 and 2,1, thus severely restricting the densifying capacity of these units and therefore requiring multiple units for the plant operators to separate at a cut-point of, say, 1,95 g/cm^3.

The Mine investigated the possibility of upgrading the existing magnetic separators with respect to the field strength of the existing magnets, the rotational speed of the recovery drum, the tank design, and the mounting position of the drum in relation to the tank.

Although the existing units appeared to have limited potential, such upgrading could still be viable with a new generation of magnetic separators. Testwork had shown that these units are capable of producing a magnetite concentrate with a relative density of up to 2,6, while non-magnetic contamination of the concentrate is also less. However, at that stage the replacement of the existing units with new-generation magnetic separators did not seem to be economically viable.

The use of centrifugal densifiers is well known to the diamond and iron-ore industries, but the coal industry has not shown much interest in these units since the separating densities are relatively low, below 1,7. These units were tested at the Grootegeluk Coal Mine for a period of 10 months, and were shown to warrant permanent installation. The separating density on the cyclone plant could be increased to 1,95, while no serious problems were identified with the cycloning efficiency. Owing to space and capital restrictions, these units were fed from a static-head box. A typical installation is shown schematically in Fig. 4.

Although this layout did not allow for variation of the inlet pressure on the units, the installation was expected to yield the required results, and the performance could still be optimized by changes in the dimensions of the inlet, and in the diameters of the vortex finder and spigot. Some typical operating results are shown in Table II, while the effects of changes to the dimensions of the vortex finder are shown in Fig. 5.

The benefits realized from the installation of these densifiers are shown in Fig. 6. This washability curve shows that operation at a higher density increased the mass yield from 50,0 to 58,3 per cent, while the ash in the concentrate increased from 18,2 to 22,0 per cent.

The curves for two Tromp cutpoints shown in Fig. 7 clearly indicate that no dramatic drop in efficiency occurs at the higher densities. Further testwork planned for this

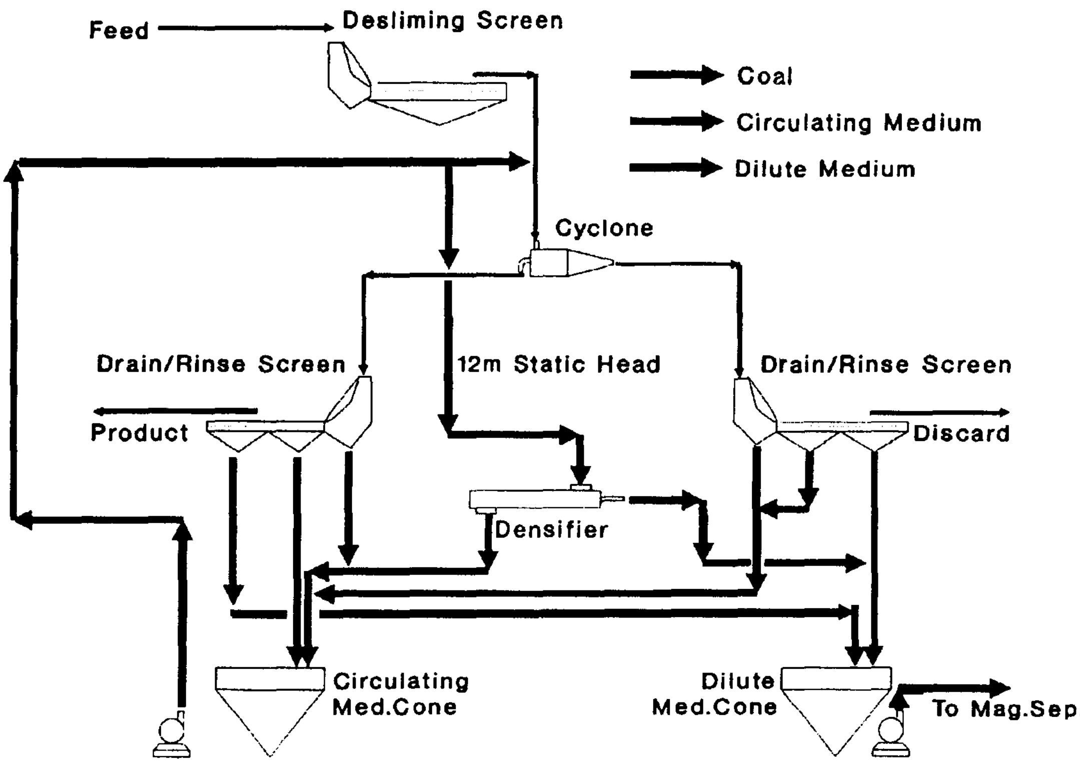

Fig. 4—A typical centrifugal-densification circuit

TABLE II
Typical desnsifier operating results

Circ. medium r.d.	Densifier Overflow r.d.	Densifier Underflow r.d.	Densifier Overflow % Non-mag	Densifier Underflow % Non-mag
1,68	1,40	1,85	7,96	6,35
1,82	1,54	2,04	7,19	5,93
1,88	1,63	2,06	8,09	6,31

Circ. medium r.d.	Tromp cutpoint	Calc. yield, %	Organic effic., %	Epm	Circ. med. % non-mag
1,68	1,66	40,1	97,4	0,013	7,71
1,82	1,76	52,1	98,9	0,010	6,20
1,88	1,85	55,7	99,5	0,014	7,31

installation included the optimization of the magnetite grading and the removal of non-magnetic material from the concentrate. Non-magnetic material was known to be removed, but its extent and effect on the quality of the circulating medium still had to be quantified.

BENEFICIATION OF FINE COAL

Froth Flotation

The original design of the Grootegeluk Coal Mine allowed for the treatment of the fraction smaller than 850 μm by froth flotation. Although various other alternatives were investigated during the pre-design phase, froth flotation was the only process capable of producing an ash content of 10,5 per cent in the final concentrate.

In practice, however, the froth-flotation plant never met the design criteria, and various projects were undertaken in attempts to rectify the problems. These included modifications to the primary distributor, conversion of the air blowers to constant-pressure units, improved efficiency of the guard screens to minimize the amount of material larger than 850 μm in the feed, and the testing of various flotation reagents. All these modifications led to a marked improvement in the froth flotation of the fraction smaller than 300 μm, but the performance on the fraction larger than 300 μm was still unacceptable.

While investigations were being conducted to find ways of improving the efficiency on the larger-particle fraction, this fraction of the tailings was recirculated to the secondary-cyclone section in order to recover some of the coking coal it contained. A schematic representation of this modification is shown in Fig. 8, and its effect on the overall plant efficiency is shown in Table III. Despite some problems with recirculating loads, this modification led to better plant efficiency.

Spiral Beneficiation

Following the development of spirals for beneficiation of the fine coal, test units were installed at the Grootegeluk Coal Mine to beneficiate the fraction between 850 and 300 μm. Although it was not possible to produce a final product with an ash content of less than 12 per cent, the tests showed that the overall plant efficiency could be improved markedly, while a substantial saving in flotation reagents could be realized. Furthermore, the tests demonstrated that the higher efficiency of the spirals could be achieved consistently, while this was not possible with the froth flotation, where the plant performance fluctuated fairly

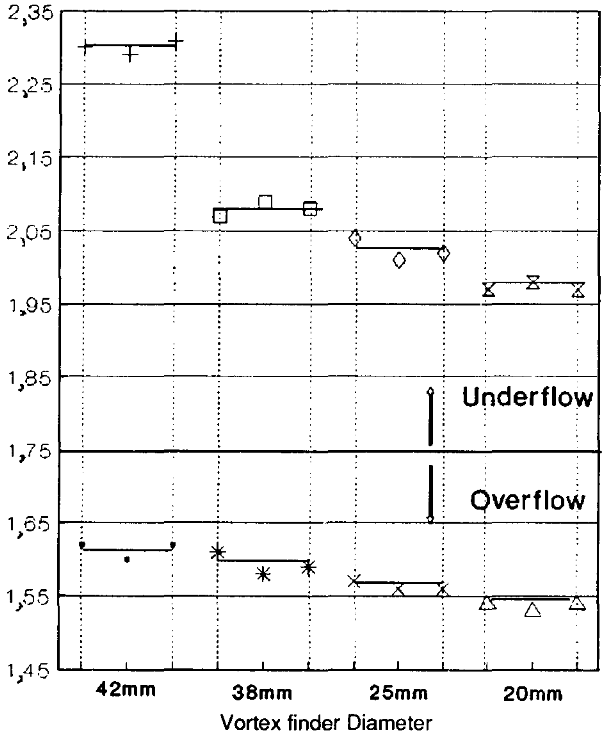

Fig. 5—Operating results with different densifiers at a feed relative density of 1,75

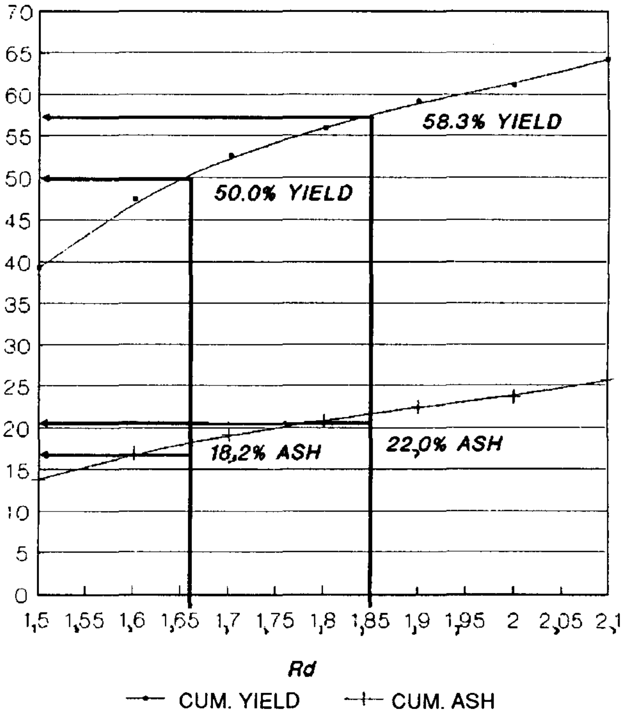

Fig. 6—Washability curves at different relative densities

TABLE III
Effect of recirculation on the fraction larger than 300 μm on plant performance

	Before implementation	After implementation
Organic efficiency of secondary cyclones, %	96,48	94,11
Total plant, %	79	90
Coking oil in tailings, %	13,73	1,95
Coking coal recovered in secondary cyclone plant (circulating load), %	–	78

dramatically according to the type of material being treated. This testwork resulted in a decision to proceed with the installation of coal spirals.

A general flowsheet of the spirals is shown in Fig. 9. The installation began in June 1989, final commissioning being scheduled for December 1989. The effect of this project on the overall plant efficiency is shown in Table IV.

Flotation

The Mine has conducted a lot of testwork on the optimization of the flotation reagents. Although some reagents gave better results than power paraffin, the Mine still had to undertake more testwork before a final choice could be made. This was mainly because some of the reagents are very sensitive to reagent dosing, thus causing large variations in the quality of the final product.

Since Grootegeluk is an open-pit operation, the nature of the run-of-mine material can change dramatically in a short space of time. This has forced the plant personnel to be flexible in their operating practices, and has led to the installation of stage-dosing points for both the collector and

TABLE IV
Effect of spirals on plant performance

	Flotation only	Flotation and spirals
Coking coal		
Mass yield, %	11,81	13,08
Organic efficiency, %	84,20	93,12
Ash content, %	10,45	10,45
Steam coal		
Mass yield, %	27,99	26,72
Organic efficiency, %	88,69	84,67
Ash content, %	35,4	36,6
Calorific value, MJ/kg	20,3	19,9

the frother reagents in the flotation plant. Also, a saving of 15 per cent in reagent costs could be realized from the mixing of reagents with high-pressure water prior to dosing, although this practice did not improve the performance of the reagent itself.

RECOVERY OF SLIMES

Vacuum Filtration

The traditional practice in the South African coal industry is to deposit slimes in large ponds, from which clarified water is recovered once the solids have settled. Since the start-up of the Grootegeluk plant, some 4,5 Mt of slimes had been deposited in five slimes dams. As this material could still yield a product of suitable quality, it was decided to recover this by vacuum filtration. This

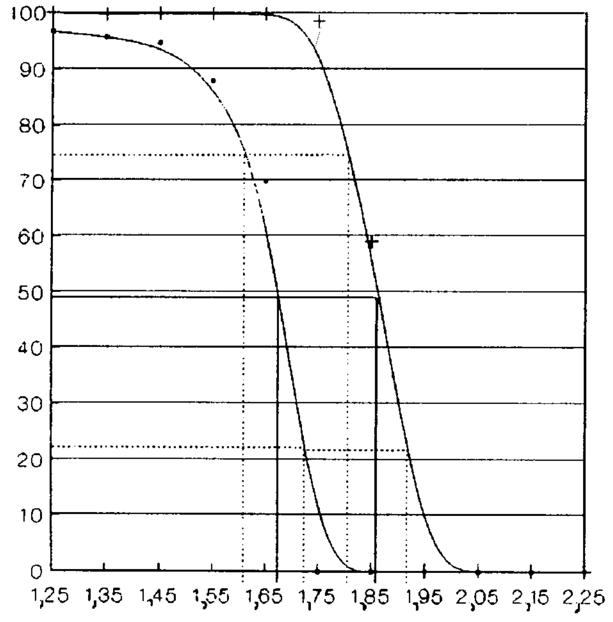

Fig. 7—Tromp curves at two Tromp cutpoints: at 1,66, with the *E*pm = 0,013, the organic efficiency = 97,38, and the Tromp efficiency = 95,28; and at 1,86, with the *E*pm = 0,014, the organic efficiency = 99,48, and the Tromp efficiency 96,26

decision led to the installation of two 81 m^2 horizontal-belt filters capable of handling up to 240 t of slime per hour. A schematic flowsheet of this plant is shown in Fig. 10, while typical operating results are shown in Table V.

Recovery of Existing Slimes

Since the quality of the slimes in the existing ponds had not deteriorated over the past eight years, the recovery of these slimes seemed feasible. The Mine investigated the possibility of hydraulic and mechanical reclamation and found that, although the operating costs were comparable, the capital investment required for hydraulic reclamation was significantly lower. Another factor in favour of hydraulic reclamation was the risk of getting mobile mechanical equipment stuck, since complete dry-out of the ponds is believed to take an indefinite time. Fig. 11 is a schematic overview of the system, which has a reclamation rate of about 60 t/h.

OPTIMIZATION OF PLANT CONTROL

On-line Ash Analysis of Final Product

The South African coal industry had a fairly bad experience with the first generation of on-line ash monitors, which had been installed in the late seventies. Although these units have always shown excellent theoretical potential, this was never realized in practice, and very few of these units are still operating today.

TABLE V
Typical operating results on horizontal-belt filters

Flocculant consumption	70,26 g/t
Filtration rate	1,2 t/m²/h
Moisture content	28,44%
Material < 45 µm	37,91 %
Average cloth life	6 months

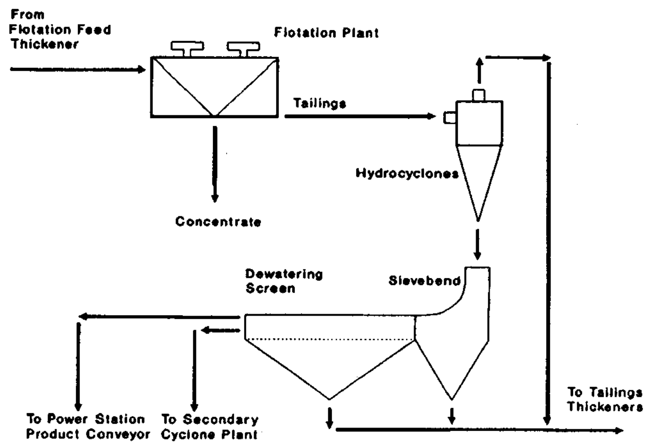

Fig. 8—Recirculation of flotation tailings

Despite this negative experience, the Grootegeluk Coal Mine in 1988 proceeded with a plant trial of the Coalscan 3500 unit. The trial led to the purchase of four of these units for installation on the conveyors of the steam-coal product from the field stockpiles at Grootegeluk 1 plant, Grootegeluk Eskom plant, and Dull coal plant. A schematic representation of this quality-control system is shown in Fig. 12, while typical test results are illustrated in Fig. 13.

The results of on-line ash measurements were to be used to control the quality of the final product based on a semi-expert system, which included a feedback loop to the laboratory for the removal of bias. Given the limited time to build the power-station coal-blending beds, on-line ash measurement would be the only viable way of achieving the high-quality control standards set by the Mine.

As a result of this testwork, it was decided to install one of these units on the conveyor of the coking-coal product at Grootegeluk 1.

The washability characteristics of the coking coal were such that a decrease in the ash content of the final product of 1,5 per cent would yield an increase in coking-coal production of 10 per cent. This increased production, if realized in practice, would result in a very favourable pay-back period for this project. This installation was commissioned during February 1990, and the standard deviation of the ash content of the coking coal decreased from 1,7 per cent to approximately 0,7 per cent.

Amdel Slurry Analyser

The Mine conducted a test run on a slurry-analyser system developed by Amdel. This system was installed in the spiral and flotation plant on one module. Tests indicated a correlation coefficient of 0,89 and 0,98 for spiral and flotation concentrates respectively between values obtained in the laboratory and those from the Amdel system. This indicated that the analyser would give representative ash values from these streams for control purposes.

The big advantage of the slurry analyser is that the problem of long feedback times from the laboratory (4 to 6 hours) is eliminated, and plant control can thus be improved.

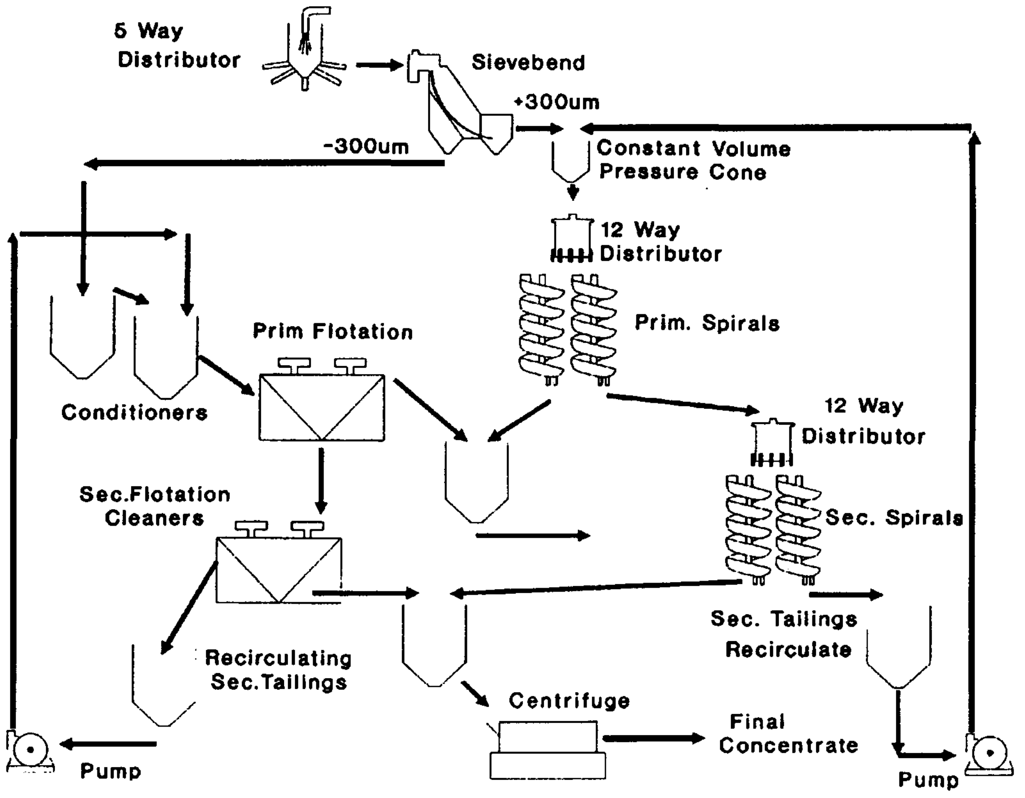

Fig. 9—The spiral plant at Grootegeluk 1

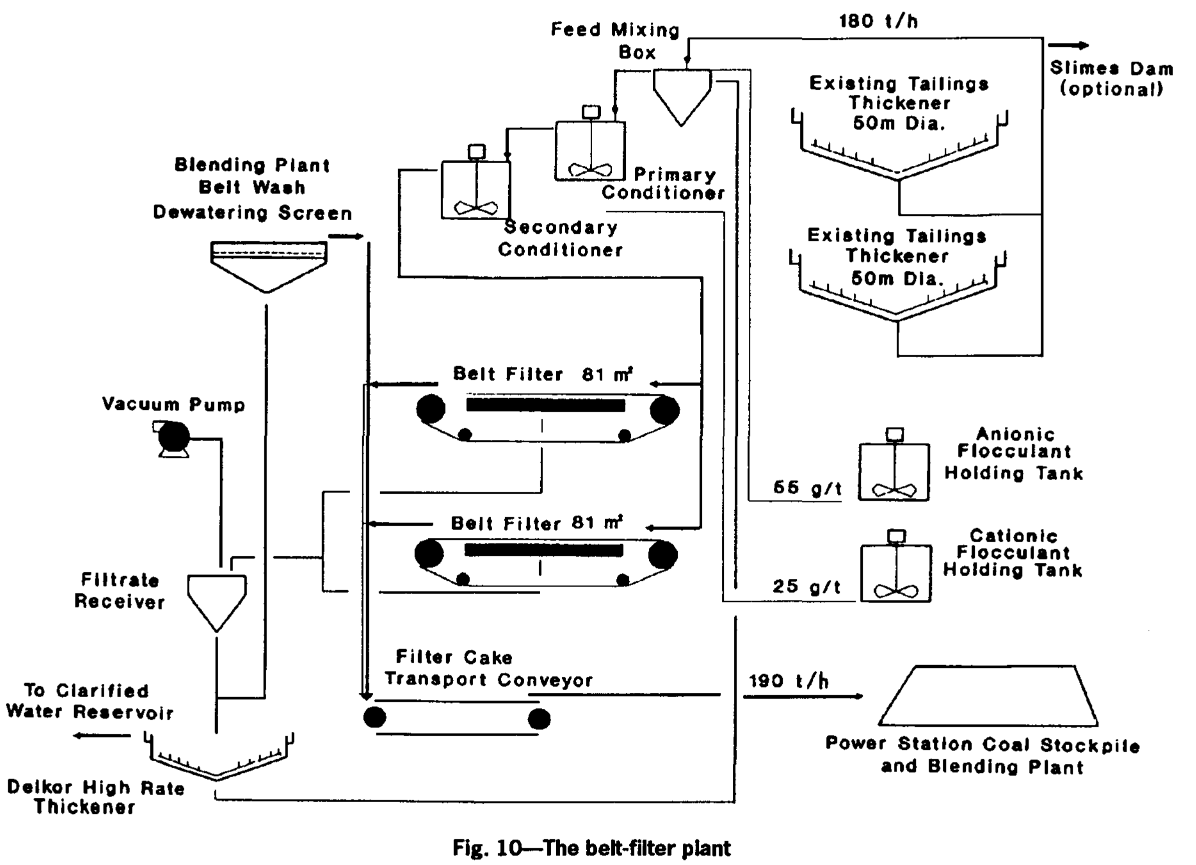

Fig. 10—The belt-filter plant

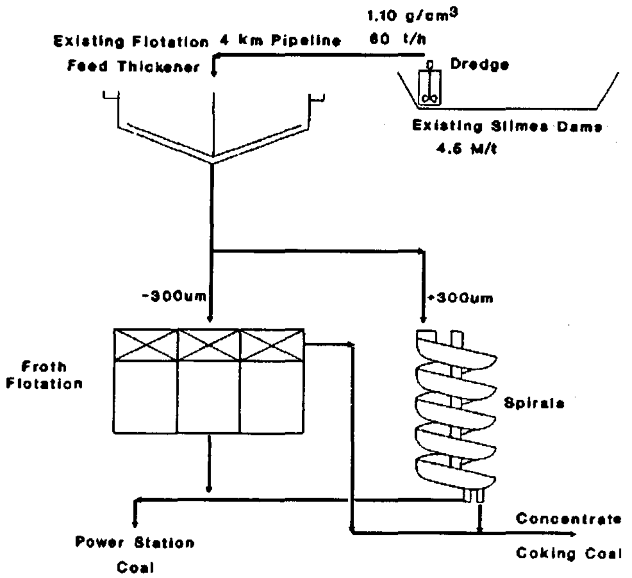

Fig. 11—The recovery of slimes

UTILIZATION OF PLANT WASTE

National Energy Council Programme

The National Energy Council (NEC) has a programme under way to utilize the discard coal that is being produced in South Africa. As the Grootegeluk Coal Mine currently produces some 22,4 per cent of all bituminous discards in South Africa, the potential is obvious provided the programme is successful in identifying a suitable process to utilize discard coal. This is even more important when it is realized that Grootegeluk's contribution of discard production will increase to 32 per cent when the extension projects are completed. The topics currently under investigation by the NEC include the beneficiation of discards, centralized and decentralized power generation from discards, and gasification of discards.

TABLE VI
Typical plant waste

Plant	Annual amount Mt	Ash content %	Calorific value MJ/kg
GG1	12	80	7
GG Eskom	7,5	80	7
Pit bottom	0,2	90	3,8

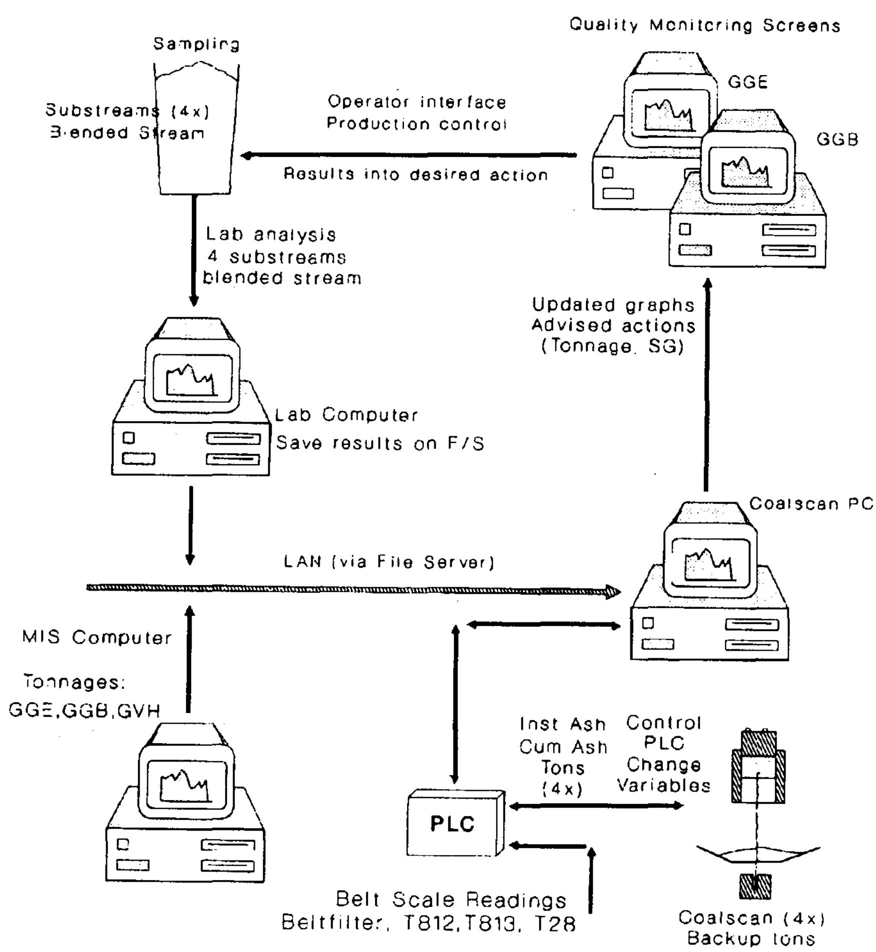

Fig. 12—A schematic diagram showing the Grootegeluk-Eskom quality-control system

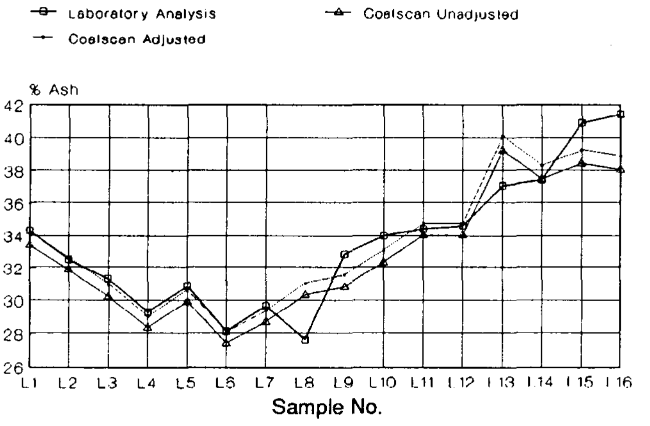

Fig. 13—Typical Coalscan results

A typical analysis of Grootegeluk's discards is shown in Table VI, which shows that the process at Grootegeluk is very efficient in yielding a product with an ash content of 80 per cent. Although the calorific value is therefore fairly low, the volumes involved are such that an economic way of utilization may still be found.

Minerals from Plant Waste

Although this project is still a long way off, analysis as shown in Table VIII clearly demonstrates that there may be potential for the recovery of minerals such as alumina from the plant waste. This project could possibly be enhanced if the plant waste were combined with the ash produced by the power station, in that the liberation and concentration of alumina might just make this a viable operation.

TABLE VII
TYPICAL ANALYSIS OF ASH IN PLANT WASTE

	Constituent, %		
Value	SiO_2	Al_2O_3	Fe_2O_3
Average	63,53	19,15	8,54
Maximum	65,80	19,90	13,00
Minimum	59,00	17,80	7,00
Std dev	1,29	0,38	1,02

FUTURE DEVELOPMENTS

Pneumatic Flotation

It was at its Durnacol plant in June 1989 that Iscor installed the first commercial Bahr flotation cell for the beneficiation of coal. The Company has also conducted a large amount of testwork on column flotation and the Bahr cell at the Hlobane Colliery. As a result of the superior results obtained from these installations in comparison with conventional coal flotation, it was believed that there would be good potential for this process at the Grootegeluk Coal Mine once the spiral plant was in full production. The results indicated that the major advantage of this process is its efficient upgrading of the ultrafine fractions, which are known to be 'natural floaters' in the conventional flotation process.

Although there is still much controversy regarding the choice between column flotation and flotation using the Bahr cell, these two processes are actually moving closer to each other. It is even possible that they may eventually end as one process. However, since the controversy still existed, it was decided to test these processes in parallel at the Hlobane Colliery and, as it was uncertain whether one process would produce better results on all applications, both units would also be tested at the Grootegeluk Coal Mine in due course. Testwork has indicated that both the Bahr and the Ekoff systems could obtain concentrates of 10 to 11 per cent ash in a single-stage operation. The conventional operation at Grootegeluk achieved ash grades of only 12 to 14 per cent from a two-stage process.

Dense-medium Cyclones

On the advice of the Multotec group of companies, 150 mm barrels were fitted to the Mine's dense-medium cyclones in the secondary-cyclone plant. This type of installation is believed to be beneficial to installations in which the amount of near-density material is very high (about 45 per cent), and preliminary testwork showed that this modification leads to increased organic efficiencies or increased capacities, depending on the requirements.

CONCLUSION

The circuit modifications implemented at the Grootegeluk plant have led to reduced production costs, increased yields, and better plant availability and production capacity. The value of these improvements can be conservatively taken to be about 5 million rands per annum.

Although the easier and more obvious modifications have now been made, further improvements have already been decided on and are in the process of being implemented. There will always be scope for further improvements, and the identification of such opportunities will remain the most important task of the Process Engineer.

ACKNOWLEDGEMENTS

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In some cases, a well-prepared review paper can be of value and will be considered for publication. All papers, particularly research papers, no matter how technical the subject, should be written with the average reader in mind to ensure wide interest.

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Illustrations should not be folded or creased; nor should they be pinned or stapled together. Care should be taken in packaging the paper and disk. If possible, a cardboard pack should be used to protect the disk.

4.4. Correction of Proofs

Papers will be returned to authors in proof form for checking. Authors are urged to read their proofs with great care to make sure that any changes to the text that may have been made by editors conform to their intentions. It should be emphasized that proofs are supplied so that authors can correct errors of fact made by the typesetter or editor, and not so that authors can rewrite or update their material.

5. PREPARATION OF PAPERS

5.1. Use of Word Processors

All authors should submit their papers in both printed and electronic form. Use must be made of IBM PC or PC-compatible disks (either $5\frac{1}{4}$" or $3\frac{1}{2}$" high or double density). Word-processing packages that are acceptable include MultiMate, WordPerfect, WordStar, and Xywrite III. If these programmes are not available, then an ASCII text file should be submitted.

The details of the word-processing package or other programs used to prepare the paper should be given.

5.2. Title Page

The first page of the manuscript should contain only the title, authors' names, company affiliations and address, and date of writing or presentation.

The complete auuress, telephone, and fax numbers of the senior author should be included.

5.3. Synopsis

The manuscript should be accompanied by a synopsis presenting a concise summary of the main text of the paper, as well as its purpose and main conclusions. The synopsis should not exceed 250 words. The synopsis should be complete in itself, i.e. the reader should not have to read the paper to understand the points made in the synopsis, nor should the synopsis contain any references, tables, or diagrams.

If the paper is to be published in the *Journal*, an Afrikaans translation of the synopsis should be included with the manuscript.

5.4. Layout and Style

The manuscript should be typed double-spaced, on one side only, on white bond A4 (295 x 210 mm) paper, leaving a margin of 30 mm. The pages should be numbered and should bear the surname of the main author at the top right-hand side of each page.

Authors should be objective, and should not include irrelevant or extraneous matter. The unnecessary use of capitals and hyphens should be avoided; punctuation should be used sparingly and be governed by the needs of sense and diction. Sentences should be short, uninvolved, and unambiguous. Paragraphs should be short and serve to separate basic ideas into compact groups. Quotation marks should be of the 'single' type for quotations and "double" for quoted matter within quotations.

Headings should be kept to a maximum of three levels:

First level - In uppercase bold: **HEADING NUMBER 1**, centred

Second level - In upper and lower case bold: **Heading Number 2**, set left

Third level - In upper and lower case italic or underlined: *Heading number 3* or Heading number 3, set left.

If an italic typeface is not available, words to be printed in italics should be underlined singly.

All illustrations and tables should appear on separate sheets at the end of the text. However, as a guide to the printer, authors should indicate by means of notes in the typescript where tables and illustrations, etc. are to appear in the text. Illustrations should be clearly identified in the text and should be referred to as Figure 1 and not Fig. 1. A few well-selected illustrations are often more pertinent than an amorphous mass of text.

Interpretations in a quotation should be marked off by square brackets [ ].

If there is any problem in producing formulae accurately by word processor, they should be handwritten in ink. Equation numbers should be placed in square brackets on the right-hand side of the page, thus [1].

Abbreviations and units are laid down in *British Standard* 1991. Units are the same for the singular and plural, e.g. cm for centimetre and centimetres, kg for kilogram and kilograms. Percentages are written in the text as 'per cent'; the symbol % is restricted to tables and formulae. A full stop after an abbreviation is used only when the last letter of the word is not included in the abbreviation, e.g. ref. for reference, but Dr for Doctor.

Units should be in metric terms and should conform to SI conventions.

Following South African practice, the decimal marker should be a comma, not a point, e.g. 3,25.

Authors are urged to have a colleague check their paper for clarity of presentation and typographical errors.

5.5. References

References should follow *British Standard* BS 4148. References in the text are numbered in order of appearance with superscripts (without brackets) e.g. ...[1], ...[2]. The references are listed in numerical order at the end of the text.

References to articles in journals should be given as follows:

KRIGE, D.G. Some basic considerations in the application of geostatistics to the valuation of ore in South African gold mines. *J.S. Afr. Inst. Min. Metall.*, vol. 76. 1976. pp. 383–391.

References to articles in books should be given as follows:

DAUM, U., and DEN OTTER, J..L. *Elasticity, plasticity and structure of matter.* 3rd ed. Houwink, R., and de Decker, H.K. (eds). London, Cambridge University Press, 1971. chap. 16, pp. 412–437.

Patents should be listed as follows:

INGRAM, H. Improvements in or relating to electrical condensers. *Brit. Pat.* 552,707. Appl. 18 Jul. 1941, acc. 18 Nov. 1943.

6. ILLUSTRATIONS, TABLES, AND PHOTOGRAPHS

All illustrations (this includes line diagrams, maps, charts, and graphs) should be of good quality in black and white. All the lettering and lines should be of consistent density.

All illustrations, tables, and photographs should appear on separate pages.

Authors are advised to consult a draughtsman or another experienced colleague on the quality required, and, if possible, to use such help when preparing the illustrations.

Computer printouts, especially in dot-matrix lettering, do not reproduce well, and should therefore be avoided. Where printouts are essential, the material should be black and equally dense, and the paper should be white (not with coloured bands). A laser printer should preferably be used. As a last resort, a 24-pin dot-matrix printout may be acceptable, but a 9-pin one is always unacceptable.

6.1. Illustrations

Numbering of figures should be in Arabic numerals, e.g. Figure 1, Figure 2, etc.

Line illustrations should be drawn in black ink on white drawing paper or on good-quality tracing film. Blue tracing cloth is not satisfactory, but 'clear-base' (i.e. transparent draughting material) gives good reproduction.

Illustrations should be clearly identified in the text and should be clearly marked with the surname of the senior author and the number of the figure thus: Smith Fig. 1, Smith Fig. 2, etc.

The style of all illustrations for a particular paper should be uniform. The illustrations should be as simple as possible, and should contain only essential wording.

6.2. Tables

Numbering of tables should be in Roman numerals, e.g. Table I, Table II, etc. Titles should be set out clearly in upper and lower case with minimum capitals, e.g. Composition of 310S stainless steel.

6.3. Photographs

Wherever possible, the use of photographs should be avoided. However, if they are essential and cannot be replaced with line diagrams, they should be in black and white and printed on glossy paper. The contrast between dark and light zones should be sharp for good reproduction. Photographs should be unmounted.

INFACON 6, in conjunction with INCSAC '92 – 8th–11th March, 1992

The first international ferroalloy congress (INFACON) was held in South African in 1974. The 6th Congress has now come back to South Africa and under the chairmanship of Dr R.E. Robinson, who was the Chairman of the first Congress. The Organizing Committee has decided to combine this Congress with the International Conference on Chromium Steels and Alloys (INCSAC'92).

RESPONSE

The response to the Congress, which is being organized by Mintek, the Ferroalloy Producers Association, and The South African Institute of Mining and Metallurgy, has been overwhelming. The capacity of 600 delegates is rapidly being approached, with nearly 550 confirmed by early February. Over 130 affiliates have been registered, and most of the Congress hotels are full. Over 30 countries will be represented and about 50 per cent of the delegates are from overseas.

TECHNICAL PROGRAMME

The technical programme for ferroalloys covers ferrochromium, ferromanganese, silica and ferrosilicon, and minor ferroalloys such as ferrovanadium, ferroniobium, and ferroboron. The chromium steels and alloys programme deals with both the processing and the properties of these products. Almost 100 papers are due to be presented by authors from around the world, although the majority are from South Africa.

ADDRESSES

The President of The South African Institute of Mining and Metallurgy, Mr Richard Beck, will present an address at the official opening. Plenary and keynote addresses will highlight the theme of the Congress, namely *Meeting the challenge of the 21st century*. This is the first time that INFACON has joined forces with the steelmaking industry in what promises to be a historic occasion.

VISITS AND CLOSURE

Cape Town promises to be a worthy venue for this international event, and the address by the State President, The Honourable Mr F.W. de Klerk, is bound to attract very special interest.

An exciting programme of technical and social visits and tours has been arranged for both affiliates and delegates.

The closing session will involve invited speakers from the major ferroalloy and steel-producing countries, who will present their views on the challenge of the 21st century facing the industry.