75TH ANNIVERSARY OF THE SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY*

REVIEW OF THE INSTITUTE AFFAIRS

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"In my Presidential address last year 'The Institute in Retrospect and Prospect', I briefly reviewed the past activities of our Institute, I commented on the dynamic growth of the mineral activity of this country and of the great contribution towards this growth made by members of this Institute. I maintained that there was still further growth to come, pointing out that our future would be very much dependent on the availability and skills of our mining and metallurgical men. This Institute had, therefore, a most important task ahead to ensure that this country would have the necessary skilled engineers to develop our mineral industry so that we would be able to compete successfully in the wide world. In my address I highlighted many of the major achievements of our members and of our Institute. In today's review, I have no wish to repeat myself and I would, therefore, ask members and visitors to regard this review as complementary to my presidential address. I must also refer you to the very full resumé of our affairs written for a special brochure in March, 1944, by E. H. Johnson, a founder member, on the occasion of our 50th Anniversary. There is no need to repeat what was given there, rather I will attempt to bring that history up to date.

Our Institute was founded under the name of Chemical and Metallurgical Society of South Africa on 24th March, 1894, by a group of chemists and metallurgists The name was changed to Chemical, Metallurgical and Mining Society of South Africa early in 1903, and in July, 1956 became The South African Institute of Mining and Metallurgy. We were not the first technical organisation in South Africa, the S.A. Association of Engineers and Architects having been formed in 1892. In that year also the British Institution of Mining and Metallurgy started in London. A chronological table of some of the more important societies is as follows:

British Societies:

Society of Apothecaries	1617
Royal Society	1660
Geological Society	1807
Institution of Civil Engineers	1818
Institution of Mechanical Engineers	1847
Institution of Chemistry	1877
Institution of Mining Engineers	1889
Institution of Mining and Metallurgy	1892

Other Societies:

Mining Society of Nova Scotia	1887
S.A. Association of Engineers and Architects—later the S.A. Association of Engineers which amalgamated with the Transvaal Institute of Mechanical Engineers	1892
Australasian Institute of Mining and Metallurgy	1893
Geological Society of South Africa	1895
South African Society of Electrical Engineers—disbanded 1904	1897
Mechanical Engineers' Association of the Witwatersrand—later, the	

*Address given at the meeting held on 24th March, 1969 to celebrate the 75th Anniversary of the founding of the forerunner of the Institute (on 24th March, 1894).

Transvaal Institute of Mechanical Engineers	1898
South African Association for the Advancement of Science	1903
Royal Society of South Africa	1905
South African Institute of Electrical Engineers	1909
South African Association of Analytical Chemists—later the S.A. Chemical Institute	1912
Associated Scientific and Technical Societies	1920

The chemists who started our Society were busy tackling the difficult problems of separating gold from the hard pyrite conglomerate rock. Some of these chemists were university graduates, whom we would now call scientists, others were what we now call technicians, that is people with lesser academic training but with a vast fund of practical skill based on experience; they knew the 'art' of gold extraction. The object in forming the Society was to compare the skills and to combine the science with the art.

Our first president was William Bettel. 'Rule of thumb,' he said, 'the giant that has ruled the world with a rod of iron, will have to give place to a younger rival, *scientific method.* We must disseminate scientific knowledge and apply it to technical processes and thereby help to scotch or kill this enemy of progress'.

CHEMISTRY

The Institute was originally known as the gold and cyanide club and the earlier papers were mostly concerned with gold extraction. The cyanide process had only just been introduced on a commercial scale and attempts were still being made to improve its efficiency. It was not an easy task; and Bettel in his inaugural address pointed out that gold assaying techniques were so unreliable that one manager prided himself on a 92 per cent recovery until check assays proved that his tailings were nearer 3 dwt per ton that the 0·95 dwt he had accepted. Another plant was for similar reasons obtaining a recovery of 125 per cent even though the tailings ran 9 dwt per ton, and Bettel commencted sarcastically 'truly such things, if true, are wonderful and indicate that we have alchemists in our midst masquerading as chemists'.

In 1897, T. W. Wood, the assayer to the Bank of Africa wrote a paper on the 'Assay of gold bullion' and this encouraged several further papers on assaying during the next year with a consequent improvement in current practices. Problems in assaying still crop up and in 1955, W. A. Sinclair in 'Non-assayable gold—a fallacy' confirmed the accuracy of modern fire assay methods and again in 1964 he demonstrated its accuracy when applied to low value residue samples. This was in reply to an interesting report presented in 1962 by C. H. Coxon and others entitled 'Radio chemical examination of systematic errors in routine mine assaying of Witwatersrand ores'. The industry is very greatly indebted to Coxon; his joint paper with H. S. Sichel presented in 1959 'Quality control of routine mine assaying and its influence on underground valuation' in which routine controls based on probability theories are applied to both assaying and sampling, has done much to raise the standard of ore valuation. These methods have been adopted by several large mines in South Africa.

In the early years attention was also paid to commercial chemical analyses and loud were the protestations within the Society when a local dispensing chemist claimed that a product 'death to rats' was 'harmless to humans since it was so strong —95 per cent arsenious oxide—that any person swallowing it would at once vomit it up'. Alcoholic liquors were also a subject for analyses, and may I refer those of you who are interested in the injurious contents of illicit liquors to Dr J. Loevy's presidential address in 1898, wherein he compares them to the best whiskies!

The study of chemistry was not limited in its application to gold extraction or to the analysis of poisonous substances. In 1898 Prof August Prister discussed the manufacture of nitro explosives. Dr Prister came from Trieste. He was Austrian and like many other chemists of those early days spoke several Contintental languages but had some difficulty with his English in open debate. One rude member was heard to remark when Prof Prister rose to speak 'Prof Prister will now address the meeting in several foreign languages'.

In his paper on explosives he referred to the problem of importing the basic materials for explosive manufacture such as glycerine, sulphur and nitrate of soda. Glycerine, he said, occurs in fats and oils together with palmitic, oleic and stearic acids used in the candle and soap industry. The Rand at that time consumed some 100,000 candles per day and together with soap and glycerine this would have been enough to support an industry; but, he pointed out, to fill the country's full requirements, 28,000 tons of fat would be required annually and this just was not available. His ideas were not forgotten and some 16 years later our soap industry was established on the basis of hydrogenation of whale oil to produce stearine from which mine candles were also made.

Sulphur, he said, was imported from England. This could be replaced by pyrites from Rand concentrates. 'If this was economically possible, we would have one of the most beautiful chemical circles. The mines would produce the dynamite they required from pyrites derived from the ore mined'. This, of course, we know became a reality some 30 years later. Nitro glycerine in explosives has now largely been replaced, firstly by sodium nitrate during the 1914/18 war and, secondly, by ammonium nitrate after the construction of the first synthetic ammonium plant in 1931. The first explosives factory was built at Modderfontein by Nobel and the German interests in 1896. Prister's paper in 1898 did much to dispel the animosity that mine managers had against this factory. Dr J. Loevy pointed out that the factory was already the largest in the world; it could produce more explosives than the country required, the quality was satisfactory and managers could not use these points in their arguments against the State monopoly. In 1902 the Somerset West factory was started. Rationalisation of the two factories took place shortly afterwards. Modderfontein has continued to expand; it is now a vast chemical complex pouring out all sorts of other products from fertilizers to plastics. An interesting development is the factory established adjacent to Modderfontein during the war for the production of poison gas, and described by Dr Wm Bleloch in 1947, in his paper 'Industrial synthesis of dichlorodiphenyl-trichlorethylene (D.D.T.) and Ancillary Operations at the Chemical Defence Factory, North Rand'. Bleloch was awarded the Institute's gold medal for this paper.

In 1958 Dr W. C. Walmsley in his paper 'Chemicals from atmospheric nitrogen', which was presented at a joint meeting with the University of the Witwatersrand, described in some detail the field of modern industrial chemistry based on nitrogen. He indicated the great strides South Africa was making in this direction with references to the local manufacture of calcium carbide, cyanide, ammonia, ammonium nitrate, nitric acid, nitro glycerine and finally urea. He stressed the necessity of increasing our use of nitrogen compounds in the form of fertilizers to augment the food supplies for our rising population.

EXTRACTIVE METALLURGY

Despite the break away by the chemists to form their own society in 1912, this Institute has continued to be the main forum in which mineral extraction has been discussed. A symposium on modern practices in diamond mining was held in 1960

and several papers dealt with various recovery plants. Foremost, of course, was R. J. Adamson's presidential address in that year 'Some account of diamond winning practises in Southern Africa'. Earlier, in 1952, R. G. Weavind was awarded a gold medal for the research work he had done in 'The treatment and recovery of refractory diamonds'.

In 1954, C. S. McLean, at a joint meeting with the University reviewed the uranium industry. This was the first time that the war time secrecy covering our uranium industry had been lifted, and at the time, was a dramatic story. He revealed that Dr Davidson's report in 1945 had said 'Present evidence appears to indicate that the Rand may be one of the largest low-grade uranium fields in the world'. He complained though that there was still a blanket of secrecy over ore reserves and the future potential of individual mines. However, in due course this was lifted, and in 1957 a very full symposium on this material was held. Prof L. Taverner, at that time head of the Government Metallurgical Laboratory, now renamed the National Institute of Metallurgy, who had been very intimately involved from the beginning, introduced the subject with a historical review. His laboratory staff described many of the concentration and extractive tests they had carried out, and indicated the basic requirements of uranium plant design. Mining group metallurgists described the plants that had been erected and some of the problems of operation. These papers, as I have said before, have all been published in the book *Uranium in South Africa* and never before has such a complete technical review been published on such a complex subject. We are still being kept up to date; in 1960 E. A. Nugent, P. Hoogervorst and R. E. Wheeler described the development of an economic process for the regeneration of cobalt and poisoned resins in a uranium plant. The process was put to practical plant test in the West Rand Consolidated Mines uranium mill and proved successful. The authors were awarded a gold medal for this excellent paper. In 1962 P. J. Lloyd read to us 'Solvent extraction in the South African industry' and C. W. A. Muir discussed the production of uranous double fluorides. In 1967, E. L. Goldblatt published 'Amine solvent extraction of uranium from sulphuric eluates' and A. Faure and others gave us 'The production of high purity uranium at a South African gold mine'. We are indeed grateful to the staff of the National Institute for Metallurgy, for so frequently giving us the benefits of their research work. It might be politic now to mention that in June of this year that Laboratory will again co-operate with us, this time for a two-day symposium on the recovery of pyrites.

Gold metallurgy has not been neglected. The first paper ever published in the world on the use of the cyclone as a classifier in closed milling circuits was that of M. J. Dennehy and S. K. de Kok published in 1953. The designs of the cyclone, its operating characteristics, and the advantages to be obtained over more costly and complicated classifiers were described. This well prepared paper earned for the authors the coveted gold medal awards. This was followed by a symposium on 'Recent developments in the use of hydro-cyclones in mill operations' which was held in 1956. T. K. Prentice discussed crushing and grinding efficiencies in 1946 and prominent metallurgists such as A. Clemes, H. Britten, A. H. Mokken, H. E. Cross and C. F. Brugman have periodically kept us posted with the several advances in design of gold plants and extraction methods.

In 1960 J. E. Williamson described 'The automatic control of grinding media in pebble mills'. This comparatively simple and yet completely reliable device for controlling the feed to large grinding mills is the answer to many a mill man's prayer and has led to one mining group adopting single stage autogenous grinding with no preliminary crushing in all its new metallurgical plants. This has led to unbelievable simplification of the communition process with a considerable saving in labour

and capital investment. This certainly has provided adequate repudiation, as R. J. Adamson suggested it would, of a mining journalist's claim that natives with wheelbarrows were indispensable for feeding pebbles to mills in South African reduction plants! In 1965 J. E. Williamson, this time with J. A. Savage, described 'The determination of osmiridium in Witwatersrand ores'. The improvements these two authors made in this determination has indirectly led to a greater production of osmiridum, so much so in fact, that the world market is today temporarily overstocked!

"Analysis of high purity gold' was the subject in 1962 for a symposium sponsored by the Chamber of Mines and certain mining group laboratories, who were interested in the development of 'four nines' purity gold' At this time also, consideration was being given to re-designing the Rand Refinery which had been brought into operation 30 years earlier and was now working at twice its designed capacity. Much of the information discussed at this symposium had an important bearing on the recommendations for the Rand Refinery. Incidentally, the renovation programme at the refinery is now almost complete.

Electric submerged arc furnaces as described in 1966 by H. J. Stockden and J. McLean have now been introduced into most gold mine reduction works and the laborious coal fired reverberatory furnaces have largely been discarded. In 1968, Prof D. D. Howat, with Messrs E. F. Statham and T. J. Coyle gave an account of some of the work done in one mining group in producing high purity gold, but so far the limited local demand for this standard has precluded commercial application.

We were extremely fortunate in 1967, to be given a paper by E. T. Pinkney and N. Plint on the Torco process, for extracting copper from refractory ores. This development is the result of many years arduous work by chemists and metallurgists throughout the world, and it is gratifying to know that the final breakthrough was made under the leadership of South African trained engineers and metallurgists. The prototype plant was erected in Zambia. This work will lead to the exploitation of other known refractory orebodies, the first of which is in Mauretania.

METALLURGY OF BASE METALS

The shortage of shoes and dies for stamp milling during the 1914/18 war led (on the initiative of our Society, together with the S.A. Institution of Engineers and the S.A. Institute of Electrical Engineers) to the formation of a committee to investigate local manufacture. As a result of the recommendations made by Profs G. H. Stanley and W. Buchanan, electric furnace manufacture of shoes and dies was started locally. Prof Stanley also designed the first two blast furnaces which commenced operation in 1918, one in Vereeniging and the other in Pretoria, producing our first pig iron from iron ore. Today it is difficult to understand the reluctance in those early days to push ahead with the iron and steel industry. C. Delfos waged a lone crusade from 1902 until in 1928 when the S.A. Iron and Steel Corporation was eventually formed; it commenced production in 1934, but Delfos had died in 1933. Meanwhile, alloy steels, manganese steels in particular, were being produced for the expanding mining industry, leading to the successful manufacture in the early thirties of mining drill steel, a product which is now exported all around the globe. But it is probably to Dr H. J. van der Bijl that we owe most for the establishment of an integrated iron and steel industry. May I digress to say something about this remarkable man. According to D. Gordon-Jones, in his chairman's address to the Base Metal Division in 1959, Van der Bijl was a man of world repute, a genius produced by a country only once in a century. A science graduate of Stellenbosch, he continued his studies in Germany, he lectured in physics at Dresden and was then grabbed by the Bell

Telephone Company of America. By the age of 30 his flair for research and his inventions in connection with the thermionic valve, radio telephony and telegraphy and the cathode ray oscillograph placed him amongst the world's top scientists. But he returned to South Africa in 1918 to become Scientific and Technical Advisor to the Government, to plan and then to administer Escom, Iscor, Amcor and Vecor. Truly a remarkable man and how proud he would be today if he could but see how his South Africa has developed—to see how other minerals and metals have taken over from gold—his country is no longer, as he once feared, dependant on a wasting asset!

In my presidential address I made reference to Dr William Bleloch's foresight in demonstrating how chromium, titanium, and vanadium iron ores could be economically processed. In 1950 Bleloch presented his paper on 'Theoretical consideration of the operation of iron blast furnaces with cold oxygen carbon dioxide blast', a process unknown in this country at that time. For this he received a second gold medal, having earlier received one for his paper on our D.D.T. factory.

In 1956, in his presidential address, Bleloch gave a very thorough analysis of the growth in the world, and the possibilities in South Africa in particular, of the electrochemical industries, indicating the large quantities of power consumed in the production of alumina, electric steel, ferro-silicon, ferro-chrome, calcium carbide, chlorine and phosphorus, saying that the above seven commodities required some 90 per cent of the power consumed in North America's and Europe's electrochemical industries. All these commodities are now being made locally or are on the point of being manufactured. This is, of course, because of our cheap electricity which is based on large efficient coal burning stations, selling power in the Transvaal at 0·5 cent per unit. This places us amongst the world's lowest cost electric power producers.

In my presidential address I referred to the Base Metal Division. Bleloch gave the opening address in 1956 and referred to our vast reserves of minerals and posed the question 'What are we waiting for?'

He went on, 'I think the answer to that is only too plain. We are waiting for members of this Base Metals section who can throw off the shackles of existing conventional technology and recover these metals with our off grade coal, from our off grade iron ores, chromites, manganese ores and aluminous clays'.

How disappointed we, the members of your council, are therefore that the Base Metals Division has ceased to exist; we bemoan too the lack of papers offered to the Institute on these most important sections of mining and metallurgy.

But, we believe, development and expansion will continue. I have already referred to the base metal activity in the Witbank and Middelburg area. I also spoke of the increased attention being given to the separation of platinum and its allied metals from osmiridium and from the ores of the Merensky Reef. We are producing more sophisticated products daily, and as an example of the success of this type of industry can I refer to our wire rope business which is steadily building up an export market. In 1967, two excellent papers, one by M. I. Tingle on 'Recent developments and current practice in the manufacture of high carbon steel wire in the Republic of South Africa', and the other by C. W. L. Fuller and E. J. Wainwright 'Recent developments in steel wire rope and hoisting from great depths' were presented jointly with the S.A. Institute of Mechanical Engineers at a meeting in Pretoria as part of that Institute's 75th Anniversary celebrations. It was also hoped that such a meeting might sow the seed and encourage greater interest in institutional affairs in our capital city. Alas, there are no signs of this happening despite the adjacent presence of Iscor and the C.S.I.R.

Probably the most valuable paper under the aegis of the Base Metal Division was Dr A. Blaney's 'Role of metallurgy in atomic energy technology' presented in 1957/58. This was a review paper in which he first discussed the physical aspects of nuclear fuels and reactors, and then described the various fuels and their preparation. Since this paper considerable research has been done by the Atomic Energy Board at Pelindaba, and may I suggest that it is time that our members were brought up to date with recent progress. In saying this I do not want to belittle the generosity of members of that Board—they have frequently arranged high level visits to their institution, and for this we are particularly grateful; but not all our members can get away for such visits and many others might prefer quietly to study the developments at greater leisure when presented in the *Journal.*

MINING

Mining was added to the title of the founder Society in 1903 after, I may say, a certain amount of resistance by the die-hards! This, as we all know, was at a time of rehabilitation after the South African War of 1899/02. Bantu labour was just not available and so indentured Chinamen were introduced to the Witwatersrand. There is no doubt that with their advent, the mines were quickly back to full output. P. Cazalet said of them—'As we knew the Chinamen on the mines he was a gentleman and when paid by results a fine worker to boot?' But the political consequences were not so happy and there was agitation to send them home.

The first mining man to occupy the presidential chair was Prof John Yates of the Transvaal University College. This was in 1907 and he claimed it was no light responsibility to be president at that troublesome time when the Chinese were being repatriated, the miners were striking, a new Government was in power and the average value of the ore treated was R3* per ton. South Africa was in a fit of depression, and what made it more bitter, 'the rest of the world seemed to be revelling in a surfeit of abundance'. But he said this would force us to put our shoulders to the wheel, and the Society would take the lead. With deeper mining he advocated larger units, bigger mills, more machinery and better education, (though he warned that many labour saving devices never lived up to their promises). The white miner must be trained in his trade of rock breaking, and, the more ambitious must be given educational opportunities and he welcomed the night classes then available. The mining course at the Transvaal University College was good but there was no provision for the practical teaching of ore dressing or metallurgy. This latter was essential if the metalliferous wealth of South Africa was to be worked. Cool reasoning counselled retaining the 'silk clad, luxury living, bicycle riding, heathen Chinese' until native labour was available! But it was to no avail, by 1910 all the Chinese were repatriated. Their introduction had though, stirred the Bantu to better output and encouraged mine managers to provide better conditions for their labourers. The Chamber of Mines organisation for the recruitment of Bantu labour to the mines was fully described by J. A. Gemmill in 1961 for the 7th Commonwealth Mining and Metallurgical Congress. Some 350,000 are now employed in gold mining and to most of them it serves as an introduction to work, to modern machinery, to education to health and to money. Prof R. A. L. Black, in 1958, was not convinced that for Bantu, money alone is a sufficient incentive to work, pointing out that the European philosophy of work and cash incentive is entirely foreign to them. He quotes an authority as saying: 'The conditions of tribal life provide no incentive to work beyond subsistence requirements. Women and girls traditionally do the routine work whilst

*For consistency, the eailier £ s. d. is converted to Rand on the basis £1 = R2.00.

men and boys take care of the cattle. Although with the coming of the plough, the men therefore now do the ploughing, there is nothing in the rhythm of tribal life to prepare workers for industrial employment . . . In tribal conditions work carries no sanction, idleness no stigma'.

He was, in this paper, reviewing the progress of mechanization in our mining industry. He was appealing for the establishment of a Mining Research Institute to analyze the problems in the mining field and to develop novel methods and machinery. It would also conduct research into work motivation. He was thinking of something on the lines of the U.S. Bureau of Mines or the British Central Engineering Establishment set up by the National Coal Board. He visualized an expenditure of up to $\frac{1}{2}$ per cent of revenue, say R2m to R3m per annum pointing out that major breakthroughs would not be achieved by half measures or skimped budgets. Similar appeals had been made by C. J. Irving in 1951 for research into the basic factors involved in the control of pressure bursts, and by F. G. Hill who had asked for more scientific research. L. A. Bushell made it the subject of his presidential address in 1954. In 1960 W. S. Findlay indicated that the Chamber of Mines and the industry were in fact spending more than R3m on research, the main subjects being ventilation, dust and biology. The Chamber's large Research Laboratory at Melville was built in 1949-51, the Applied Physiological Laboratory at Crown Mines, with its climatic chamber, was completed in 1956. Dr W. S. Rapson joined the Chamber in 1962 as Research Adviser and the Mining Research Laboratory was set up under Dr N. G. W. Cook in 1964. A very major breakthrough has already been made in rock mechanics, particularly in the development of the electric resistance analogue for calculating the stresses above, below or within the workings produced during mining operations. A rather controversially and dynamically novel piece of equipment is the rock cutter described by Dr N. G. W. Cook last year. But I think this is just what Prof Black visualized—he wanted a major breakthrough along a completely new line of thought. Major improvements would only be obtained by a dynamic approach.

ENVIRONMENTAL CONDITIONS

In the early years the subject of miners' phthisis or silicosis was frequently discussed. Dr L. G. Irvine, in summarizing some of the developments that had taken place up to 1934, said 'many of the papers contributed on this subject have been of signal merit and permanent value; all have been serious contributions to the subject. And what is particularly attractive is the singularly catholic nature of (the) discussions; they have exhibited the true symposium spirit and have brought together technical evidence from all quarters likely to be helpful, alike in South Africa and from overseas, so that (the Institute) has almost lived up to the suggestion made in the early days by Dr Macaulay that (it) should adopt as its title that of the Chemical, Metallurgical, Mining and Medical Society of South Africa!' I am not sure if such a suggestion is not still applicable to our Institute!

From February, 1903, until February, 1907, the subject of phthisis was under practically continuous discussion at the meetings of this Society with an immense effect in educating not only its own members but the whole of the mining community in regard to the realities of the position, but it may be firmly said that in these years the fundamentals of the problem so far as local opinion was concerned were clarified and established.

(1) It confirmed that the primary factor was silicosis dust.

(2) The importance of the predisposition to tuberculosis as an aggravating factor was recognised.

(3) Gases such as carbon monoxide and nitrous fumes were also an aggravating factor.

(4) Attention was directed to the necessity of adequate mine ventilation.

The general attitude towards possibilities of prevention was optimistic and was summed up in the simple formula 'Water for the dust; ventilation for the gases'. I may say that at this time all the mines of the Rand relied on natural ventilation alone to circulate the air underground.

In 1908/09 the first large mechanical fans were installed on mines and during the next decade all the deeper mines found it necessary to follow suit. This new advance was reflected in an important paper contributed to the Society in August, 1910, by S. Penlerick, entitled 'Ventilation and health conditions on the mines of the Witwatersrand, with special reference to the ventilation system of the East Rand Proprietary Mines'.

Regular dust determinations were only started after Mr A. MacArthur Johnstone had read a paper in 1912 on 'Dust determination by filtration through sugar'. In 1918 J. Innes gave an admirable demonstration to the Society of the results obtainable on the konimeter designed by Sir Robert Kotze. It was now possible to make quick comparisons of dust conditions and it was soon realised that the efficacy of water in removing very fine dust suspended in air was decidedly limited.

In 1952 P. H. Kitto and D. G. Beadle described a modified form of thermal precipitator and this apparatus has now been accepted as the only reliable instrument for dust measurement in mines.

The symposium on miners' phthisis held by the Society during the years 1921/23 again highlighted the importance of increased ventilation and in 1924 Dr Hans Pirow introduced his classic paper 'Underground conditions liable to affect the health of workers in the gold mines of the Witwatersrand'. He drew attention to the humidity problem which in subsequent years has become of greater concern than silicosis. A very full symposium was held 'On the problems arising out of temperature and humidity in deep mining' in 1935/36. This covered a wide field, ranging from the medical and physiological aspects, to the possibilities of dry mining. Much attention was given to the measurement of rock temperatures and the transfer of heat from wet and dry walls and from ducting.

In 1940, J. Spalding and T. W. Parker reported on the air conditioning plant at the Ooregum Mine, Kolar Goldfield. On this mine they had reached a vertical depth of over 8,000 ft below surface where the virgin rock temperature was 134°F, without recourse to artificial cooling. 'Dry mining' was practised, though mining conditions were described as somewhat trying. With surface mine cooling they were planning to go to 11,000 ft where a rock temperature of 160°F was expected. Later in that year Dr J. H. Dobson gave his presidential address 'Some practical and economic factors involved in the choice of plants for improving temperature and humidity conditions of mine atmospheres at great depths'. This must rank as the epic paper on mine cooling. Dobson as many of us remember, had been a Professor of Electro-technics and was at this time the head of a contracting firm responsible for the supply and erection of most of the large refrigeration plants in the country. He introduced his paper by an outstanding discussion on the fundamental principals of hygrometry and then described in considerable detail all the essential features of cooling plants. Surface plants utilizing mine air as a carrier of the cooling units were then most in favour and he indicated that 'wet' mining as practised in South Africa could be carried out to much greater depths than the then limit of 8,000 ft,

if capital, or preferably Government assistance, was available for new shaft systems. An extra four years of life could be given to each central Rand mine for every 1,000 ft of extra mining depth gained by such improved ventilation and cooling. In 1946, H. W. Unwin, A. Malcolm and R. E. Campbell-Pitt discussed the new refrigeration plant on the surface at No. 4 Shaft, City Deep. This mine had already reached depths of 7,500 ft below surface and thanks to the new cooling plant, plans were then being made to sink a new series of sub-incline shafts to take the workings down to 9,000 ft where rock temperatures of 110°F were expected.

In 1948, A. W. T. Barenbrug followed up Dobson's discussion of psychrometry and provided us with his sets of psychometric charts. These have been revised in recent years and are used throughout the world by ventilation engineers when dealing with heat and humidity problems.

In more recent years the Applied Physiological Laboratory under Dr Cyril Wyndham has given us the results of their very advanced research into the output that can be expected from men working in hot humid atmospheres.

Wyndham's first paper was in 1950 'Methods of expressing the evidence of thermal environments on man'. In 1953 he and his co-workers published their paper 'Practical aspects of recent physiological studies in Witwatersrand gold mines'. In this he dealt with a new method of acclimatizing underground workers to hot humid conditions. Other papers have followed and he has by now completely renovated the system of acclimatization, and I make bold to say has so considerably reduced the hazards of working under such conditions, that fatal cases of heat stroke are now extremely rare. In 1968 he was awarded the Institute's gold medal for all the work that he has done in this direction.

I cannot leave the subject of environmental conditions underground without referring to the paper written in 1944 by F. G. Hill and E. C. Ranson (Visitor) entitled 'A major changeover in the ventilation of a deep level mine'.

Hill was awarded a gold medal for this paper. To changeover completely the ventilation of a large and prosperous undertaking requires courage and confidence and its successful achievement is an indication of the ability of its instigators. Thanks to these new arrangements E.R.P.M. has succeeded in mining down to a depth of 11,000 ft below surface. I might add that having changed the ventilation system, Hill was still not satisfied that the ultimate benefits had been obtained, and in 1952 called in the assistance of Dr Wyndham.

ROCK MECHANICS

Problems associated with support of workings and rock bursts underground have frequently been discussed in this Society. Once again we have to turn to Hill for a dramatic development; having largely solved the ventilation troubles of E.R.P.M., he promptly tackled the rock burst problem and initiated the first large scale research investigation into this subject. The Council for Scientific and Industrial Research was called in to help and the benefit of the combined scientific and engineering approach was soon apparent. In 1955 Hill received a second gold medal for his portion of the paper called 'An investigation into the problem of rock bursts—an operational research project'. Dr Roux and Dr Denkhaus of the C.S.I.R. collaborated in the second portion of the paper.

The improved results stemming from this work not only spurred the mining industry to continue with the scientific approach but attracted engineers and scientists from all over the world; here was a country that appreciated the theoretical analysis

—here was a laboratory where the scientist and the engineer could test their theories in deep level mines on their doorstep. In 1964 Dr M. D. G. Salamon derived, from a massive mathematical analysis, the basic solutions and practical methods of measuring the stress problems which he described to us in his gold medal paper 'Elastic analyses of displacements and stresses induced by the mining of seams or reef deposits'. This paper, and several other important contributions on the subject, were published in book form under the title 'Symposium on rock mechanics and strata control in mines'.

TUNNELLING AND SHAFT SINKING

The wide variety of subjects discussed at our meetings is exemplified in the paper presented in 1949 by R. N. Lambert 'Wartime tunnelling in the Apennine range, Italy, 1944/45'. The rehabilitation of this major railway route from Florence to Bologna through the heart of the Apennines and of the subsidiary route from Leghorn to Florence was one of the major wartime engineering feats, since further advance to the north of Italy was dependent on this vital supply line. Many of those who saw the results of the demolitions carried out by the retreating enemy would have described the task as hopeless, and the Germans had boasted it would take several years to bring the line back into use. It had to be done in time for the Spring offensive. The first reconnaissance of the route to Bologna was done in October, 1944. The decision to go ahead was given in November and on 10th May, 1945, General Sir Brian Robertson travelled on the first train from Leghorn through the Apennine range to Grizzana. The work had been done in seven months and it was largely done by South African mining personnel.

R. R. M. Cousens in 1957 and D. M. Jamieson in 1958 have kept us up to date with trends in modern development and tunnelling practice. A very full review was given to the 7th Commonwealth Mining Congress in 1961 by S. C. Newman. He classified the material factors that had enabled monthly advances to be increased from 615 ft in 1937 to 1,903 ft in 1957 as follows:

(i) length of round reduced to 8 ft and two rounds broken in six hours
(ii) increased air pressures
(iii) improved shovel loaders
(iv) use of tungsten carbide tipped steel
(v) use of air-legs, jackhammers and light mobile drill carriages
(vi) improvements in car changing
(vii) use of ventilation columns.

These were the measurable material factors and he added two others of great importance—

(*a*) the enormous improvement in general organisation resulting from training
(*b*) the very high morale of modern high speed drill crews and their excellent team spirit.

As an indication of the progress in mining during the life of this Institute, it is interesting to recall an early paper on shaft sinking 'Notes on vertical shaft sinking on the Witwatersrand,' by H. Fraser Roche in 1905. The best sinking up to 1899 he said, was by hand labour in the Jupiter East Shaft where Basutos sank a 28 ft by 8 ft shaft 211 ft in one month and averaged 165 ft per month over 10 months. The shaft was timbered and its total cost was apprpximately R40 per foot. In 1904 a record for machine shaft sinking as opposed to hand drilling was established at the Village

Deep mine. Admittedly conditions were inferior but we read that the footage accomplished during October of 150 ft was a world's record. Costs were R60 per foot! Such were the first attempts at mechanization! During the next 20 years no dramatic advances in the rate of sinking were accomplished, most operators finding that water considerably delayed progress. To counter this, some advocated circular concrete-lined shafts and a record of 242 ft was established for such a shaft. In 1942, F. G. H. Waller described very fully how very wet ground could be tackled in his 'Circular shaft sinking, cementation, sealing and equipment at Libanon'. Then Vail established a world record of 422 ft in one month for a large six-compartment timbered shaft at Vlakfontein and the majority of the early shafts in the Orange Free State field were sunk with a rectangular shape. In 1949 a symposium on Shaft Sinking was organised by this Institute and once again a great deal of important information on a vital subject has been collected in a single volume. Dr J. T. McIntyre was awarded a gold medal for his paper 'Shafts of the New Consolidated Gold Fields Group'. This paper gave a very full description as to the reasons behind sinking various types of shafts and was of immense benefit to engineers planning for the future. In June, 1958, G. A. Merricks described in very great detail the record breaking achievements on Free State Saaiplaas, a new mine in the Orange Free State under the control of the Gold Fields Group. 834 ft were sunk and lined in this 27 ft 6 in. diameter shaft during September, 1957, and the average for four months sinking—September to December—was 634·5 ft. This was a terrific advance on what had been achieved to that date in the Orange Free State. Discussion on this paper was of great interest and, with due apology for my personal interest, I refer to K. A. B. Jackson's contribution. On St. Helena mine it was anticipated, he said, that sinking would be delayed by water and hence instead of sinking a bare shaft from top to bottom as quickly as possible, a fully equipped shaft was sunk from which work on intermediate stations could be conducted if shaft progress was delayed. Overall time taken from cutting the first sod to the start of full-scale development compared very favouraly with that obtained in most record breaking shafts. Shortly afterwards S. Newman described the sinking and equipping of No. 2 Shaft, Harmony. This 26 ft diameter shaft was also sunk, lined and equipped contemporaneously. Pre-grouting techniques were used in both these shafts and the improved results in sealing off water ahead of shaft sinking operations that can now be obtained has led to greater confidence, and a preference for sinking the bare shaft rather than an equipped shaft.

Numerous shafts were being sunk at this period, and in 1959 H. MacConochie in his 'Shaft sinking practice in South Africa' and D. M. Jamieson and M. P. Pearse in their 'Shaft planning for mines in the New Consolidated Gold Fields Group' provided further evidence of improved techniques. In discussion on these papers, it was interesting to hear G. Thorburn discussing the application of the caisson method to the installation of the shaft collar excavations for the No. 3 Shaft system at President Steyn.

MINE VALUATION

In 1902, T. Lane Carter read the first paper on this subject to the then 'Cyanide Club' pointing out it was just as vital to know the value of a mine as it was to ensure the proper foundations for a building. Good sampling practice was essential. Ore valuation was of vital interest to the mill men because they were responsible for the mill output and it was often difficult to balance this against the miners call. John R. Williams, a metallurgist and, according to E. H. Johnson, a trenchant debater, was President when this paper was presented. In the discussion that followed he said that on his property he usually took his own samples 'One month I was laid up with an attack of quinsy and the underground manager took the samples for me. His average was over 45 oz to the ton. The mine was then producing 25 dwt to the ton!'

No wonder that when metallurgists could make such statements with impunity, they were reluctant to admit miners to their society! There were several other biting comments passed at this meeting, indicating that members had taken to heart our first President's valedictory message: 'if the Society commences its career on the mutual admiration principle it will die'.

In 1904 B. I. Collins suggested, that to obtain a greater reliability in the estimation of tonnage and grade, ore reserves should be audited by an outside agency. This was not acceptable but once again attention was drawn to the inadequacy of sampling techniques and to the inaccuracy of ore reserve estimations.

In 1919 Prof G. H. Watermeyer demonstrated how some semblance of order could be elicited from underground sampling by using curves showing the relative frequency of values. Prof S. J. Truscott carried this a little further during the Empire Mining Congress in South Africa in 1930 and started a discussion which has continued to the present day, becoming more and more complicated with advances in mathematical analysis. In recent years, with the advent of the computer, capable of digesting every possible bit of information that can be fed into it, more and more variables are taken into consideration. Improvements have been made, but nature still refuses to comply with mathematical laws.

Dr D. G. Krige has followed up the statistical approach and has frequently given us the results of his findings. A big advance was made in 1961 when Krige in his paper 'On the departure of the ore value distributions from the log normal model in South African gold mines' was able to show that the estimates of the gold content of blocks of ore are either too high or too low according to whether they are above or below the mean value. He then offered a means of applying a regression factor. He also indicated how the log normal distribution curve could be used with greater accuracy by applying 'an adder'. Later he suggested improved methods for the valuation of stope faces, using a moving average technique. This led up to his 'Two dimensional weighted moving average trend surfaces for ore valuation' paper which was one of the main items discussed at the symposium on 'Mathematical statistics and computer applications in ore valuation' held in 1966. This symposium was sponsored by the Chamber of Mines and arranged jointly with this Institute. For his paper and for the consistently high standard of research work he had done in previous years, Krige was awarded the Institute's gold medal, and the term 'Kriging' which refers to his moving averages, has been accepted into valuation parlance.

In 1947 L. W. Luttrell-West gave his paper 'Some aspects of mineral valuation in South Africa'. He discussed valuation more specifically in relation to the mining lease system and mine taxation. He explained the background to the various formulae used by the State, and analyzed the effects of changes in working costs, grade or revenue on the present value of a mine. This paper has frequently been referred to in subsequent years and has withstood the test to time. More recently Krige in 1968, in explaining to us some of the implications of the new assistance formula for low grade mines, demonstrated how the various formulae can be adjusted to encourage the mining of sub-marginal ore and thus lengthen the lives of our low grade gold mines. When an increase in the gold price is imminent this can amount to direct financial assistance to keep the mine operating until such time as a rise in price occurs.

COAL MINING

Coal mining started on the Witwatersrand shortly after gold mining, and an entertaining historical review of this side of our mining industry was provided by R. W. Grout and R. L. Lechmere-Oertel in 1958 in 'A brief history of the progress

of efficiency in South African collieries in the last 70 years'. As in the gold mines, adequate ventilation was an early problem, especially in the gassy Natal collieries, and one reads that in 1921 F. A. Steart patented the propeller fan, his experiments at Northfield colliery having shown that six suitable aeroplane propellers mounted in tandem on the same shaft could produce 300,000 cfm. This was the forerunner of the axial flow fan which has altered the whole concept of mine ventilation by means of fans, most modern fans being of this type.

In comparison with overseas operations the South African mining industry has been slow to mechanize except in shaft sinking and development on large gold mines where speed has been the overriding factor. It was, therefore, gratifying in 1958 during the symposium on 'Mining progress in Southern Africa' to have C. J. Wantenaar's paper on 'Mechanization in coal mining as applied to Sigma colliery'. This mine supplies approximately 7,000 tons of coal a day for conversion by synthetic processes in the Sasol liquid fuel factory. The life of the mine was then estimated at some 100 years. The bord and pillar system is used and the coal is cut, blasted, loaded mechanically into shuttle cars and transported to surface on conveyor belts. The simplicity of the operation, the economies in the number of workers both on production and in the offices, the safety performance and the output were most impressive and well described. In 1959 T. F. Muller and J. C. Fourie discussed the introduction of trackless equipment into coal mining.

In 1967 R. T. Naude and M. J. Deats in 'The pioneering of fully mechanized longwall coal mining in South Africa' described very fully the excellent work being done towards achieving a fuller extraction of coal from our now diminishing reserves. This problem requires further discussion and it is hoped that other operators will shortly be prepared to bring us up to date with advances in this direction which they are now making.

In 1966, we were fortunate to be given a lecture by Prof Dr Reerink, Director of the Fuel Research Centre in Essen, on the coal industry in Germany. It was stimulating to hear how that country's coal industry has withstood the inroads of mineral oil and natural gas as suppliers of primary energy.

GEOLOGY

A paper of historic interest was presented to a joint meeting of the Geological Society and our Society in 1946. It was entitled: 'The discovery and prospecting of a potential gold field near Odendaalsrus in the O.F.S.' and was prepared by A. Frost, R. C. McIntyre, Edw. B. Papenfus and O. Weiss. It traces the early history of the pioneer prospecting carried out by Western Holdings and describes how geophysics was used to determine potential drilling areas. Surveys with the Eötvos torsion balance served to eliminate large areas where the Ventersdorp basic lavas were unduly thick, and sharp gravity gradient anomalies suggested Witwatersrand quartzites at shallow depths. Heavy Witwatersrand shales could be traced by well defined magnetic horizons. The first borehole, St. Helena No. 1, drilled in 1938, carried gold values and provided a sensation in the gold mining world, since at the time this area was generally considered unfavourable. This 'potential' field now produces over one-third of South Africa's gold!

In 1952, in conjunction with the Diamond Research Laboratory (Johannesburg) a symposium on diamond drilling was held. The subjects discussed ranged from the occurrence and recovery of diamonds, through the fundamentals of diamond drilling, to the use of diamond drilling for underground blasting and to pre-grouting techniques. Several contributors were well known overseas specialists. Since this

symposium South African drilling companies have considerably expanded their overseas activities and their expertise is spreading throughout the world.

GENERAL

But to return to those early days, I cannot resist a reference to a lecture by Sir Williams Crookes in February, 1896, since it gives an indication of the great changes that take place during 75 years. Crookes described the then novel experiments in the liquefaction of air and the development of the vacuum flask or container. He also spoke on the latest developments in photography and made mention of the work done by Prof Hertz in 'using electric rays to photograph bone structures'. He had been informed that the discovery 'had been already applied in a London hospital in a case of an obscure fracture and the photo had clearly shown the ends of the fractured bone' and, since I have an English background, I cannot resist quoting a little more . . . 'he also understood that the effect of these photos had been to convince a certain foreign potentate that John Bull had a far bigger, stiffer and stronger backbone than he had believed!'

In 1953/54 a symposium on safety in mining was held. In the opening address W. G. Pyne-Mercier reported that the European accident death rate for the three-year period 1905/7 was 4·66 per 1,000 per annum, in 1962 it was 0·82—certainly a dramatic improvement; and no doubt much of this improvement was due to the recommendations of the Mining Regulations Commission which was appointed in 1907 and whose work led largely to the framing of the Mines and Works Act of 1911. Dr N. B. Strydom discussed heat stress underground and advised that more attention be paid to the recommendations of the Applied Physiology Laboratory of the Chamber of Mines. C. O. Deane presented a paper on the safe removal of remenants; and F. A. Steart reported on the strength and stability of coal pillars. R. C. Briggs described the safety organization on the Sub Nigel Mine probably the safest of all mines in the gold mining industry. The importance of good ventilation was stressed by several speakers—with particular reference to the incidence of methane in the Orange Free State.

Another paper of unusual interest was Dr V. Bosman's 'A graphical study of the mineral and industrial developments of South Africa' published in 1934. Dr Bosman was a visitor from the Department of Commerce and Industries. In 1930, he said, gold, diamonds and coal represented 76·8 per cent, 14 per cent and 5·9 per cent or 96·7 per cent of the total mineral output. The rate of increase in output per annum of gold and coal is shown in the following table:

RATE OF INCREASE PER ANNUM OF GOLD AND COAL OUTPUT

GOLD			COAL		
Period	No. of years	% Increase	Period	No. of years	% Increase
1901-1912	12	+14·2	1904-1912	9	+9·5
1913-1922	10	− 1·9	1913-1922	10	+4·7
1923-1930	8	+ 2·0	1923-1930	8	+1·4

The State's Industrial Census department was instituted in 1915, and it was now possible to compare trade activities within the country. The following table gives the percentage changes per annum in certain activities.

RATE OF INCREASE PER ANNUM IN TRADE ACTIVITIES

Period	No. of years	Exports %	Imports %	Railway revenue %	Agricultural development %	Wholesale index %	Cost of living index %
1910-1920	11	9·4	8·5	7·0	—	9·1	6·2
1922-1929	8	4·7	6·2	3·8	5·8	−1·5	−0·2

For the younger generation may I say that the years 1920/21 were known as the worst of the depression years and 1922 was the year of the mining industry strike. The important thing to note though, and these days it seems unbelievable, is that there was a period of eight years when the cost of living index was actually going down! Some of us can remember this lean period and it did not end until 1936.

In 1937 Brig R. S. G. Stokes, in his presidential address, stressed the importance of maintaining costs and sought the help of the Government for this purpose. Costs in 1936, he said, were equivalent to R1.88 per ton and showing a tendency to rise. If we re-examine the history over a number of years in those halcyon days we note that costs were under R2.00 per ton from 1908 to 1939 except for the six years from 1918 to 1923 which was recognised as an unsettled period. Despite Stokes' warning, costs have risen alarmingly since he gave his address as can be seen in the table on page 526, taken from the Chamber of Mines annual report.

Stokes appealed for sympathetic tax considerations claiming that as mining was a speculative business, taxation should be conservative, quoting what he said had become a Canadian industrial axiom: 'Long experience appears to show that the maximum amount which may be taken from anyone engaged in an enterprise involving hazard, without discouraging him, is about 10 per cent'. Many of our present mines would be greatly relieved if they only had to pay even three times that figure! According to Stokes, gross profit in 1936 was some R65m, taxation and Government share of profit R28m and dividends paid, R35m. The price of gold as you recall was then R14.00 per ounce.

In 1949 W. J. Busschau discussed the 'Glamour of Gold'. 'Mining engineers,' he said, 'are mainly concerned with the engineering problem of obtaining fine gold from masses of gold bearing rock, but my title tonight is intended to cover some rambling thoughts on the use of and the search for gold in the past'.

His 'rambling' thoughts are most apt in the present context when all and sundry are discussing the monetary importance of gold. By 1949 total accumulative gold production was just over 1,600 million ounces and of this, he said, some 1,100 million ounces, say 70 per cent, was in the world's monetary stocks. Nine-tenths of this gold has been mined since 1849, the date of the great California gold rush. It would seem, said Busschau, that despite the large increase in mined gold, it has not been sufficient to finance without difficulty the growth of international trade. The remedy, he argued, was an upward revaluation of gold in order to restore the gold/credit ratio high enough to allow a large volume of international trade.

DECLARED WORKING REVENUE, WORKING COSTS, AND WORKING PROFITS

TABLE SHOWING THE AVERAGE DECLARED WORKING REVENUE, WORKING COSTS AND ESTIMATED WORKING PROFIT PER TON MILLED FOR TRANSVAAL AND ORANGE FREE STATE GOLD MINES, MEMBERS OF THE CHAMBER

Year	Working revenue per ton R	Working costs per ton R	Working profit per ton R	Year	Working revenue per ton R	Working costs per ton R	Working profit per ton R
1902	4·20	2·57	1·65	1935	3·36	1·89	1·47
1903	3·97	2·47	1·49	1936	3·20	1·88	1·32
1904	3·85	2·43	1·42	1937	3·14	1·89	1·25
1905	3·58	2·35	1·25	1938	3·10	1·92	1·18
1906	3·45	2·22	1·25	1939	3·16	1·94	1·22
1907	3·39	2·08	1·32	1940	3·54	2·07	1·47
1908	3·14	1·80	1·34	1941	3·48	2·12	1·36
1909	2·89	1·71	1·15	1942	3·42	2·12	1·30
1910	2·85	1·76	1·05	1943	3·46	2·19	1·27
1911	2·79	1·80	·96	1944	3·41	2·28	1·13
1912	2·90	1·87	1·00	1945	3·46	2·38	1·08
1913	2·77	1·79	·95	1946	3·49	2·56	·93
1914	2·65	1·71	·90	1947	3·46	2·66	·80
1915	2·62	1·74	·84	1948	3·48	2·62	·86
1916	2·67	1·81	·82	1949	3·89	2·70	1·19
1917	2·71	1·92	·75	1950	4·69	2·96	1·73
1918	2·79	2·16	·60	1951	4·69	3·18	1·51
1919	2·86	2·29	·55	1952	4·71	3·42	1·29
1920	3·53	2·57	·96	1953	4·84	3·65	1·19
1921	3·53	2·58	·95	1954	5·09	3·86	1·23
1922	3·16	2·36	·80	1955	5·38	4·04	1·34
1923	2·96	2·01	·95	1956	5·72	4·29	1·43
1924	3·00	1·97	1·03	1957	6·28	4·53	1·75
1925	2·81	1·93	·88	1958	6·57	4·69	1·88
1926	2·79	1·91	·88	1959	6·99	4·53	2·46
1927	2·86	1·97	·89	1960	7·42	4·65	2·77
1928	2·85	1·99	·86	1961	8·21	5·04	3·17
1929	2·82	1·98	·84	1962	8·65	5·18	3·47
1930	2·83	1·96	·87	1963	9·00	5·33	3·67
1931	2·80	1·95	·85	1964	9·43	5·49	3·94
1932	2·76	1·92	·84	1965	9·79	5·74	4·05
1933	3·59	1·94	1·65	1966	10·10	6·02	4·08
1934	3·52	1·94	1·58	1967	10·00	6·15	3·85

But I wonder as a mining engineer if we have not concerned ourselves too much in the production of gold and too little in ensuring its consumption and its value. If gold is to be a measure of credit and a measure unfortunately which governments are at pains not to use openly, then it is essential that we as producers prove its worth in terms of the goods that it can buy. Its properties of steadfastness and beauty are well known, but surely we can do more to increase its popularity particularly as an adornment for the fair sex? But an even greater demand can be stimulated in the electronics industry where its workability, its corrosion resistant and high conductivity properties are second to none. We must be the only industry in the world which has hardly spent a penny on advertising the virtues of its wares or in research into the properties and uses of its major product.

We have been told within this institute by leaders of our gold industry that it has two basic problems—the first to locate a payable orebody, and the second to exploit that orebody to the best advantage. A lesser problem was said to be the raising of the necessary capital to establish the mine. But little thought has, in my opinion, been given to an equally important problem, that of maintaining or enhancing the value of the product. Are we content to let the value of our gold continue to decline in line with the purchasing power of the dollar?

Do not let us fall under the spell of the sophisticates. Gold is not a 'barbarous metal' nor will I accept what the famous economist J. M. Keynes* said in the thirties —'The form of digging holes in the ground known as gold mining not only adds nothing whatsoever to the real wealth of the world but involves a disutility of labour'.

Rather let us examine all the possible uses of the metal. Can we not in this country develop a gold jewellery industry directed by the leading artists and designers of the world? Have we examined all the permutations of gold in metal alloys? Should not some portion of our research budget be devoted to a Gold Development Association? Ten years ago, D. Gordon-Jones told us that the nickel industry spends R5m on development and research annually, and nearly half was on product usage.

If we were to spend R1m on product usage, this would be about 0·15 per cent of our annual revenue. Such research should not cease—even if the price of gold goes up.

EDUCATION

A. F. Crosse, in his presidential address in 1895, hoped that there would in due course be a School of Mines on the Witwatersrand rather than in Cape Town. In discussion Dr Hahn of the Cape University and the School of Mines said his school had been started in the Cape the previous year after agitation lasting some five years. The first two years of the course was theoretical and would be done at the South African College in Cape Town, there would then be a year at Kimberley where mine engineering would be studied, and finally practical work would be done on the mines, after which the students would take their diploma. In due course Dr Hahn anticipated, when Johannesburg had become a settled community, the school would move there. In 1897 John Daniell, who was connected with the Council of Education advocated a School of Mines or technical college for the Witwatersrand based on the Clausthal system. This envisaged a very close relationship and interdependence between the mines and the school. Tuition would be for youth and for those a little older and employed in industry. He was criticised by Prof Lawn, head of the School of Mines, for not demanding a high enough standard. Lawn wanted a very full training in

*_The General Theory of Employment Interest and Money_, page 129. MacMillan.

mathematics and science, plus languages and something of the humanities, particularly if the graduate wished to progress in the mining world. Lawn doubted if the part-time student could ever complete such a full syllabus. The first two years of basic science and humanities could be taken at Cape Town, Stellenbosch or Grahamstown, and the engineering courses at Kimberley. The major difficulty of course was to persuade the Transvaal government to establish such educational facilities for the 'uitlander' in Johannesburg.

William Cullen, in 1905, in his presidential address criticised the mining industry for its dilatoriness in training artisans and described the improvements that had been made in this direction within the explosive industry. Up to this time mine managers and mine engineers had firmly believed that the only good artisans were those trained overseas. Apprentice training then became an accepted fact and the high standard reached by the artisans trained in the mining industry was exemplified during World War II when they demonstrated to the Allied powers that they could make anything from intricate instruments to heavy bombs with practically no period of adjustment. Cullen, at that time, also made reference to the newly established Transvaal technical institute, saying that there was now no need to send one's children overseas for higher education, but he did deplore the fact that the highest branches of technical education were only available to those of wealth. Evening classes, he said, were now available for those of lesser means and it was therefore possible for all, rich or poor, to study technical subjects, and any matriculated lad could, therefore, become an engineer if he had the will and the determination. We are faced with very much the same problem today. There is a snob value about university education and I believe many of us, particularly those of us who are university graduates, can do more to recognise the ability of those who have studied, possibly more diligently, through the years and who have now qualified as advanced technicians. Many are fully capable of doing the jobs of engineers and should, therefore, be so designated.

As I said earlier, Prof John Yates was the first professor of the School of Mines on the Witwatersrand, and I made reference to his appeal for more facilities for the training of metallurgists which was made in his presidential address in 1907. In 1926 Cullen discussed the education of chemists, and in 1929 Prof G. H. Stanley, in order to further the profession of metallurgy, described the work and the future of metallurgists on the Witwatersrand. In 1956 Prof R. A. L. Black spoke on the future of the graduate mining engineer in South Africa. He examined the world's mineral needs in the light of the Paley report with reference to South Africa and pointed out that lower grade deposits would, in due course, come into their own. Mining and metallurgical engineers would obviously have to have higher qualifications in order to find and develop such deposits. He advocated a much higher standard of scientific training and stressed the importance of management ability. He felt that there were two directions in which the mining engineer should move—one would be towards that of the highly trained specialist with an interest in research, and the other would be towards the executive or managerial engineer. The latter, in order to take his place amongst the engineers of the country, must first be a scientific engineer. Both types of engineer must in subsequent years continue their education; he encouraged post graduate courses but also emphasised that much could be gathered by personal study. He quoted the words of Dr Johnson as recorded by the faithful Boswell in his journal in 1766: 'People nowadays have got into a strange opinion that everything should be taught by lectures. Now I can never see that lectures can do as much good as reading the book from whence the lectures are taken. I know nothing that can best be taught by lectures except where experiments are shown. You may teach

chemistry by lectures, you might teach the making of shoes by lectures'. It is gratifying to know that since Prof Black made this statement the number of metallurgists and mining engineers taking post graduate courses has considerably increased—there is still room for more though.

In 1960 a symposium on education and training within the mining industry was opened by Prof Black. He dealt mainly with university training, saying it was difficult to predict that sort of technical world with which the future engineers would have to deal, but he was certain that, whatever it was, exact science would find a fuller place in the mining technology of the future. For example, more and more research work work was being done in the field of rock mechanics and he warned us that if the mining engineer did not accept this academic challenge he would be left by the roadside whilst others better equipped with higher engineering skills took over his function. Once again he advocated a thorough training in engineering sciences with the provision for students in the final year to become specialists in those more scientific or engineering aspects which appealed to them. Others might tend towards economics and administration, and then there would be the middle road category, what he called 'bread and butter engineers', which I would describe as mine management. Each stream in its own would lead to the highest positions in the industry and would offer fulfilment to the dicates of each person's inner desires.

In this symposium other papers were read concerning the education and training of apprentices, learner officials, trends in management training, and on the role of technical colleges in training for the mining and metallurgical industries. C. d'C. Murray discussed the training of foremen, with reference to the chemical industry. I would like to draw your attention to a sentence in his concluding remarks, as I believe this message applies to all levels of supervision. I quote: 'I honestly believe that if we really can solve the problem of training of future foremen in industry we should have gone a long way towards solving our problems of "on the job training" of those workers under foreman'. I would also like to refer you to 'Some thoughts and reflections on the training of metallurgists' by C. E. Mavrocordatos.

Training and education of technicians and university students still demands much attention. The Straszacker Commission has provided us with a great deal of information, which we must use before it is out of date. There is a lot to be done to improve our training, and I fear we all do too much talking and individually take insufficient action.

THE INSTITUTE

The earlier meetings of our Society were held in the Board Room of the Chamber of Mines. In 1895 arrangements were also made to rent a room for R15 a month in the Chamber of Mines Building for use as a library and reading room. This was to be shared with the Engineering and Architects' Association. A secretary was also shared 'at a salary not exceeding the sum of R10 per month to each society'. Members' subscriptions were raised from R4.20 to R6.30 per annum to pay for these costly facilities! Our membership at this time was 54, and that of the Association, 64. It is evident that the secretary was underpaid because four months later we read that he had disappeared. Nothing had been seen of him for six weeks, there were no books, no minutes, not even a list of members!

This early association with the S.A. Association of Engineers and Architects seems to have been doubly unfortunate since soon after attempts were made by the engineering societies to establish a closer liaison between each other, and our Society repeatedly turned this down. We were determined to maintain our own individuality, but were nevertheless interested in the possibilities of sharing a lecture hall where our

meetings could be held. In 1903 a Technical Education Commission was appointed to enquire into the steps to be taken to bring into existence a technical institution which should form part of a teaching university. Within six months, please note, their report was published. Their recommendation was that Plein Square should be set aside for a teaching institution for day and evening classes and that the various scientific and technical societies of Johannesburg, the mineral collection of the Colony, the Physical Testing Laboratory—later known as the Government Mechanical Laboratory—and the public library should be housed under the same roof. If I may digress a little, a second recommendation was that a permanent site for a teaching university for the Colony should be chosen within a convenient distance of Johannesburg, and as the most important branch of this university would be the School of Mines it had to be near the mines. Evidence was given that 'Johannesburg is very good as a mining centre but the immorality of the place is so great that it might be bad for students'. This was countered by another statement 'It is in certain respects desirable that students from rural districts accustomed to a somewhat narrow and primitive daily environment should be brought into contact with the wider circumstances and refining influences of modern urban social life' and 'that the presence of a university in Johannesburg would have an intellectual and elevating affect on the general life of the chief population centre of South Africa'. Others were thinking of the professors when they recommended: 'Among the advantages in placing the university in the country away from the town, we would refer to the absence of those conditions of life which make the cost of living so high in Johannesburg. Were the university to be placed in Johannesburg itself it would be necessary to provide the staff of professors with salaries out of all proportion to those which the finances of the country would justify'.

By 1909 a large lecture theatre with three offices for secretarial services had been erected in Plein Square and Fredk. Rowland, the Secretary of our Society, the Land Surveyors, the South African Association for the Advancement of Science and the Institute of Electrical Engineers, moved in. Our Society was the first to hold its monthly meeting there and the Chairman of Council of the university college in welcoming us said 'You are tonight as a Society in your own home and I hope that the sense of security and comfort arising therefrom may long avail you and tend to increase your sphere of usefulness'. Some members were not quite so satisfied, they preferred the room in the old Chamber of Mines Building on Market Square with its upholstered armchairs. R. S. G. Stokes said of the old room, 'it was particularly academic though cheerful and conducive to keen debates. The dense smoky atmosphere harmed us little—after all there are many deep thinkers who cannot function without a smoke—and there is not much satisfaction in a pipe if the smoke is drawn away from you before you have really finished with it'.

In 1919, the various technical and scientific societies agreed to amalgamate with a view to establishing a permanent home for their individual offices and for their meetings. In 1920, the proposed body took the title 'The Associated Scientific and Technical Societies of South Africa'. With financial help from the Chamber of Mines, it purchased the old Johannesburg Club building at 100 Fox Street. The first meeting was held there in June, 1920. The Societies' new building, the present Kelvin House was opened on 29th October, 1937.

In February, 1921, our Society moved into the new premises in Fox Street. We had held our meetings since 1909 in the old Transvaal University College lecture room. Our secretary, Fredk. Rowland, was still with us though he had since 1915 had to move his offices into the 'Tin Temple', the temporary home in Plein Square of the S.A. School of Mines and Technology, later to become the University College,

Johannesburg, and finally in 1925, to be the University of the Witwatersrand. Fredk. Rowland, as representatives of the Land Agencies Co., had looked after our affairs since 1897, and he continued to do so until he retired in 1939 when we accepted the services provided by the A.S. & T.S. Since then we have again been exceptionally well cared for and I would like to pay my personal tributes to the late A. J. Adams, our secretary until his retirement on 31st January, 1965. Mr Adams was assisted by Billy Watt with whom I had a closer personal relationship, and who was a most devoted and loyal worker. In recent years Eric Boden, Manager, and Don Visser, have carried this task with the same tradition of loyalty and generous service.

Our Institute continues to be a proud member of the Associated Scientific and Technical Societies, we continue to be represented on their council. Since 1943 several of our members have had the honour of being president of that body:

1944 Dr J. H. Dobson (respresenting the C.M.M.S.)
1945 Dr Bernard Price
1946/47 Prof G. H. Stanley (respresenting the C.M.M.S.)
1953/54 F. G. Hill (representing the C.M.M.S.)
1960/61 Dr F. Meyer (representing the S.A.I.M.M.)
1962/63 L. T. Campbell Pitt
1966/67 Dr W. S. Rapson
1968/69 Dr H. J. Nel.

We are, too, grateful to those many organisations industrial firms and, of course, the Chamber of Mines for the financial support given to this parent body to enable them to renovate so successfully this building five years ago. Office accommodation for the staff though limited is adequate, our meeting rooms and council chamber are extremely comfortable, and this main lecture hall is a great improvement. Some of us, of course, get more satisfaction within the confines of the club on the ground floor, despite those early admonitions of Dr Loevy!

SEVENTH COMMONWEALTH MINING AND METALLURGICAL CONGRESS

The Seventh Commonwealth Congress was held in South Africa from 10th April to 7th May, 1961. Nearly 1,300 delegates attended, and of these some 500 came from outside the borders of South Africa. In his inaugural address Dr C. S. McLean referred to the Third Empire Mining Congress held here in 1930. At that time, the quickest route to Cape Town from Johannesburg was by train—in 36 hours. The road to Durban was used for trials of endurance for cars! Gold output was then 10·4 million ounces, in 1960 it was 20·9 million ounces. The base minerals industry had shown a greater increase, the value of production of metallic ores having climbed from R1.6m in 1930 to R142m in 1960. The site for Iscor was just being levelled in 1931, and in 1960 Iscor's production was just on $1\frac{3}{4}$ million tons. Today incidentally, it is over 3 million tons—some three-quarters of the country's output.

From Johannesburg the congress moved north to the Federation of Rhodesia.

The papers presented at this congress were outstanding; they covered practically all the aspects of mining, metallurgy and economic geology in Southern Africa. Once again this Institute was responsible for the editing and publication. In lighter vein perhaps I can quote Hugh Husted, the Congress Manager—

'Long may the congress thrive! Despite the cast of suits
Worn by the French, Rhodesians, too though nicely tanned

Are tough; Red Indian braves (how I adore the brutes!)
Sing loud and late; Canadians go to sleep when canned;
Australians have an accent I can't understand
The Scots wear kilts and coatless Englishmen their braces;
The Welsh harp on their Fathers' cold if llovely lland.
Yet all is well: To hell, I say, with social graces.'

What is the future of this friendly gathering of select miners, metallurgists and geologists? Next month several of us will leave to attend the Ninth Congress in London—and our major question for debate will be this very problem.

PROFESSIONAL RECOGNITION

The question of professional recognition for the various technical societies was dealt with very fully by Professor John Orr in his presidential address on 16th February, 1938, to the Associated Scientific and Technical Societies of South Africa. As I have stated the South African Association of Engineers and Architects was the first technical society to be formed on the Reef and in their first annual report in 1893 we read 'it is suggested that when sufficient numerical strength has been acquired the association would be warranted in applying for a charter'. The matter was frequently discussed in the following years and in 1898 the architects separated and formed their own Transvaal Institute of Architects. That institute obtained its own registration in 1909, and in 1929, having changed its name to the South African Institute of Architects, was given full recognition throughout the country. In 1899 it was noted that a charter had been granted to the Society of Accountants and that, therefore, further steps should be taken to obtain a charter for the South African Association of Engineers. In succeeding years various attempts were made by those technical societies catering more particularly for the engineering professions to obtain registration but the difficulty was generally the demarcation between the engineering activities of the various societies.

In 1909 a determined attempt was made to form a federation of all the engineering technical societies, including the mining branch of our Society. The committee handling this federation said of our Society—'This Society can claim to be one of the most active and successful technical societies in existence. It has corresponding members in various parts of the world, and arrangements have been made for the formation of local sections. . . . Although we have not in any way approached the Council of this Society we have every reason to believe that it is their desire to continue to conduct it on the present lines, which have proved so successful in the past. The proceedings are of a high standard and have a world-wide circulation, and recently the Institution of Mining and Metallurgy (London) has invited the President to become a corresponding member of Council. The membership is to a great extent constituted on a popular basis, and it is certain, from the success attained, that there is sufficient justification for the existence of this Society, which opens its doors to the junior mining men on the Rand, even though it should involve a certain amount of duplication as regards sphere of influence and membership'.

There were one or two other minor problems connected with federation and the scheme was not acceptable to the Transvaal Institute of Engineers or the S.A. Association of Engineers, so the matter was again shelved. Perhaps I should mention at this stage that in 1915 the British Institution of Mining and Metallurgy which had been founded in 1892 was incorporated by Royal Charter as a professional body.

Later, as we have noted, in order to have a common home and to share secretarial services, the various technical societies joined forces to form the Associated Scientific

and Technical Societies. Once this was established it was again possible to consider the question of legal recognition of technical societies and discussions took place with the government but without success. In 1956 considerable discussion took place within the council of our own Society, since it was realised that registration of engineers would in due course come into effect, and that therefore we should make it possible for those engineers in our Society to be classified as such, without them having to join other societies. Certain changes in the constitution were made, restricting the entry into corporate membership. At the same time attention was given to the title and it was decided that the name be changed to The South African Institute of Mining and Metallurgy. The new constitution ruled that a corporate member of the Institute shall be entitled to use the following authorised letters denoting his grade of membership in the Institute:

Hon life members, Members } M.S.A.Inst.M.M.

Associate members —A.M.S.A.Inst.M.M.

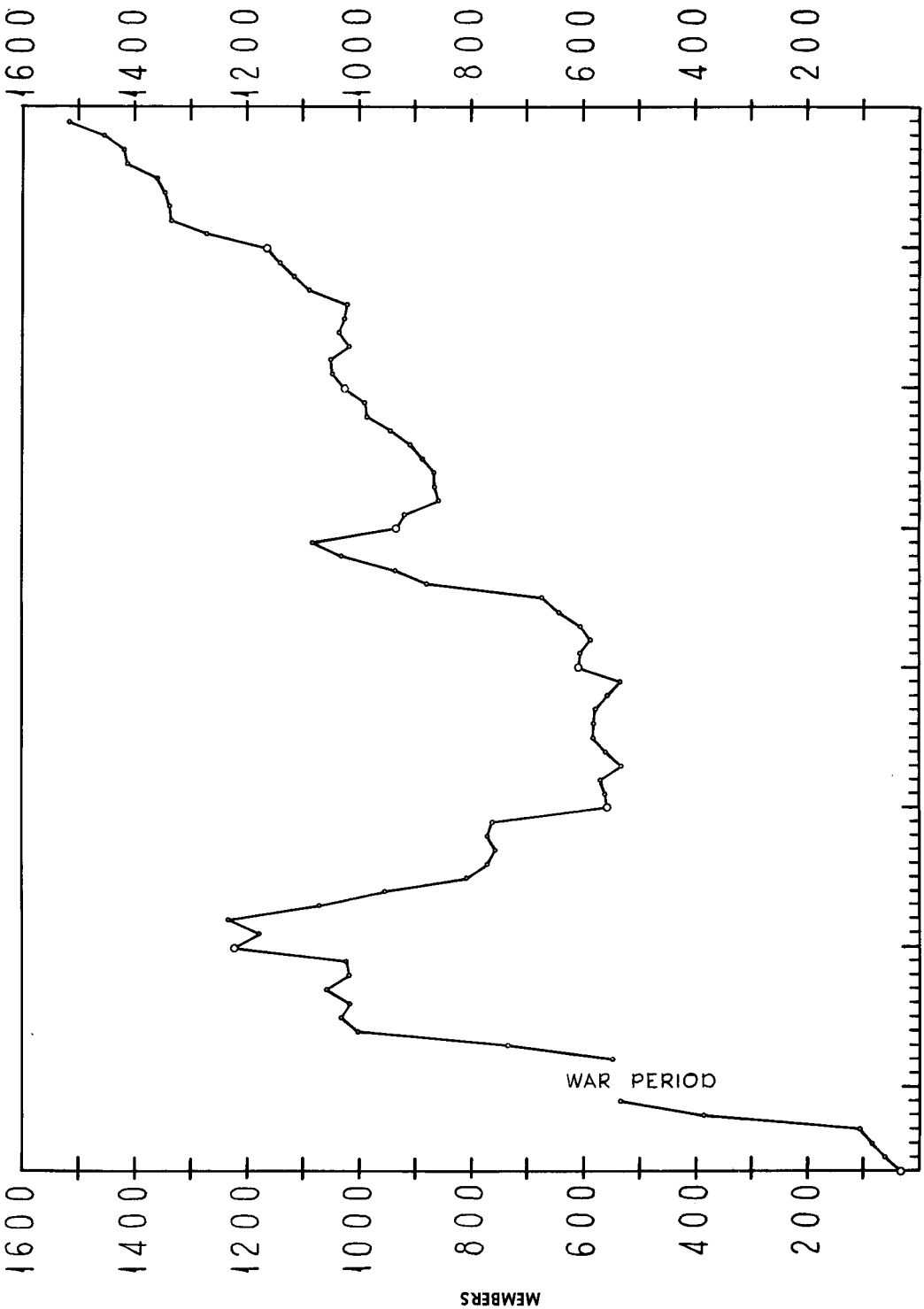
and it added that no corporate member should describe himself by any other description nor is any person who is not a member of the Institute entitled to make use of the above letters. May I remind members that no change has been made in these clauses.

Since its formation in 1961 the Professional Engineers Joint Council has pressed for statutory recognition of professional engineers and in June of last year an Act of Parliament to provide for the establishment of the South African Council for Professional Engineers, for the registration of engineers and engineers in training and for matters incidental thereto, was passed. All the branches of engineering catered for by our Institute are represented on the council of this body and final arrangements are now being made regarding the qualifications for registration of engineers and a description of the work that can only be performed by them. I believe this to be a very satisfactory result, since those chemical, mining and metallurgical engineers within our Institute will now be able to apply for registration as professional engineers. The Act furthermore provides for the statutory recognition of professional engineering societies and this will enhance the status of our engineering institutes. This will, however, in no way affect the autonomy and standing of our Institute in its representation of the more general disciplines associated with the mining and metallurgical industry in this country.

MEMBERSHIP

The accompanying graph shows the membership of our Institute from the time of its inception to date. Since 1944, the following prominent members were awarded Honorary Life Membership:

1946—J. V. Muller
1946—T. K. Prentice
1946—J. A. Woodburn
1946—J. Gray
1946—Prof John Orr
1946—C. J. Gray
1946—Dr J. V. N. Dorr
1946—R. S. G. Stokes
1946—Prof S. G. Truscott



Membership of the South African Institute of Mining and Metallurgy over seventy-five years, 1894-1969.

1946—Prof G. A. Watermeyer
1947—R. A. H. Flugge-de Smidt
1950—A. A. Wood
1950—W. W. Mein
1951—Prof B. de St.J. van der Riet
1952—Dr P. E. Hall
1954—Prof C. Biccard Jeppe
1955—P. N. Lategan
1959—F. Wartenweiler
1960—A. S. Andrews
1960—G. Hildick-Smith
1960—A. J. Walton
1960—Dr H. J. van Eck
1960—Dr A. J. Orenstein
1961—Dr C. S. McLean
1963—Sir George A. Davenport
1965—F. G. Hill.

AWARDS

Since 1944, the number, variety and standard of papers presented to the Institute has continued to improve, and it has been an invidious task to select papers for awards. Awards are now only made to members of the Institute and the certificate of merit, which has in past years been awarded for papers just below the gold medal standard, has now been replaced by a silver medal. The following is the list of awards since 1944:

1944—F. G. Hill. 'A major change-over in the ventilation of a deep level mine.' (E. C. Ranson co-author).

1945—C. J. Irving. 'Some aspects of rock drilling practice. (The Witwatersrand Gold Field).'

1947—Dr Wm Bleloch. 'Industrial synthesis of dichlorodiphenyl trichlorethyline (D.D.T.) and ancillary operations at the Chemical Defence Factory, Northrand.'

1948—A. W. T. Barenbrug. 'Psychrometry and psychrometric charts.'
L. W. Luttrell-West. 'Some aspects of mineral valuation in South Africa with appropriate reference to mining taxation and the mining lease system.'

1949—Dr J. T. McIntyre. 'Shafts of the New Consolidated Gold Fields Group.'

1950—Dr Wm Bleloch. 'Theoretical consideration of the operation of iron blast furnaces with cold oxygen carbon-dioxide blast.'

1951—No award.

1952—R. G. Weavind. 'The treatment and recovery of refractory diamonds.'
C. J. Irving. 'Some problems on the control of pressure bursts in mining operations.'
P. H. Kitto and D. G. Beadle. 'A modified form of thermal precipitation.'
M. Barcza. 'A review of the ventilation of some deep mines.'

1953—M. J. Dennehy and S. K. de Kock. 'The application of the liquid-solid cyclone as a classifier in closed circuit grinding at the Rand Leases (V) Gold Mining Co., Limited.'

1954—Prof Andre Houberechts. 'Cooling plants for underground workings in Belgium.'

1955—F. G. Hill. 'An investigation into the problem of rock bursts. An operational research project, Part I. The approach to the problem and analyses of rock bursts that occurred on the E.R.P.M. during the years 1948 to 1953.'

1956—M. Barcza and M. J. Martinson. 'An investigation into the resistance to airflow of No. 5 Shaft, City Deep, Limited.'

1957—No award.

1958—No award.

1959—C. H. Coxon and H. S. Sichel. 'Quality control of routine mine assaying and its influence on underground valuation.'

1960—E. A. Nugent. 'The regeneration of cobalt poisoned ion-exchange resins and their subsequent performance in a uranium plant.'

1963—H. E. Cross—'A new approach to the design and operation of thickeners.'

1964—Dr M. D. G. Salamon. 'Elastic analysis of displacements and stresses induced by the mining of seam or reef deposits.'

1966—Dr D. G. Krige. 'Two dimensioned weighted moving average trend surfaces for ore valuation.'

1967—E. J. Pinkney. 'The treatment of refractory copper ores by the segregation process.'

1968—Dr C. H. Wyndham. 'For work done on methods of acclimatizing underground workers to hot humid conditions, as reported in a series of papers between 1950 and 1968.'

In January 1965 your Council, in order to encourage the younger generation instituted a revised prize scheme for students. The following awards have been made:

1966—R. J. Schmitt. 'Ondersoek om die tempobeherende reaksie in die drukloging van komplekse Cu-Zn-Fe sulfiederste te bepaal.'

1967—J. P. Hatfield. 'Presplitting—a means of obtaining longer development rounds.'

J. J. Geldenhuys. 'The principles and development of modern techniques for solution of mine airflow distribution problems.'

P. Anderson. 'Analysis of base metal markets.'

L. Anderson. 'The mechanical aspects of open cast mining.'

1968—W. D. Winship. 'Developments of methods for differential thermal analysis.'

D. R. Fleming. 'An investigation of possible methods of preventing loss of gold ore caused by escalation of the pay limit.'

J. A. Cruise. 'Hydraulic hoisting.'

E. C. Nicolas. 'The problems of equitable gold mining taxation in the Republic of South Africa.'

SYMPOSIA

During recent years, a pleasing development has been the number of symposia which have been so enthusiastically supported by members. Reference has already been made to several of these but I believe a full tabulation is warranted. Most of these have received outside support, and where known, I have tried to give acknowledgement:

LIST OF SYMPOSIA

Date	*Title*	*In co-operation with:*
1949	Shafts and shaft sinking	Major mining groups.
1952	Diamond drilling	Diamond Research Laboratory, Johannesburg. Industrial Distributors (1946) Limited.
1953/4	Safety in mining	Prevention of Accidents Committee of the Chamber of Mines.
1955/6	Recent developments in the use of hydrocyclones in mill operations.	
1957	Uranium in South Africa.	
1958/9	Mining progress in Southern Africa	Chamber of Mines.
1960	Education and training within the mining industry.	

1961	Modern practices in diamond mining in Southern Africa	Anglo American Corporation Limited.
1962	High purity gold	Chamber of Mines Group Laboratories, C.S.I.R., N.I.M.
1963	Mine shaft design and its effect on air flow	S.A. Inst. Mech. Engineers Mine Ventilation Society.
1963	The use of mathematical statistics by the mining industry	Chamber of Mines Statistical Society of South Africa.
1963/5	Rock mechanics and strata control in mines	Chamber of Mines.
1964	A.N.B.A. (ammonium nitrate blasting agents)	Chamber of Mines.
1965	Iron and steel making	Iron, steel and base metal industries.
1966	Mathematics statistics and computer applications in ore valuation.	Chamber of Mines.
1968	Use of ANFEX in underground mining	Chamber of Mines.

In conclusion may I apologise for the inadequacy of this review, but in mitigation may I say I have found the task too time consuming! Certainly it has not been laborious—far from it—since once I started perusing back numbers and old papers, I became so absorbed in them and the discussions that I preferred to read rather than to write. Perhaps the few extracts I have given may entice others in my audience to look up back papers and in this I know I will have served my purpose. They, too, will find a fund of knowledge and will come away with deep admiration towards so many of those who have gone before and who so nobly played their part to foster our society.

Throughout the years the papers presented have been of extremely high technical merit and novel in outlook. Discussion has been constructive and at all times courteous; I believe we have, in Bettel's words, disseminated scientific knowledge to the best of our ability, we have kept abreast of the more recent trends, and we have achieved recognition of our proper status as mining engineers, metallurgists or scientists. For those who come after, may I say we have a noble heritage, and yours will be a harder task to maintain it.