SPOTLIGHT

on chemistry in the utilization of the resources of Southern Africa*

by R. E. ROBINSON†

I shall present a concept for the development of the resources of this country and its neighbours that represents a fantastic challenge to our scientists and entrepreneurs. This concept offers prospects of development that must make our previous achievements seem equivalent only to the first act in a drama enacted on the stage of Southern Africa. I hope to illustrate how, in Act Two, chemistry will play a dominant role, and chemists and chemical engineers will be among the principal actors.

Industrial Expansion

Of the many problems in Southern Africa, the most urgent problem requiring solution is that of unemployment, that is the provision of a means by which all the people of this sub-continent can earn a decent living with prospects of better incomes and opportunities.

In most people's minds, the first thought towards a solution is the creation of more industries and factories. Certainly, in the Republic of South Africa, the stage in Act Two is set for dramatic new developments in this regard. We have never had such opportunities as are evident today, particularly in the chemical and in the mining and metallurgical industries. There has never been such a great demand for gold, platinum, uranium, manganese, ferrochromium, and a host of other metals and minerals; and our resources are enormous. In the chemical industry, the rise in the price of petrochemical feedstocks has placed us in a situation where our coal resources as a raw material are an important advantage. The opportunities for the chemist and chemical engineer to use this situation to the maximum advantage are extensive. Not only could we become strategically independent of many important basic chemical commodities such as rubber, plastics, pesticides, and even liquid fuels, but we can become a major exporting force in the world-wide chemical community. Thus, we can enter such an age of industrial expansion as to make the other industrialized countries of the Western World green with envy, and our economic future must surely be very bright.

But, reluctantly, I must put it to you that, in Africa, this essential and exciting industrial expansion is not going to be enough to solve our main problem.

To achieve the full advantage of our unique situation, our new mines and our metallurgical and chemical plants must be economically competitive with those of other countries of the world. This means technical sophistication, and a degree of automation that will increase with every year. Our plants of the future will involve beautiful computerized control panels and automated machinery. But, in no way will they provide adequate employment opportunities, nor can we provide a rate of education to enable the many million members of the average tribal families in the homelands to participate meaningfully in the economic benefits arising from these industrial developments.

We talk in terms of many billions of rands in capital expenditure, but unfortunately, in terms of job opportunities, we can talk only in terms of trivial tens of thousands. We can talk of mighty industrial empires and hefty dividends to shareholders but, also inevitably, of inflation and increasing difficulty among the poor to make ends meet. Indeed, if we do nothing more than promote our industrial expansion, we shall reach a situation in which the rich will get richer and the poor poorer, with, inevitably, catastrophic results.

There is another component that we need to counteract mass unemployment, particularly in the homelands of our country, and that is a flourishing agriculture.

Agricultural Development

Many people have recognized that the development of agriculture on an enormous scale is the only solution. But there are many problems, and I believe that one of the keys to our future success lies in an almost unnoticed experiment that is taking place in Bophuthatswana. This experiment has come to be known as the 'Mooifontein and Sheila projects', and I am sure that few of you have even heard of them.

It is an experiment in communal farming very similar to the Moshav System in Israel, and is strongly supported by a group of white farmers, co-operatives, and industry. It is co-ordinated by a dedicated group of people in the Department of Agriculture. President Mangope, with his great foresight and acumen, has provided the strongest support both morally and financially for the project, which involves scientific farming methods, land ownership, and co-operative planning in two farming areas, Mooifontein and Sheila. It is a most exciting story on its own account.

The areas being cultivated at Sheila and Mooifontein are by no means the most productive agricultural land

*The lecture, in abridged form, given by the author on his receipt of the Gold Medal of the South African Chemical Institute for 1979, on 21st November, 1979. The Gold Medal of the Institute, which is available for award annually, is given in recognition of contributions in the field of chemistry or chemical technology that are considered to be of outstanding merit, and is the highest award in the gift of the council of that Institute.

†Senior Manager, Sentrachem Limited, Johannesburg, and a Past President of the South African Institute of Mining and Metallurgy.

in the country, and one wonders what could be achieved if this experiment could be perfected and duplicated a hundredfold in Bophuthatswana, the Transkei, Kwa-Zulu, Vendaland, Kangwane, Quaqua, and all the other underdeveloped areas of this country. The concept is not limited to maize production. There are vast areas of the country suitable for the cultivation of sugarcane, sorghum, timber, and a host of other crops. Forestry is of particular importance where this is possible, since it is important to provide the farming families with a supply of fuel for cooking and heating until more sophisticated methods become available. Attention and assistance must be given to the problem of water supplies, fertilizers, the eradication of pests, and the clearance of bush. Mooifontein is by no means a peasant type of farming. The methods used are modern and scientific, and this embryonic experiment could, I believe, be the beginning of an agricultural revolution in this country.

There is, of course, one other vital component if this dream of agricultural revolution is to become a reality. We have to find a market for the agricultural products.

South Africa is a country of agricultural surpluses. We produce some 10 million tons of maize, of which only 6 million is consumed locally and the rest is stored or is exported into a saturated world market at an economic loss. Informed opinion indicates that we could double our production of sugarcane, and vast areas of Kwa-Zulu, the northern Transkei, and the eastern Transvaal would be ideal for this purpose. But, we already produce 20 million tons of sugarcane and, if we were to double our production, what could be done with the surplus? In this case we couldn't even export it since the whole sugar industry is on a strict international quota system. The same problems apply to most other crops in the country, and there would only be chaos if such an agricultural revolution in the homelands were to oversaturate the existing markets with a large volume of maize and similar materials. At the same time, the production of food is vital, and indeed the supply of the correct quality of food to Africa is of strategic importance.

It is this dilemma that calls on the Chemist to play a dominant role, and I have used an almost obsolete word to describe this contribution — *Chemurgy*.

The Chemurgy Concept

Chemurgy means the utilization of agricultural surpluses to provide many of the raw materials that are essential to the chemical industry. Moreover, it implies that this is achieved in a way that does not jeopardize local and exportable food supplies, but converts raw materials from agriculture into more valuable forms of food and chemicals. *Chemurgy* also involves the use of one of the inadequately recognized energy sources plentifully available in Southern Africa — sunshine — and represents the utilization of biomass in the exploitation of solar energy.

I should like to describe how the chemurgical concept could form the basis of a development plan for this country that, I believe, could solve many of our problems. I am not alone in this belief, and indeed I have made use of many suggestions from a host of other people. At the same time, this master plan incorporates certain aspects that still require demonstration and testing, but they will serve to illustrate what might be achieved.

In this plan, I visualize the establishment of a large number of what might be called *agrochemurgy complexes* in the homelands and in border areas. These would consist of a central chemical plant surrounded by a number of agricultural communes like those at Mooifontein and Sheila.

There are many products that could be derived from the agricultural raw materials produced by these complexes, such as timber in the form of building timber for the construction of houses and of firewood for heating, cotton for clothing, and oils for paints and varnishes. I should like to focus on the most important one — ethanol.

Ethanol is a liquid fuel that can, without any difficulty, be used to supplement petrol and diesel fuels. The quantities that can be utilized in motor fuels could easily amount to several million tons per annum, and these very quantities make chemurgy possible on a suitably large scale.

Many different crops are being considered as raw materials for the production of ethanol in a fermentation plant. Of immediate importance are maize, sugarcane, and sorghum, and, at a slightly later stage, cassava. The size of a central ethanol plant for each of my suggested agrochemurgy complexes would, of course, depend on many geographical, climatic, and other conditions. But, for purposes of illustration, I should like to present a module that would produce approximately 100 000 tons of ethanol per annum from maize.

Production of Ethanol

It is easy to calculate that the amount of maize required to supply a typical module would be approximately 300 000 tons per annum. Thus, in agricultural terms, the central ethanol plant would have to be surrounded by approximately 100 to 150 000 hectares of maize-growing areas.

It is envisaged that the central ethanol plant would be a private industrial undertaking, and therefore must be an economically viable and profitable enterprise. The company erecting and operating the ethanol plant would negotiate for the supply of their raw material with the farming communities surrounding it. These negotiations must comply with the provision of the agricultural marketing act, and for this reason the closest co-operation of the relevant marketing boards and state departments will be essential. In essence, such contracts would involve a guaranteed take-off at a guaranteed price, and would also include a positive commitment from the farmers. The total value of these contracts with the farming community would amount, for one module, to approximately 30 million rands per annum, and, with firm contracts of this magnitude, I see no difficulty in raising capital from industry and government to provide loans to the farmers for the purchase of machinery, fertilizers, and other requirements.

Obviously, there would need to be significant involvement in the marketing of ethanol by the state, because it is essential for the company to be assured that its product will be added to the liquid-fuel system of the country. The selling price would almost certainly be determined by the state, would have to provide an adequate return to the company, and would have to keep pace at least with the general rate of inflation. This would enable the farmer to be sure of a price for his product that would rise as inflation increased.

Of course, the first question asked is whether it will be possible to produce ethanol at a reasonable price, and I shall deal with this question later.

Storage systems would have to be provided to allow for the seasonal nature of maize farming and for variations in rainfall, but these systems would not need to be unduly large. Fortunately, it would not matter at all if the maize showed some deterioration in storage since this is of no consequence to maize that is to be used in a fermentation process.

The employment possibilities in this agrochemurgical complex are, of course, the most important aspect of all. Each module of the ethanol plant would provide direct agricultural employment for some 3000 farmer families, and probably 200 to 300 workers in the ethanol plant itself.

Animal Feeds

The concept does not end with the production of ethanol. Our chemical ingenuity goes a lot further than that. One of the byproducts of a fermentation plant operating on maize is a high protein-containing residue derived from the non-fermentable portions of the maize, and the residual yeast cells used for fermentation. It is referred to in the trade as Dried Distiller's Grain and Solubles (DDGS). It is an extremely valuable animal feed, particularly as a protein concentrate that is to be added to other roughage material.

It also becomes feasible to collect a significant fraction of the maize stover from the farms and to transport it to a central location for treatment with caustic soda or ammonia by the newly developed Rumensoda process to convert it into a highly digestible animal-feed roughage material. The collection and transportation of maize stover are not usually regarded as economically viable, but the situation in our envisaged agrochemurgical complex is different from the existing farming structure in the Republic. A large number of small farmers would need labour-intensive operations in the off-peak periods. Moreover, the distances to collection points in a communal system would not be large. An agricultural area of, say, 100 000 hectares is equivalent to a circle with a diameter of 36 kilometres and; even allowing for topographical variation from a circular orientation, distances to the central point would not be large. This treated roughage would then be supplemented by the DDGS to form a highly valuable animal feed, which although bulky, could be returned to the farming community by the same transportation system as that used to deliver the raw material. Thus, a secondary farming activity would be generated, producing, for example, mutton beef, and pork.

For every ton of ethanol produced, approximately 1,5 tons of maize stover and 0,75 ton of DDGS would be mixed to give an animal-feed production for the whole agrochemurgical complex of approximately 225 000 tons per annum. This animal feed could be used in feedlots or to supplement natural grazing. We can calculate that every 7 kilograms of such a feed would be equivalent to 1 kilogram of red meat. In the case of pork or poultry, the ratio could be even smaller. Thus, our agrochemurgical complex would produce 32 000 tons of meat per annum, which is equivalent to 150 000 head of cattle. This alone could provide direct employment for at least another 2000 families, and this figure could be increased if other possibilities such as milk production were also considered.

This is still not the end of the possibilities. The wise chemist will look at all the possible chemical products of a fermentation process, and will focus attention on an important and often neglected byproduct — carbon dioxide. Indeed, for every ton of ethanol produced, 1 ton of carbon dioxide is usually generated and dispersersed into the atmosphere. A limited amount of this carbon dioxide could be used for the freezing of vegetables, poultry, and other perishable goods that could be produced in the winter months. However, a great deal of thought has been devoted to the use of most of this byproduct in other ways. This thought has revealed a most interesting possibility, which, although at first sight seems to border on science fiction, is a most exciting and probably viable economic proposition.

The Algae Concept

The idea is to use the carbon dioxide to cultivate algae. I am sure you are aware that algae, although a very simple form of life, are also extremely efficient converters of solar energy into useful chemicals. The algae live and grow by absorbing sunlight and, by a photosynthetic chemical process, converting simple molecules like carbon dioxide into more complex molecules such as carbohydrates, cellulose, and, if a nitrogen source is also present, proteins. The concept is to utilize the waste carbon dioxide as a food for algae, which will be grown in ponds covered by plastic sheeting so as to maintain an atmosphere rich in carbon dioxide. A pictorial representation of such a pond is given in Fig. 1. Oxygen is evolved in the photosynthetic process, and the utilization of this oxygen as an energy source by means of more ingenious chemistry can result in the production of ammonium nitrate from atmospheric nitrogen. The ammonium nitrate would not only provide a source of nitrogen for the algae to synthesize proteins, but could also be used as a fertilizer for the farmers.

It is possible to select algae that can produce a material of high protein content — say, 60 per cent protein and 40 per cent carbohydrate, or the reverse ratio. The algae can be harvested and returned to the fermentation system (after an enzymatic treatment to break down the polymeric substances comprising the algae cell walls). The carbohydrates in the algae can then be converted by fermentation techniques into ethanol, thus increasing the overall efficiency of the fermentation process. The proteins contained in the algae cells would be precipitated with the residue, and would thus supplement the protein content of the normal DDGS byproduct. These additional proteins in the DDGS would not only increase

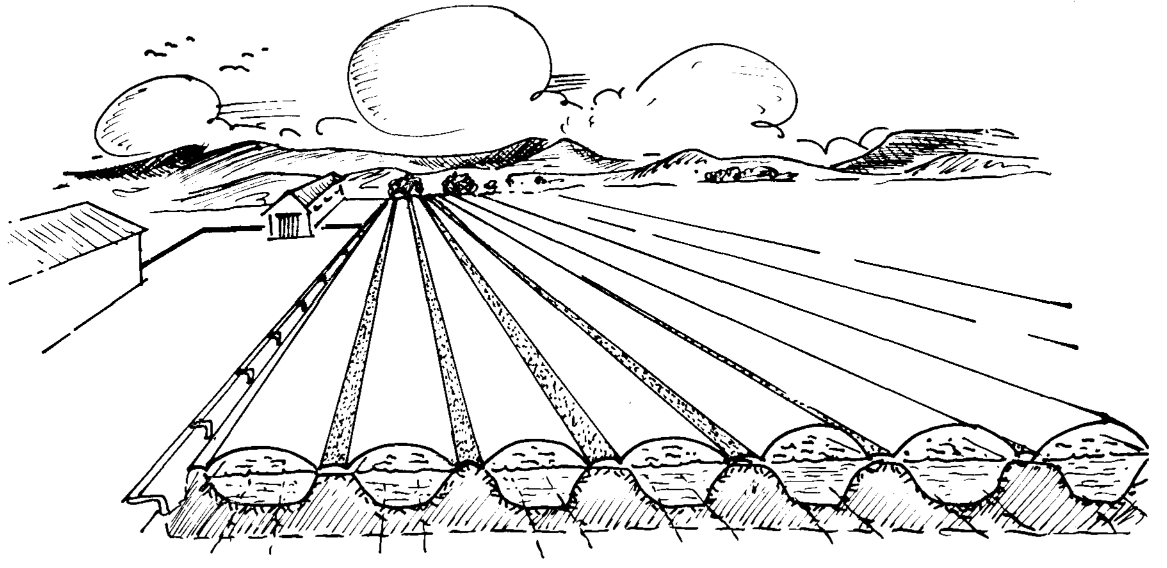

Fig. 1—Algae ponds covered with plastic sheeting

the quantity but would also enhance its protein value.

Another way in which the algae can be used is even simpler (and in many respects more attractive from the point of view of the main objectives of the agrochemurgical concept) — to feed algae to fish. There are certain fish species — the silver carp, for example — that grow exceptionally well on a diet of algae. The algae fish-pond is a convenient way of solving the problems of algae harvesting, and avoids the need to recycle the algae to the fermentation plant. The fish pond offers yet another opportunity for employment. There is an ever-growing demand for fish and fishmeal, a demand that can only expand dramatically as the conventional fishing grounds around the world are depleted. Thus, there are employment opportunities not only in harvesting the fish, but also in canning it for export purposes and producing fishmeal, which in turn can lead to the production of poultry and other white meat, which, in their turn, provide yet more employment for the agrochemurgical complex.

Here are a few figures to illustrate the importance of the algae concept. It is conceivable to think of utilizing approximately 100 000 tons of carbon dioxide per annum to produce some 50 000 tons of algae. This quantity of algae could conceivably produce 100 000 tons of fish, which would have a value, in one form or another, of at least 20 million rands per annum, and in turn would represent another 2000 to 3000 job opportunities.

Job Opportunities

If one now adds to the agrochemurgical complex the job opportunities represented by the various supporting personnel that are essential to an economic centre — personnel such as shopkeepers, school teachers, tractor mechanics, salesmen, and public servants — and if one assumes further a moderately low figure for the ratio of supporting personnel to directly employed personnel of 4 to 1 (in Zimbabwe this is usually assessed at 6 to 1), then one can calculate that one agrochemurgical complex producing only 1 per cent of our fuel requirements has catalysed the development of an economic activity equivalent to a decent living for some 40 000 families.

I have used the word *catalysed* purposely. It is a chemical term, and justifiably indicates that the concept has come about by the application of chemical techniques. Secondly, the word *catalyse* implies a speeding up or initiation of a rapid rate of reaction, and this is what we so desperately need in this country.

Imagine the impact if twenty of these agrochemurgical complexes could be established in different parts of the country, using a variety of crops to produce approximately 2 million tons of ethanol a year, representing only one-fifth of our liquid-fuel requirements. The complexes would give rise to job opportunities for approximately 800 000 people, and would probably mean the end of malnutrition. The total value of the ethanol produced would alone amount to 625 million rands per annum, and the value of the animal feeds and other materials produced by the complexes would be of the same order of magnitude. An enormous market for secondary goods would also be created, with an even greater catalytic effect on the economy. Is it too much to believe that an economic community would be established equivalent to a Western nation of 25 million people?

This is not science fiction, and I am the first to admit that there is an enormous amount of work to be done. It is impossible, in the time available, to go into all the scientific details and the calculations of the technical and economic feasibility on which this concept depends. However, a few comments on certain cardinal points may help to convince you that there is some realistic basis for the concept.

Technical and Economic Feasibility

The production of ethanol, which is the starting point of the concept, depends on proven technology that is being applied in many countries. The use of ethanol in fuel, including diesel fuel, is also a proven concept. If you doubt this, I can refer you to the 25 countries in the world and the 12 states in the U.S.A. that are using ethanol in fuel, and I can remind you of the Union Spirit that was used in South Africa after the Second World War.

The use of residues from fermentation for animal feeding is also commonplace. In the U.S.A., for example, DDGS is used extensively for this purpose. The use of residues from sugar fermentation has been extensively developed by the Rumevite Company in South Africa, and EC (ethyl concentrate) is exported from South Africa to many other countries. The use of roughage such as maize stover and bagasse as a feed to animals has also been studied extensively, and the treatment of roughage with caustic soda, which is the basis of the Rumensoda system, is gaining ground slowly in this country. I admit that much work remains to be done to optimize the system of collection and treatment, and to determine whether treatment with ammonia hydroxide has advantages over that with caustic soda.

The cultivation of algae under carbon dioxide atmospheres is perhaps the area that seems closest to science fiction. This is the subject of an extensive research project at the University of the Orange Free State, and I must acknowledge the contribution being made in the crystallization of this aspect into scientific fact by Professor Toerien and the scientists of the Environmental Unit at that university. Algae cultivation has been examined in many countries, and major advances have been made in countries such as Israel. It is close to utilization on a much larger scale, although I admit that it is at present confined to the production of materials of relatively high value such as carotene. This is largely because of the high cost of harvesting and drying the algae, and the capital cost of the plants. In the systems I have described, the cost of harvesting and drying to produce a concentrate have, to a large extent, been bypassed by incorporation of the algae slurry into the fermentation circuit, where it is used as makeup water. The capital cost depends, of course, on the yield of algae per hectare of pond area. The use of carbon dioxide atmospheres is critical in this regard, and most of the cost figures in the literature are based on systems that do not incorporate this feature. However, I have seen one set of results from an experimental plant in Texas that has used the carbon dioxide concept. Algae-production rates of at least 100 tons (dry mass) per acre (220 tons per hectare) were achieved over a year's operation. At peak periods, the algae-production rate was more than 150 tons per acre (330 tons per hectare).

If we take the lower figure to calculate the size of algae ponds for a module such as I have described, we estimate that an area of 180 hectares would be required to produce 50 000 tons of algae. This is by no means excessive. A square pond with a side of 0,5 km would be adequate. By comparison, the concept of tunnels covered by plastic sheets for the cultivation of crops is now commonplace, and the crop yields, at best, are only one-tenth of those possible from algae. Areas much larger than this are in commercial operation in Israel. The capital cost to convert such an area into a covered algae pond would not be more than 10 million rands, which is equivalent, at normal commercial rates of return, to approximately R60 per ton. Algae are valued at not less than R200 per ton. The supply of nutrients would cost not more than R20 per ton of algae — based on South African prices for nitrogen and phosphorus — and this does not allow credit for any oxygen produced. The feeding of algae to fish ponds is already being done in this country on a profitable basis.

Finally, the utilization of oxygen to produce hydrogen and then ammonia is well-known technology.

If there are any among you who have doubts about the availability of land and water for such a grand scheme, I can only ask you to visit Israel and imagine what the Israelis would do with a land area the size of the homelands in South Africa. The total area required for the agricultural component of an agrochemurgical complex if the lowest-yielding crop (maize) is used is equivalent to an area 140 kilometres square.

One big advantage of the concept is that one can start in a small way. Stage one could be the erection of an ethanol-production module (which need not be as large as the one I have described). This in itself would be an economically viable system, which could expand as agricultural development took place. The animal-feeding system and the algae systems could be developed at a later stage, together with the other infrastructure that would evolve with the demands of the community.

Education and Infrastructure

The evolution of educational facilities is also a fascinating topic for conjecture. Obviously, there would need to be schools and agricultural training centres, which in time could expand into technical colleges and even universities, following a pattern similar to the evolution of many universities from the A & M colleges in the U.S.A. This development would not be imposed artificially, but would evolve with natural demand. May we even dare to hope that these educational centres would attract students and teachers from other parts of Africa?

The implementation of this master plan for the establishment of agrochemurgy in centres around the country is not going to be easy. There are many problems to be solved; perhaps one of the most important of these is that relating to the utilization of agricultural land. The motivation derived from land ownership requires that the existing tribal system in most of the homelands would have to be changed dramatically. However, I consider that the first steps towards solving this problem could be taken in the near future by following a suggestion made by Dr W. J. de Villiers. There is much talk about the consolidation of land into the homelands, and I am fairly sure that this will be a major feature of government policy in the next few years. Dr De Villiers suggests that it would be appropriate to insist that all the land that is consolidated into the homelands be made available for private ownership.

Another big problem relates to the question of whether we can possibly educate and train the people for whom the scheme has been developed. They would need to work efficiently and scientifically, and to develop the communities on their own account around these complexes. Certainly, industry would have to play a prominent role in training, but it is doubtful whether industry alone could carry this burden.

This is certainly going to be a major task, but I believe we already have a mechanism that could go a very long way towards achieving this. Once again, this is a concept suggested by Dr W. J. de Villiers.

This mechanism is the military training scheme, and I am sure I am not treading on anybody's toes when I say that these young people could make a major contribution. I visualize, for example, the establishment of military task forces that can be sent to different parts of the country to assist in establishing the infrastructure that is so essential to the evolution of the agrochemurgical master plan. From a military point of view, such activity in the country can be only of benefit, since the personnel involved will get to know the people, the area, and the problems. In my view, nothing could be more valuable in preventing the type of terrorist war that we all hope will never materialize.

Certainly, a tremendous effort and an enormous amount of work would be involved in the implementation of the master plan as I have propounded it. But, I believe this could be the most exciting challenge that faces the White community of this country. You may well ask what we are waiting for.

TABLE I

COST OF ETHANOL PRODUCTION

		From Maize	From Cane
Capital Cost	R x 10^6	37,2	41,1
Working Capital	R x 10^6	5,1	6,4
Total Capital	R x 10^6	42,3	47,5
Agricultural Raw Material, C/l		27,8	21,8
Other Variable Costs, C/l		1,9	0,7
Total Variable Cost, C/l		29,7	22,5
Less by Product Credit, C/l		13,0	0,6
Nett Variable Cost, C/l		16,7	21,9
Fixed Costs, C/l		2,6	2,6
Rota at 15%, C/l		6,3	7,1
Total Cost, C/l		25,6	31,6

Ethanol, the Key

The key to this agrochemurgical concept is the use of ethanol in motor fuels, and, no matter how keen we may be to implement this concept, the approval of the State is all important. No alcohol can be added to fuels without State consent.

Unfortunately, there is considerable opposition to the use of ethanol, and some of the most incredible arguments have been raised against it. Most of these arguments can be refuted scientifically. There is one that must be dealt with here: the contention that the production of ethanol is uneconomic in comparison with that of other fuels such as imported petrol or diesel fuel.

Table I gives a breakdown of the costs involved in the production of ethanol from maize and sugarcane for the simplest case, i.e. without allowance for the benefits of animal feeding and the utilization of carbon dioxide by algae.

Fig. 2 gives an analysis of the existing price structure of liquid fuels derived from oil in comparison with the price of fuels derived from agricultural materials. As you know, the detailed pricing structure for petrol is

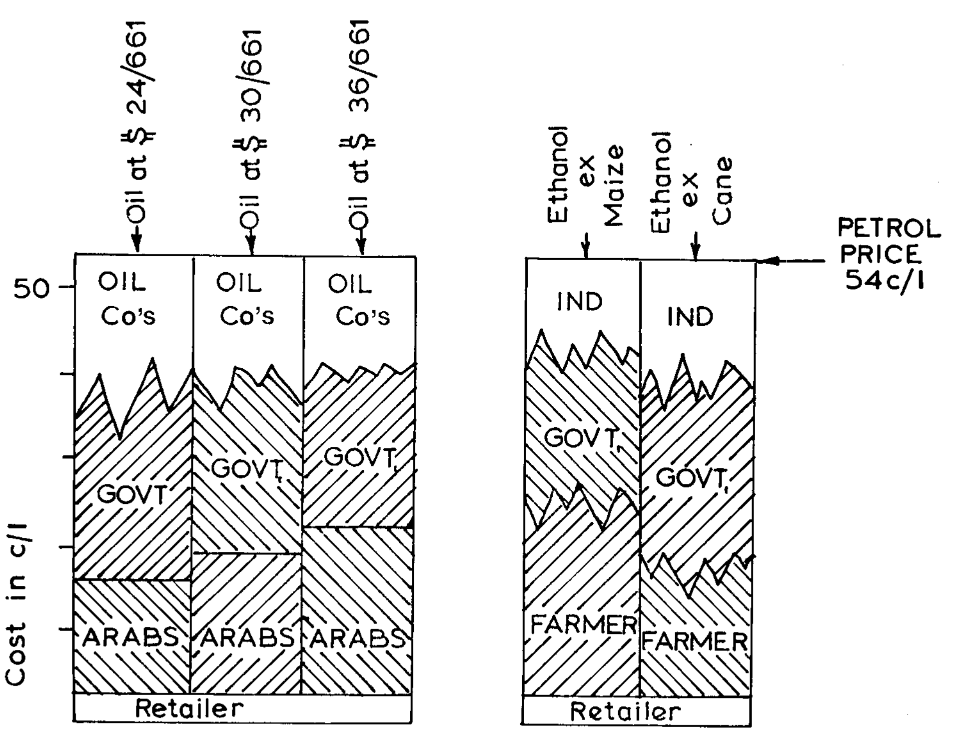

Fig. 2—Comparison between the benefits derived from oil and those derived from ethanol

confidential; indeed, it is against the law to quote such figures. However, these values are derived from published sources, and, to comply with the law, I have not indicated the exact cost figures.

In the case of fuel from oil, there are three main parties who benefit from the sale of petrol or diesel fuel: the crude-oil suppliers (I have called them Arabs), the oil companies, and the State. Ethanol also concerns three parties: the farmers, the chemical industry, and the State. You will see from Fig. 2 that, even at the highest cost of ethanol, the State will not lose, i.e. the taxpayer will not have to subsidize ethanol. The only losers are the Arabs, and the oil companies if the latter are foolish enough not to join the chemical industry in making the ethanol concept possible.

By far the greatest proportion of the cost of ethanol production goes in the form of payments to agricultural communities. It is in the form of wages, payments for fertilizers, and operating costs. Indeed, virtually all of the total expenditure envisaged, which might perhaps amount to some 500 billion rands, will be spent inside South Africa. It is a direct contribution to the gross domestic product, and, if only by way of taxation, the State will gain even more than indicated in the diagram.

A National Campaign

Obviously, there are many similar opportunities in other fields. I have not even had time to consider one of my favourite topics — the use of minerals as the basis of a similar master plan for the development of our resources. However, if there is any merit to be derived from the concept that I have outlined, it must be tackled as a national campaign. We require guidance from the leaders of the country in industry and government. We need an act of far-sighted statesmanship to launch this programme, and I believe we have such statemen in our midst.

But, the most important message that I want to convey is that it is the scientist, the chemist, and other technical people who must play a major part in making such concepts viable. An enormous amount of research and scientific development will have to be undertaken to make this master plan a success, and our universities and research organizations will have to be involved in a major way in education and research. It is a fantastic challenge, and, although at first sight it might appear to be an impossible dream, I can assure you that the concept has been analysed very critically, and I believe it is something that can be achieved.

Metallic corrosion

The International Congress on Metallic Corrosion (ICMC) takes place at four-year intervals. The 8th one will be held in Mainz (Federal Republic of Germany) from 6th to 11th September, 1981.

About a thousand participants are expected to attend the event. The Congress is supported by the International Corrosion Council, the European Federation of Corrosion, and the German Corrosion Group (AGK). The official language is English.

The topics are as follows:

1. Processes in Material/Environment Systems — Testing — Prevention
   - 1.1 General and Localized Corrosion
   - 1.2 Mechano-Chemical Corrosion
   - 1.3 High Temperature Corrosion
   - 1.4 Corrosion Protection
2. Solutions to Problems in Industry and Every-day Life
   - 2.1 Offshore and Marine Techniques
   - 2.2 Chemical Industry
   - 2.3 Petrochemical Industry
   - 2.4 Oil and Natural Gas Winning
   - 2.5 Power Industry and Related Techniques
   - 2.6 Nuclear Industry: Nuclear Fuel Reprocessing, Waste Storage
   - 2.7 Water Supply and Central Heating
   - 2.8 Buildings, Constructions, and Pipelines
   - 2.9 Agricultural and Food Technology
   - 2.10 Future Techniques
3. Economics, Education, Information, R&D Programmes

All persons wishing to contribute papers or who are interested in receiving more details on the Congress (Call for Papers) are invited to contact the organizer by October 1980: DECHEMA, 8th ICMC, Postfach 97 01 46, D-6000 Frankfurt/Main 97, West Germany.