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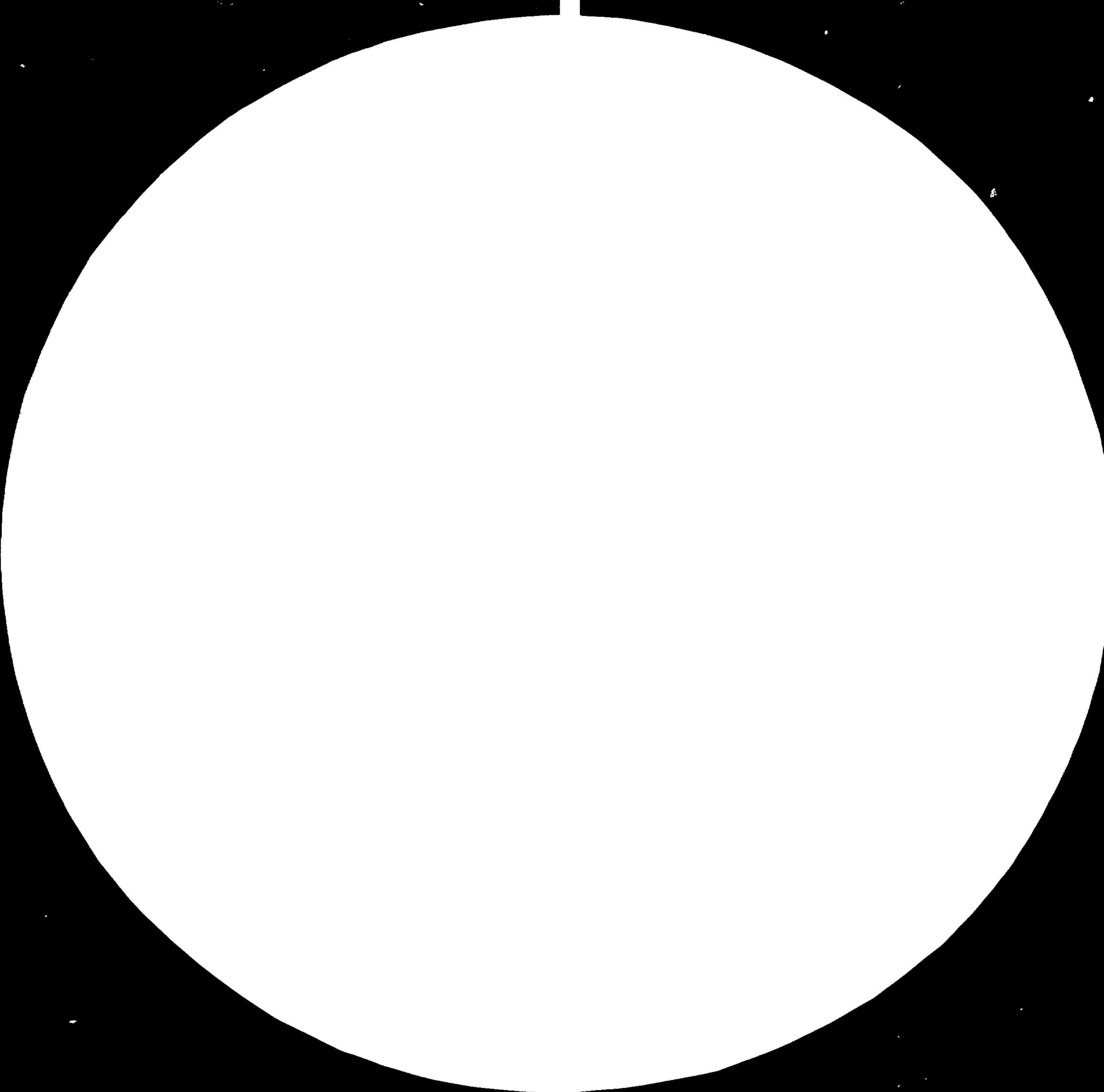

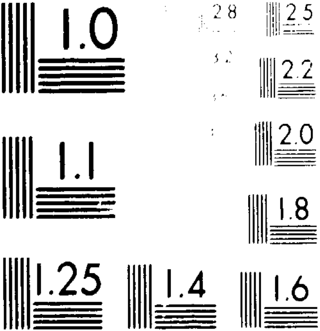
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L H Manderstam and Partners Limited have the honour to submit their report "Sectoral Study on the Development of Chemical Industries in the Peoples Democratic Republic of Yemen" - Project No SI/PDY/79/801, Contract No 80/31/DR commissioned by UNIDO on 17 March 1980.

The team visited the Prohect Area from 26 March to 23 April. One member of the team was requested to return to PDRY for a further period of one week in August to report on the oil seed situation in more detail.

The members of the team would like to acknowledge the helpful cooperation given by organisations and individuals visited in PDRY, the UNIDO resident team and the Ministry of Industry. In particular we would like to thank Mr Uthman Abd-el-Jabber, the Deputy Minister of Industry, and Mr Salem Basabrain, Director of Investment in the Ministry of Industry, for their interest and encouragement and our counterpart Mr Bahanain whose courtesy and assistance was unfailing throughout the period of the team's visit.

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SECTORAL STUDY ON THE DEVELOPMENT OF CHEMICAL INDUSTRIES IN PDRY

Prepared for

THE GOVERNMENT OF THE PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN

On behalf of

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

by

L H MANDERSTAM AND PARTNERS LTD

OCTOBER 1980

Contract N° 80/31/DR Project N° SI/PDY/79/801

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I INTRODUCTION

1.1 L H Manderstam and Partners Ltd were engaged by the United Nations Industrial Development Organisation (UNIDO) to undertake a sectoral study for the development of chemical industries in the Peoples Democratic Republic of Yemen (PDRY) on behalf of the Ministry of Industry.

The purpose of the mission was to provide assistance to the Government of the PDRY in identifying potential chemical industry projects which will benefit the long-term development of the economy.

1.2 The original Terms of Reference are given at Appendix I. However, with the agreement of both UNIDO and the Ministry of Industry in PDRY the scope of the study was expanded to include industrial development in general. Soon after the team's arrival in PDRY it became apparent that the additional effort involved in looking at the whole industrial sector would be useful to the Ministry of Industry for the following reasons:

(i) As discussed elsewhere in this report there appears to be little likelihood of developing a petrochemical complex downstream of the existing oil refinery unless an indigenous source of oil is discovered and produces commercial quantities.

(ii) Geological exploration in the PDRY is still in its early stages and whilst the country may well have considerable mineral wealth, the proven reserves so far offer limited scope for the development of a viable chemical industry.

(iii) A number of feasibility studies, covering a wide range of industries, have already been carried out. It was considered that an independent review would be of assistance to the Ministry of Industry in determining priorites and placing these studies in perspective. (See Chapter V)

(iv) The Government of the PDRY is about to implement a new Five Year Plan and it is an opportune moment to comment on its industrial components.

(v) There is the inevitable problem of defining what is and what is not a chemical industry. The Terms of Reference mention paints, matches, soap, plaster of Paris and writing chalk which could be classed as chemical industries, but would normally come under the heading of process industries.

1.3 A sectoral study conducted with a limited budget and time scale has to rely on overall impressions and broad generalisations far more than would be the case in a detailed feasibility study. In one month's field work the team visited 22 factories and 8 Government Ministries or Departments; interviews normally lasted for two or three hours and in all factories except one we also managed to have a quick tour of the premises. This approach allows one to form a fairly reliable opinion about the current state of a company and the nature of its principal problems, but is not sufficient to uncover the fine detail.

However, since there is a great lack of reliable statistical data, in many cases much more time might have been spent in individual factories without any great improvement to the profiles which are given in Section IV.

The layout of this report is as follows:

Section II is a summary of the report and its conclusions.

Section III is a survey of the economic background of PDRY and a review of natural resources which includes minerals agriculture and fisheries.

Section IV contains profiles of 22 existing factories.

Section V reviews feasibility studies which are still outstanding.

Section VI discusses candidate industries for further study.

A number of the candidate industries are then developed further in the Appendices. Again because this is a sectoral study there is an inevitable lack of detail particularly from the point-of-view of marketing so that we have had to make reasonable assumptions about the appropriate size of different industries. Nevertheless, it is hoped that this report contains sufficient information to show that many of the projects suggested are worth further study and that an adequate number have been included to enable the Ministry of Industry to maintain the pace of development for at least a decade.

II SUMMARY AND RECOMMENDATIONS

2.1 It was agreed with UNIDO and the Ministry of Industry in PDRY, that the object of this study is to carry out a survey of the full range of industry in PDRY and to make specific recommendations for further development, particularly in the chemical sector.

2.2 This report begins by reviewing the country's mineral, agricultural and fisheries resources and examines the provisions of the new Five Year Plan in so far as it affects industrial projects (see Section III). This is followed by a survey of 22 factories operating in Aden and Mukalla (see Section IV). Section V comments on various feasibility studies which are still under consideration. Section VI gives brief outlines of 24 projects which in the long term have a reasonable chance of proving viable, and in Appendices II - XI ten of these projects are developed in some detail. At the request of the Ministry of Industry, Appendix VIII explores the options available for improving the performance of the new oil seed mill.

2.3 PDRY is not well endowed with proven natural resources, but the search for minerals, and in particular oil, is still in its infancy. This report considers the non-metallic building materials (limestone, gypsum, clay etc) glass sand, salt, scrap metal and water. The new Five Year Plan allocates 60% of the industrial budget to a single cement project and a further 12% to the rehabilitation of the salt industry. Whilst these may both be highly desirable, this seems too much emphasis to place on two projects when there are so many other worthwhile projects which need to be considered in the context of overall industrial development.

2.4 The agricultural potential of PDRY will always be limited by the availability of water and although a great deal of attention is being paid to the expansion of irrigation, there do not appear to be many opportunities for further agro-industrial development. A cotton ginnery, a textile mill, a vegetable oil mill, tomato and vegetable canneries and a tannery have been established, although many of them are beset with problems which are dealt with in Section IV. With the steady growth in urban population there is bound to be increasing competition for water between industry and agriculture and this represents one of the limiting factors for industrial expansion in PDRY.

2.5 By contrast the fish resources along the South Arabian coastline appear to be plentiful (although the evidence is largely from research vessels and needs to be interpreted cautiously). There should be considerable scope for further development in this field. However, we believe that the sale of frozen, tinned and dried fish is likely to prove more profitable than the production of fish meal and oil which is the course currently being pursued.

The immediate requirement is to increase the number of fishing vessels and to improve catching techniques, transport and unloading facilities.

2.6 The Aden refinery constitutes by far the largest single industry in PDRY and its operations have a significant effect on the Balance of Payments. From a low point at the time of the closure of the Suez Canal, its fortunes have gradually improved, and in the last few years, since it has undertaken contract refining, the throughput has increased considerably. Nevertheless, it is still operating well below design capacity and there is little doubt that if this could be increased by negotiating more processing contracts it would be of much greater benefit to the PDRY economy than practically any new industrial project. Nevertheless, the refinery's Vis Breaker project would increase both flexibility and range of products, and should be given high priority.

2.7 Our inspection of existing factories revealed a number of problems and difficulties which recurred frequently:-

(i) There is a great shortage of skilled manpower despite the fact that considerable effort is being expended on apprentice training schemes. In part this is the inevitable result of the high wages offered by neighbouring oil producing countries.

(ii) Although it is claimed that PDRY is short of labour, there are several over-manned factories and there is no reason to expect that shortage of unskilled labour will restrict the rate of industrial development. However, unlike most developing countries unemployment is not a pressing social problem in PDRY.

(iii) A number of factories have been given to PDRY as a form of bilateral aid. The economic justification for some of these was never very clear and the standard of engineering applied in the construction left a great deal to be desired. The net result is that there are a number of plants making the wrong products and wasting the valuable management talent which is trying to rectify them.

(iv) Fire fighting and safety precautions are well catered for in some factories, but in others there is an urgent need for a detailed review.

(v) There is a general shortage of reliable statistical and accounting data. The resident UNIDO team in the Ministry of Industry are making a valuable contribution towards correcting this situation and it is desirable that this work should be continued.

(vi) A problem related to the above is the lack of adequate market research data. Many factories use the Home Trade Company as their selling agent which inevitably leads to a lack of awareness on the part of the manufacturers as to the precise market requirements.

(vii) Shortage of skilled personnel has led to a lack of maintenance planning and production is frequently held up by lack of appropriate spare parts. There is a good case for centralising at least some of the maintenance facilities and extending the procedures currently practised by the Aden Refinery.

(viii) Little attention seems to be paid towards conserving water or treating effluents and yet because of the overall shortage of water these problems will inevitably loom larger as time goes by and need to be tackled soon.

(ix) Few companies appeared to have precise ideas of how and where to sell in foreign markets and their overseas contacts need to be developed considerably if they are to make any real impact. By the same token, any feasibility study for a new project which pre-supposes that part of the output will be for export should be required to make some allowance for the cost of developing overseas business, a point which seems to have been ignored in most of the studies we examined.

(x) Construction of new factories appears to take far longer than normal. This is probably the result of insufficient supervision and coordination of contractors. Whilst the Ministry of Industry has a good planning team, it needs to strengthen those departments concerned with project execution, and not place too much reliance on turnkey contractors.

2.8 Despite these problems there has been considerable progress made in a remarkably short time in converting the PDRY from a service economy, designed to supply passing ships and the British military base, to a manufacturing economy which is becoming steadily more self-reliant. But there have been so many companies started since Independence that there may well be more to be gained in the short term by concentrating on improving existing plants than in launching new projects.

2.9 24 candidate industries are recommended for further study in Section VI, the list being made up as follows:

*Polypropylene Sacks	*Iron Foundry
General Printing and Packaging	Wire Products
Waste Paper Recovery	Galvanising Plant

- Lube Oil Blending
- Pesticide Formulation
- Aerosol Filling Line for Cosmetics and Toiletries
- *Plastics Blow Mouldings, Pipe Extrusion and Film
- Calcium Carbonate Filler
- *Lime Kiln
- Gypsum Building Panels
- *Chloralkali
- Deodorising of Fish Oil
- *Processing of Sesame Seed
- Mixed Fibre/Fine Thread Production
- *Bitumen
- Tyre Retreading
- Sodium Sulphide
- Sodium Silicate
- *Glass Bottles and Tableware
- *Glass Fibre

Those marked with an asterisk are dealt with in more detail in ten Appendices. The total investment required for eight of these projects is approximately US $35 million compared with the total of US $100 million allocated to the industrial sector under the new Five Year Plan. Together with the other 14 suggested projects this should provide ample scope for further development of the chemical and manufacturing sectors over the next decade.

III ECONOMIC BACKGROUND AND SURVEY OF NATURAL RESOURCES

3.1 General

3.1.1 The PDRY lies at the South-Western corner of the Arabian peninsula and has a population of 1.73 million. The capital and main port, Aden, was developed as a major staging post and ships bunkering station for traffic between Europe and Asia and the fortunes of the country were largely dependant upon the Suez Canal until its closure in 1967. In that same year British aid and military expenditure, which had more than covered the visible trade deficit, was discontinued making it impossible for the new Government to balance its budget.

3.1.2 As is to be expected in a Centrally Planned Economy, virtually all industry is owned and directed by the Government. However, in a number of smaller companies of low strategic importance, minority private share-holdings have been permitted and are now being encouraged. This is known as the Mixed Sector. There is also a growing private sector mainly concerned with clothing and minor hardware.

3.1.3 To assist the country in the transition from a service economy to one based on agriculture and manufacturing, the Government has requested and received external financial aid and technical aid, much of it on very favourable terms. In 1969 all foreign assets in the Republic were nationalised.

3.2 Economic Planning - Five-Year Plan

3.2.1 The first Three-Year Development Plan (1971-74) was largely inhibited by a severe shortage of funds. However, through outside assistance the second plan for the five years, 1974-79, saw considerable growth and development, particularly in respect of fisheries and the oil industry. Bilateral Assistance was received from USSR, China, Cuba, Bulgaria, German Democratic Republic and North Korea.

3.2.2 The current Five-Year Plan should have commenced in 1980, but Government has delayed it for one year, and it will not start until 1981. By this means the PDRY has brought its planning into line with the COMECON countries.

3.2.3 At the time of the Consultant's visit, the final plan for 1980-85 had not been released. However Table I sets out the draft plan for expenditure by the Ministry of Industry. It is understood that the total provision of 25.9 Million YD (US $100 million) is unlikely to be changed significantly in the final version. It should be noted that 63 per cent of the total budget has been allocated to one single project - the Cement Plant - while a further 12 per cent has been set aside for the rehabilitation of the Salt Works.

3.2.4 Whilst there may be a strategic argument in favour of having a cement plant, there seems little likelihood of it being justified on economic grounds alone. Likewise the viability of the salt project depends entirely upon being able to secure a large and stable export market. The need for a new oxygen plant should also be questioned, bearing in mind thatthe existing factory only operates for two weeks in every month and that the Aden Oil Refinery also has an oxygen plant with spare capacity.

3.2.5 We doubt whether these three projects will maximise Domestic Added Value and Net Foreign Exchange Benefit when compared with some of the other less capital intensive projects which have been suggested and we would recommend that the resident UNIDO team should be asked to carry out a cost/benefit analysis of the projects on the programme so that there is no confusion between those projects which are carried out for strategic reasons and those whose primary object is profit.

3.3 Economic Situation

3.3.1 Between 1973 and 1977 there was an increase in GNP (Constant 1974 Prices) of just over 32 per cent. All industry sectors showed growth with the exception of the Aden Oil Refinery which at current market prices declined by just under 60 per cent. However, since 1977 there has been much improvement. (see Table II.)

3.3.2 As a result of the Government's policy of developing the Republic's industrial base, production in this sector increased by 181 per cent. As an indication of the meagre resource base in the PDRY the Agricultual sector showed the lowest rate of growth at 19.5 per cent. Performance in this sector was inhibited by a period of severe drought which drastically reduced livestock production. Currently numbers are increasing and a faster rate of growth should be achieved over the next five years.

3.3.3 The higher rate of increase in Gross National Product was due to an acceleration of workers' remittances from abroad. The advantage of this cash inflow to the general economy of the Republic is considerable. However, from the industrial development aspect, there are obvious disadvantages. Many of those working abroad are skilled in trades urgently required in PDRY, but while they earn the level of wages offered in, say, Saudi Arabia it is unlikely that they will return.

3.4 Imports and Exports

3.4.1 Details of imports and exports for the period 1973 to 1977 are set out in Tables III and IV. Growth in imports has been almost twice as fast as the growth in exports and the trade deficit has been widening steadily. As a result, Government exercises a very strict control on imports. The level of individual imports is therefore often more influenced by Government control of foreign exchange than by demand. This feature has made demand forecasting, particularly in the consumer sector, highly subjective as can be seen in later sections of this report.

3.4.2 In 1977 machinery and transport equipment accounted for the major portion of imports at 35 per cent, while food and livestock accounted for 23 per cent. Petroleum products amounted to 15 per cent. The largest growth over the period was in the machinery and transport equipment sector, in particular trucks.

3.4.2 There are two major export earners, fresh fish and petroleum products which together earn 75 per cent of the Republic's hard currency. In 1976 and 1977, there was a substantial increase in the earnings of petroleum products and there has been a further improvement since them.

3.4.4 Cotton has been a major export earner, but in recent years production has declined and also some of the output has been used in the local textile mills.

3.4.5 Coffee, hides and skins all make small but useful contributions. Salt exports have shown a highly variable performance over the years, but presently show signs of some improvement.

3.5 Industrial Production

3.5.1 Between 1973 and 1976 the industrial sector (excluding the Aden Refinery) grew fairly rapidly at 15 per cent per annum. In Table V, production of major industries from 1973 to 1977 is given in basic units of output. The growth in some industries represent a very creditable performance for example leather shoes, machinery spare parts, dairy products and plastic footwear. On the other hand, the production of cotton has been disappointing - a fact which is also reflected in the relatively small production of vegetable oil.

3.5.2 Table V gives production figures in units of output and not of value and does not therefore give any indication as to whether individual industries are profitable. Nevertheless it gives an idea of their relative importance.

3.6 NATURAL RESOURCES

3.6.1 Geological Resources

The Department of Geology and Mineral Exploration was established in 1970 and given five main objectives:-

(i) The search for non-metallic elements to support the construction industry.

(ii) Exploration for metals.

(iii) Geological, geophysical and mineralogical mapping of the entire PDRY.

(iv) The establishment of a laboratory for mineralogical and chemical testing.

(v) The training of local staff.

3.6.2 Non-Metallic Elements

Priority has been given to this first objective and the work is nearing completion. The results can be summarised briefly as follows:-

(i) A suitable site for lime and cement manufacture has been found at Wadi Bana in the Abyan Governorate and detailed studies of reserves and methods of extraction have been made. An hydro-geological study has established that there is sufficient water in the vicinity to sustain a cement complex.

(ii) An alternative site for a lime kiln is being investigated at Sarrar not far from Wadi Bana. However the limestone deposit at Shemosa near Mukalla, which is being worked, has not been studied in any detail. (see Section 4.22.)

(iii) Gypsum deposits have been studied at Gil Bawazir in the Hadrahmut Governorate and at Mahfid in the Abyan Governorate. The former deposit is estimated to have reserves of six million tons and the latter two million tons. (see Section 4.21.)

(iv) High purity sandstone, suitable for glass making, has been found at Haban, not far from Mahfid and preliminary estimates put the reserves at three million tons.

(v) Several clay deposits have been found which would be suitable for brick making. On the other hand, the only kaolins found so far are impure and not suitable for ceramics.

(vi) The quarrying of volcanic tuff used in the manufacture of breeze blocks has been developed at Shukra and at Bir Ali and a building stone quarry near Mukalla is under study.

(vii) No good sources of asbestos have been found nor any extensive guano deposits even on the island of Socotra, although this might have been expected, given that the South Arabian coast is such a fertile fishing ground.

3.6.3 The significance of this work from the point of view of this review is that it provides the foundation for a cement project which has become the central feature of the next industrial Five Year Plan, and also demonstrates that the resources are available to develop such products as lime (see Appendix VI) building plaster (see Section 6.26) and glass (see Appendices X and XI). Solar salt also falls within the category of non-metallics, but is the responsibility of the Ministry of Industry rather that the Department of Geology and Mineral Resources. This is discussed in Section 4.2.

3.6.4 Metals

The search for metal ore bodies has, until now, been relatively limited, but it is to be hoped that more progress will be made when the geological and geophysical mapping of PDRY on a 1:100,000 scale has been completed. At the moment there are a number of maps of different areas on different scales and it is obviously of crucial importance to bring some order to this diversity and to ensure that the gaps are filled in. It is estimated that this work will take until about 1984. So far traces of copper have been found, beach sands have been tested for heavy metals, and some low grade iron ore deposits have been investigated, but none of these show promise of being commercially viable. One obvious source of metals which should not be ignored is the scrap iron which has been accumulating for many years in the country. This is considered further in Appendix III.

3.6.5 Oil

Both Russian and Italian companies are currently exploring for oil in the Eastern Governorates, where the formations are predominantly sedimentary as opposed to the western parts of the country which are largely igneous or metamorphic. So far the results of drilling are said to be 'encouraging' and there seems to be no lack of enthusiasm for continuing the search.

However, in the absence of any indigenous oil, there appears to be little chance of developing petrochemical industries downstream of the existing refinery. (see Section 4.1)

3.6.6 Whilst the discovery of oil would inevitably bring about profound changes in the PDRY economy, it is worth remembering that the controlling factor in most industrial developments is more often the size of the potential market rather than the availability of a particular raw material. The discovery of oil would probably lead to the building of another refinery and, possibly, some large petro-chemical plants, but these would, of necessity, be export-orientated for their products would find only limited outlets in PDRY. The secondary effect, namely that the discovery of oil brings increased wealth to the population and an increasing demand for goods and services, does not necessarily imply that the opportunities for investment in profitable local industries are thereby increased.

3.6.7 Water

Hydrogeological studies are the responsibility of the Ministry of Agriculture whilst the development of water resources for domestic and industrial purposes comes under the Water Corporation. From the point of view of this industrial survey there are several important aspects which need to be taken into account:-

(i) The fact that water will never be in plentiful supply anywhere in PDRY limits development to those industries which do not require large volumes of process water.

(ii) Industries which require a great deal of cooling water should be sited near the sea.

(iii) Water is the limiting factor in agriculture and the allocation of land between food and cash crops will affect the quantities of raw materials such as cotton which can be made available to industry.

(iv) Every effort needs to be made to reuse domestic and industrial effluents which implies building fairly extensive sewage works as opposed to pumping effluent into the sea.

(v) The treatment of water for domestic/industrial use represents an outlet for chlorine.

(vi) The development of wells and pipelines, not only for domestic and industrial use, but also for agricultural irrigation schemes, represents a potential market for plastic and metal pipes, glass fibre channels and water tanks, metal valves and pump impellers, all of which could conceivably be manufactured locally.

3.6.8 In considering the industrial demand for water it is important to retain a sense of proportion. At present the total industrial and domestic water requirements of Aden alone amounts to about 19 million m^3/annum. On the assumption that reasonably well-irrigated land receives the equivalent of 50 cm/annum, then Aden's total consumption is equivalent to an irrigation scheme of about 3,800 hectares.

3.6.9 By 1983 it is expected that Aden's population will have increased to around 800,000 people with an estimated water requirement of 32 million m^3/annum which is the equivalent of a further 2,600 hectares irrigation scheme. Bearing in mind that the total amount of land under irrigation is currently 46,000 hectares this implies that by 1983 Aden's water consumption will be equivalent to 15 per cent of the total irrigation demand. This, again, emphasises the importance of installing proper sewage treatment plants and ensuring that the effluent from these plants is recycled.

3.6.10 The consumption of chlorine for water purification will obviously depend on the quality of water abstracted from the wells, but is likely to be in the region of 3-4 ppm, so that by 1983 the requirement for the Aden water system should be in the region of 100-150 tons/annum of available chlorine. This forecast should be compared with the 1975 consumption quoted by the Water Corporation of 9½ tons/annum, which suggests that the present supply is not being properly treated. Together with the requirements for other towns and also the oil refinery which consumes 75 tons/annum this could be sufficient to support the very small chloralkali plant which is discussed in Appendix VII.

3.6.11 During the period 1980-83, it is estimated that 112 kilometres of new pipelines will be required for the provision of domestic and industrial water; this does not include a possible 50 km pipeline between Abyan and Aden or any pipes used in connection with irrigation projects. Whilst no figures are available on the separate requirements of plastic, metal, glass fibre and asbestos/cement pipes, it is more than likely that a plastic pipe-making plant could be justified, particularly if the demand for electrical conduit is also taken into account. If it turns out that there is sufficient scrap metal to justify a small iron foundry, it would be worth considering a pipe-spinning machine, the smallest of which will normally produce about 1,800 tpa of 4" cast iron pipe.

Likewise, if glass manufacture is to be pursued, the possibility of producing glass fibre should be investigated at the same time. There is a small plant on the market capable of producing 250 tpa of fibre, the equivalent of 50 km/annum of 8" pipe. (see Appendix XI).

3.6.13 It is clear from the report on non-metallic elements, that the Department of Geology and Mineral Exploration is making a major contribution to the development of PDRY and our only comment is that there is perhaps insufficient coordination with the Ministry of Industry. For example, the gypsum plant at Gil Bawasir is designed to produce only 750 tons/annum and it is hardly worth spending time and effort establishing that the potential reserves are six million tons. Short cuts could be taken if, in future, the Ministry of Industry were to indicate what quantities were likely to be required rather than asking for a particular deposit to be examined in full detail.

3.7 AGRICULTURAL RESOURCES

3.7.1 The Ministry of Agriculture's statistics for the planted acreages, tonnages and yields for a variety of crops for the period 1974-77 are reproduced in Tables VI and VII. Table VIII which represents the private sector of agriculture has been derived by deducting the figures in Table VII from those of Table VI. Table IX shows quantities, values and prices for the same period.

For an industrial survey, the agricultural sector is of interest both as a source of raw materials and as a potential consumer of finished products, but it is not part of our task to examine the workings of this sector in any detail. Nevertheless, it is perhaps worth making the following observations on Tables VI to IX.

(i) The total areas of arable and irrigable land available to the State and Co-op farms were given by the Ministry of Agriculture as:-

(acres)

	Arable	Irrigable
1974	178,016	89,083
1975	211,212	104,770
1976	227,532	103,095
1977	232,263	90,329

but the total acreages planted by the State and Co-op farms which are given in Table VII were:

1974	69,045	representing 39 per cent of the total available
1975	91,207	representing 43 per cent of the total available
1976	100,663	representing 44 per cent of the total available
1977	93,451	representing 40 per cent of the total available

This rather suggest that only the irrigable land is being cultivated and, presumably the remaining 60 per cent should be classed as grazing rather than arable until such time as the irrigation works can be extended. In other words, there is no large acreage lying fallow which could provide an immediate increase in production as the statistics seem to suggest.

(ii) It is apparent from Table IX that the overall revenue from the agricultural sector has increased by slightly less than 10 per cent between 1974 and 1977, whereas the total acreage planted has increased by 19 per cent. Thus, not only has overall productivity fallen, but, in a period of world wide inflation the annual income of farmers, who represent a significant proportion of the total population, has remained static. It would be surprising if this did not lead to a sense of disenchantment particularly with those crops which require a good deal of physical effort. This may be one explanation for the rapid decline in cotton acreage and the corresponding increase in cereals and fodder crops which have lower labour requirements. It does not, however, account for the phenomenal rise in the acreage under sesame.

(iii) The same trend in reduction of cotton acreage and increase in cereals and sesame is noticeable in both the State and Cooperative farms and the private sector.

(iv) Despite the increased acreage under cereals the quantity produced has not increased significantly and the cost of importing wheat and flour has continued to rise.

(v) There appears to have been a significant decline in the acreage of dates, which form an important part of the staple diet in rural areas.

(vi) The State and Cooperative Farms account for the following proportions of the total acreage under cultivation:-

1974	36 per cent
1975	56 per cent
1976	49 per cent
1977	41 per cent

However, with the exception of cotton, vegetables and fruit, crop yields appear to be identical in both private and public sectors which seems disappointing considering the amount of investment which has been made in the State farms. In fact this is more likely to be a function of how the statistics have been compiled, but the comparisons between the two sectors are important as a means of showing whether or not investment, which is designed to raise productivity, has actually had the desired effect.

3.7.2 From the point-of-view of agro-industrial development it is important to determine whether the shift in emphasis away from cotton and towards sesame and cereals is a deliberate long term trend and likewise whether the decline in date production is to continue. There may be very sound agricultural and economic reasons for such changes, but nevertheless the Ministry of Agriculture must appreciate the fact that altering acreages by wide margins from one year to the next makes it exceedingly difficult for the Ministry of Industry to plan a coherent strategy for agro-industrial investment. To take a specific example, the new oil seed mill which was built by the GDR represents a major investment, but it was designed to process 40 tons/day of cotton seed whereas the current crop is only sufficient to keep the plant occupied for about 3 months in the year. Whilst is is perfectly possible to modify the plant to cope with sesame seed, this will entail considerable extra investment. At the same time much of the equipment which is specifically for cotton seed processing will lie idle for most of the year as indeed will the ginnery. Although we were not able to investigate other agro-industrial projects in detail, we were led to believe that the same is true of the tomato paste and the vegetable canning factories where there is likewise insufficient raw material to keep them operating at an economic rate. Given the evidence of the decline in date production, is it possible that the proposed packing plant may suffer the same fate? Again the Ministry of Industry has plans to develop the spinning and weaving of long staple cotton, but to do this it will need an assurance that the long term supply of good quality ball cotton can be guaranteed in sufficient quantities.

3.8 FISH RESOURCES

3.8.1 Whilst the PDRY may have only limited agricultural resources, its territorial waters are considered to be potentially one of the richest fishing grounds in the world. The reason for this is the up-welling of deep water currents relatively close inshore, which bring with them the nutrients required to sustain the huge quantities of phyto-plankton upon which the fish population feeds.

3.8.2 The fishing industry provides a source of raw material for fish oil and fish meal (see Section 4.12) and there are also two fish canning plants. (See Section 4.13) Total production in 1977 and 1978 was as follows:

	1977	1978
Fish Meal	1,645 tons	1,364 tons
Fish Oil	115 tons	90 tons
205 gm Cans	2,632,052 tins	3,841,204 tins

(Source - Ministry of Fish Wealth)

Despite the evidence for abundant fish resources derived from marine surveys there are a number of problems which are currently restricting output:-

(i) Availability of fish is seasonal, being dependent on the monsoon.

(ii) A great deal has yet to be learnt about where to find and how to catch the fish.

(iii) There are logistical problems associated with supplying and maintaining a fishing fleet based in Mukalla, particularly when the only heavy maintenance equipment is in Aden.

(iv) Because the fishing grounds are long and narrow, the boats inevitably have to spend much of their time travelling to and from base with consequent loss of fishing time. This problem could be overcome by providing mother ships whose sole function is to transport the catch to harbour, or by having trawlers with much larger freezing facilities.

3.8.3 The development of a fishing fleet is never easy and the PDRY's is still in the early stages, but it is of great importance to the economy that this enterprise should succeed. From the point of view of further industrial development, it is clear that until such time as the supply of fish oil has risen substantially and can be seen to be reliable from one year to the next, it would be premature to embark on a plant to

manufacture ghee as has been suggested. (see Section 5.5)*
For the time being a more sensible development would be the refining of fish oil which is currently being allowed to go rancid and hence fetching very low prices.

3.8.4 The development of cuttle fish and lobster fishing, together with the provision of cold stores for distribution to the inland towns and villages, are immensely important to PDRY, but are outside the scope of this report.

3.8.5 The relative prices which have been quoted for sardines and fish meal seem to suggest that the export market for dried fish may well prove more profitable than fish meal and deserves further investigation.

* See also pages 156, 157

IV SURVEY OF EXISTING FACTORIES

4.1 The Aden Refinery

4.1.1 The refinery at Little Aden was built by BP in 1954 and was designed to process 8 million tons/annum of crude oil. By 1966-67, production was nearing full capacity, but with the closure of the Suez Canal, the demand for bunker fuel fell dramatically. At the same time BP began switching its refining operations to more modern refineries in Europe with the result that production at Aden fell to around 1½ million tons/annum. (see Table X.) In 1977 the Government, whilst retaining BP's services under a management contract, took full control of the refinery which now operates for the purposes of :-

(i) fulfilling PDRY's requirements for oil products

(ii) undertaking contract refining for national oil companies which may find it expedient to refine in Aden.

This policy appears to be bearing fruit, as production rose to 3.5 million tons in 1979 and it is hoped that it will increase to between 4 and 5 million tons in 1980.

4.1.2 Product ratios vary considerably, but a typical product yield applied to the 3.5 million tons of crude processed in 1979 would be as follows:-

Product	Yield (%)	Thousand Tons
Gas + LPG	5.00	175.0
LDF	5.0	175.0
MOGAS	10.0	350.0
ATK	6.5	227.0
Gas Oil	20.0	700.0
Fuel Oil	53.5	1872.5

This should be compared with the PDRY's current consumption of:-

	Thousand Tons
LPG	10
Kerosine	60 (including 20,000 tons of ATK)
Regular Petrol	45
Premium Petrol	15
Gas Oil	65
Fuel Oil	80

Even allowing for an increase in the amount of bunker fuel supplied to the growing number of ships which are once again calling at Aden, it is evident that the vast bulk of the refinery production will remain for export.

4.1.3 Contract customers include the national oil companies of Kuwait, Abu Dhabi, Libya, USSR and India as well as BP and Total. An important consequence of the policy of contract refining is that, with the exception of the oil which the Yemen National Oil Company buys for use in PDRY, the output of the refinery belongs to the various national oil companies, who have complete control over the final destination of the product. This is one of the reasons why we can see no immediate prospect of setting up a petrochemical industry in PDRY since one of the prerequisites for such an industry is a stable supply of raw material. This is a key factor which a jobbing refinery is not able to guarantee. There are several other reasons which also make petro-chemical projects unattractive in PDRY such as:-

(i) The domestic market in PDRY is too small to sustain even the smallest petrochemical plant and it would be necessary to rely very heavily on exports. The oil-rich Gulf states are already creating several large petrochemical complexes, but have the obvious advantage of being able to fix the price of feed stocks to suit their own purposes.

(ii) The refinery is 24 years old and by the time a new petrochemical plant had been fully depreciated, it would be approaching 50. Its reliability by that stage would be questionable.

(iii) The capital investment required for even a small petrochemical complex would dwarf the total allocation of funds to the industrial sector under the new Five Year Plan and is unlikely to be justifiable in cost/benefit terms.

4.1.4 To take a simple example, there are designs available for a small ammonia plant with a capacity of 180 tons/day based on naphtha feedstock and package plants have been sold to Sudan, Mauritius and Kenya amongst others. The cost of such a plant is around US $30 million and yet it is a relatively simple exercise to demonstrate that it is cheaper to import ammonia from a large producer, who uses an indigenous natural gas feedstock than to import the naphtha raw material, even without taking into account the capital and running costs of the plant. Furthermore, the total market for nitrogenous fertilisers in PDRY is less than 6,000 tons/annum and, even allowing for the most optimistic expansion, there does not seem to be even a remote possibility of creating a sufficient home market. Table XI shows utility and manpower requirements for a range of common petrochemical plants. The capacity figures are for the smallest plants known to have been built in Europe or the USA in the last ten years. It is clear from this that the outputs of even the smallest are well in excess of PDRY's possible requirements.

4.1.5 The picture will undoubtedly change if substantial quantities of oil or natural gas are discovered in PDRY, but until this occurs it would be wise to delay indefinitely the development of a petrochemical industry.

4.1.6 This does not mean that there should be no further development of the refinery. At present there are a number of projects under study, the most promising of which appears to be the installation of a Vis Breaker. At present the refinery has a Naphtha 'Cat-reformer' of 10,000 - 12,000 BPD capacity, a BP 'Auto Finer' for 3,000 - 4,000 BPD of gas oil, an SO_2 extraction unit for kerosine and a 'Copper Chloride Treater' for sweetening of gasoline and kerosine products. Whilst the cost of a Vis Breaker at around US $50 million is enormous by comparison with any other industrial project in the PDRY, nevertheless it represents one of the cheapest methods of widening the range of products and making better use of the 'lower end of the barrel'. It is worth noting that, if such a project were to go ahead, the excess hydrogen, which is currently produced by the Cat Reformer, would be used up in new hydro-treaters and therefore would not be available for use in the hydrogenation of fish oil as has been suggested. (see Section 5.5.)

4.1.7 Other small-scale developments which may be worth further investigation are lube oil blending and bitumen production, neither of which entails very large capital expenditure. The current consumption of lube oils in PDRY is 2,000 - 3,000 tons/annum, which hardly justifies the effort involved in importing the special ingredients and then having all the problems associated with quality control for a range of different products. Nevertheless, it would be worth keeping this under review as living standards rise and the number of vehicles increase. As far as bitumen is concerned, the refinery management are of the opinion that an economic unit should have a capacity of around 100,000 tons/annum whereas the demand in PDRY is nearer 10,000 tons/annum. Nevertheless, small units of around 10,000 tons/annum are used and we believe that it might be worth re-examining the possibility of producing 'semi-blown' bitumen particularly if there is any intention of installing a vacuum unit in conjunction with the Vis Breaker project.

4.1.8 It should be remembered that local production of bitumen would obviate the necessity for using barrels, which have to be reheated and are ultimately discarded, which represents a significant proportion of the total cost of laid bitumen.

4.1.9 The refinery has a waste stream of about 150 tpa of hydrogen sulphide which is currently converted to sulphur dioxide and discharged to atmosphere. It would be possible to absorb this in caustic soda solution under which circumstances sodium hydrosulphide is formed, which can then be filtered to remove heavy metal sulphides and, after concentration, reacted with more caustic soda to form sodium sulphide.

$$H_2S + NaOH \longrightarrow NaHS + H_2O$$

$$NaHS + NaOH \longrightarrow Na_2S + H_2O$$

4.1.10 If all the refinery H_2S were absorbed this would yield nearly 340 tpa of sodium sulphide and would create a demand for 320 tpa of caustic soda. This is well in excess of any requirements of the Aden tannery which currently uses about 15 tpa and it would imply creating an export market. Whilst, on the face of it, this does not look attractive, it is worth remembering that Ethopia, Somalia, Kenya, Uganda, Sudan, and North Yemen all have tanneries and are all trying to discourage the export of dry-salted skins. None of these countries currently manufactures sodium sulphide. It is however doubtful if the manufacture on such a small scale would be economic and in our view this is not a project which should be afforded any degree of priority.

4.1.11 By contrast we believe that since the refinery produces kerosene and the agricultural sector has a growing demand for insecticides, there should be a good case for a small insecticide blending plant which would dilute imported concentrates and pack them in suitable containers. This is clearly not a refinery operation, but would make use of a refinery product and also provide a market for plastic drums and containers which could be manufactured locally.

4.1.12 The chemicals consumed by the Refinery in 1979 were as follows:-

Sulphuric acid	40 tons
Caustic soda (solid)	242 tons
Chlorine (liquid)	75 tons
Pumice (fine)	112 tons
Copper Sulphate	21 tons
Ferric Chloride	22 tons
Diethanolamine	11 tons
Diethylene glycol	30 tons
Propylene dichloride	2 tons
Sodium Sulphate	500 kg
Sodium Phosphate	150 kg
Sulphur	36 kg

Of these the only ones which might be reasonably be manufactured locally are chlorine and caustic soda which are considered in Section 6.2 and Appendix VII.

4.1.13 Maintenance at the Refinery:

The refinery workshops are extensive and well-equipped. The mechanical engineering training school has an intake of 30 to 40 men every year, of which about half subsequently leave to find employment elsewhere. There is also an annual intake of about 15 staff for process and laboratory work.

4.1.14 The maintenance work load is high because of the age of the refinery and the reduced scale of operation and maintenance in the past. Tasks include such things as repair of tanks, especially corroded bottom plates, piping and fittings replacement, exchanger retubing, furnace relining and the replacement of hangers. All these are fabricated in the refinery workshops except for large items requiring substantial stress-relieving furnaces. Instrument repair, motor rewinding, and pump and compressor maintenance are routine tasks regularly undertaken.

4.1.15 With a range of jobs which can vary from maintenance of diesel engines in the power house down to repair of office air conditioners, there is a very substantial demand for spare parts. The arrangement whereby the refinery can call on the services and assistance of BP in London for the procurement and shipping of spare parts and replacement items is essential for effective maintenance and operation.

4.1.16 The General Problems of Maintenance in PDRY:

The refinery receives frequent requests for maintenance assistance from other industries in Aden, and does its best to help, but obviously has to give first priority to its own problems. Our visits to the various factories in Aden clearly showed that effective routine maintenance was generally lacking.
This is a problem which must be dealt with soon if there is to be any hope of achieving a prosperous industrial sector. Clearly, it would be a waste of scarce man-power and resources for each small factory to have a fully equipped maintenance workshop with its appropriate staff and it is recommended that some central facilities should be established. Three essential components are required, namely:-

(i) Specialised tools, in particular large metal working machines such as turning, milling, grinding and boring machines which any one industry will use only infrequently.

(ii) Skilled specialists who can cope with problems which are common to many industries such as those associated with air conditioners, boilers, electric motors and switchgear.

This should not be taken to mean that all repair work should be centralised for this would rapidly become unwieldy. There will always be a place for the plant engineer/fitter to cope with day-to-day maintenance breakdowns and adjustments.

(iii) Properly organised stores and procedures for obtaining the necessary number of the required spare parts at the right time and at a minimum cost.

4.1.17 During our visits, we noticed a number of machines lying idle because spare parts were on order, but had not yet been delivered. The solution to this problem is not to invite an 'expert' to make an inventory and suggest a spares list for the next two years, for inevitably this involves an element of guess work and the list quickly gets out of date. Such a list can be useful as a starting point, but unless proper procedures are set up for recording which spares have been used, and how often particular machines are breaking down, and detailed plans are laid for the scheduled replacement of worn parts before they break down, it is inevitable that costly delays will ensue. But even with the best conceived systems there will always be occasions when the necessary part is not available and there is no way of effecting temporary repairs and, under these circumstances, it is vital to have an overseas agent who can find the part and, if necessary, send it by air freight without going through all the formalities of asking for quotations and opening Letters of Credit.

4.1.18 Our impression is that the refinery's maintenance department is extremely effective because:

(i) It is run by experienced and well-trained engineers who have the ingenuity to cope with the unusual.

(ii) It has the necessary heavy metal working machinery.

(iii) It has a properly organised stores and a computerised re-order system.

(iv) Much time and effort goes into the planning of shutdowns, and the necessary spares are ordered in good time.

(v) It has a direct link to the BP purchasing organisation in London, who have the authority to spend money on the refinery's behalf.

(vi) Over the years there has been heavy investment in the training of apprentices.

If the Ministry of Industry decides that it would be worthwhile to create a similar system to provide a service to small industries, then it must ensure that all these elements are covered, for without any one of them the system will inevitably break down.

4.1.19 Our own feeling is that since BP has been operating in Aden for so long, and is presumably highly regarded by the Government, discussions should be held with the company concerning the provision, under a separate contract, of a few experienced engineers plus the extended use of their purchasing department in London. Combined with the heavy equipment available in the Dockyard Company and the training facilities available at the Technical College, the Electric Power Corporation and the Refinery, this could form the nucleus of an organisation which we believe would be much more effective than any programme of short-term visits by outside experts whose advice, however good it may be, can only have a limited impact.

4.2 Aden Salt Works

4.2.1 This company was formed in 1970 following the amalgamation of three private concerns and has at present 258 employees. Currently its fortunes are at a low ebb. The harvesting equipment, which is mostly of Chinese origin, has suffered badly from corrosion and spares are difficult to obtain. With sales being well below expectations, stacks of salt are becoming contaminated with wind-blown sand which adversely affects its export marketability. Furthermore the loading of ships which involves trans-shipment from barges, which can only leave the salt jetty during the top half of the tide, inevitably leads to prolonged delays and high demurrage charges.

4.2.2 The salt works has a nominal capacity of 150,000 tpa but in the last two years sales have been as follows:-

1978	52,000 tons
1979	25,000 tons
1980 (first quarter)	14,000 tons

In addition, about 1.7 million 1 lb polythene bags of table salt are produced for the local market, equivalent to a further 760 tpa. The cost of production is quoted as US $23-24/ton fas (free alongside) plus US $3.5/ton lighterage.

4.2.3 The new Five-Year Plan includes a sum of YD2.7 million for rehabilitation of the salt works which makes this the second most important project after the Cement Factory.

4.2.4 Two studies of the salt works have been carried out under UNIDO auspices. The first by G L Mulhotra of India in 1970 and the second by Studio Technico Ingegneria (STI) of Italy in 1972. Both discuss methods for improving the quality of the salt and increasing production to around 300,000 tpa. A third study is about to be undertaken by a Bulgarian company; nevertheless it may be helpful to emphasise the following points:-

(i) Aden is technically a good place for solar evaporation pans since there is plenty of suitable flat land and the climate allows for salt production all the year round. But the fact remains that many other countries have comparable advantages and a price of US $26.5-27.5 fob is too high to be competitive in the export markets for bulk salt.

(ii) The solution which has been suggested to overcome this problem is to increase the scale of operations. This, however, should be treated with great caution unless there is (a) an assured market for the increased production and (b) real confidence that the increase in scale will in fact bring about the necessary reduction in unit costs. It should be noted that one of the major cost items in a solar works is labour and as 'a rule of thumb' 1,000 tons/man year is about the minimum output which could reasonably be classed as efficient operation (some highly mechanised fields produce 5,000 tons/man year). On this basis, the Aden facility is seriously over-manned, a phenomenon which we found was not confined to this unit alone.

(iii) Malhotra's UNIDO report is correct in laying emphasis on the proper control of brine density and the importance of discharging bitterns and not allowing these to dry out in the crystallisation ponds.

(iv) Rather than going to great lengths to alter the size of the crystallisation ponds to make them large enough to accommodate large harvesting machines, it would be worth considering an alternative system whereby salt is pumped out of the ponds as a suspension in brine, and is then separated in a hydrocyclone with the liquid being returned to the pond. In addition to requiring considerably less maintenance than a harvester, this technique has the advantage that it can be used on small ponds. The action of pumping the salt crystals in suspension has much the same purifying effect as the first stage of a washing plant.

(v) The stacking of salt in large heaps is done in many salt producing countries with the object of 'sweetening' - that is to say that rain water will preferentially dissolve residual magnesium salts and improve the purity of the sodium chloride. However, in Aden there is no rain to perform this service, whereas there is plenty of wind-blown sand to cause contamination. Whilst it is reasonable to hold some stocks to allow for mechanical breakdowns or irregular shipments, it would in general be more efficient to cut back on the rate of production or to build up thicker layers of salt in the crystallisation ponds rather than to continue increasing stock piles which after a time become virtually unsaleable.

4.2.5 The most intractable problem with the Aden salt works is the loading of ships. Re-siting the stock pile on the other side of the causeway would certainly improve matters and allow lighters to work round the clock, but the provision of a floating loading area as suggested by STI is liable to prove very expensive and will only be justified if an assured market can be found for large tonnages of bulk salt. Such a facility offers relatively little advantage when loading bagged salt for the controlling factor is usually the rate at which the bags can be stacked in the ship's hold rather than the rate at which they come aboard from a lighter.

4.2.6 The extensive use of polypropylene sacks in place of jute should be considered, particularly, if the polypropylene sacks were to be manufactured in PDRY.

4.2.7 An agreement for the supply of bulk salt to Bulgaria is currently being considered. This will in all probability, be required for industrial purposes and the PDRY will need to install a washing plant to ensure that quality standards are met. The equipment required for this is relatively simple, but particular attention should be paid to specifying the correct materials of construction as the corrosion problems are severe.

4.2.8 Whilst it would make little impact on the overall tonnage of salt, consideration might be given to the production of salt blocks for cattle licks which command a premium price and could form the basis of a small export market. The only other outlet which we can envisage for salt is as feedstock to a small chloralkali plant which is considered in Section 6.2.

4.2.9 Nearly every report written about salt production goes to great lengths to explain the techniques for recovering magnesium salts, bromine and potash. Suffice to say here that the world markets for the first two are grossly over-supplied and that to the best of our knowledge the only commercial plants recovering potash by solar evaporation are those on the Dead Sea and in the USA which have abnormally high concentrations of potassium and where the scale of operations has to be very large indeed before it becomes economic.

4.3 Industrial Gases Factory

4.3.1 This factory which started in 1975 operates a Russian-built oxygen plant and a fully automatic West German acetylene unit. A second oxygen plant supplied from Hungary blew up a few months after commissioning and has not been rehabilitated.

4.3.2 The Russian unit has an output of 25m^3/hr of 99.7 per cent pure oxygen, thus making it suitable for medical purposes. The oxygen is filled into 15 m^3 cylinders, the current monthly demand being:

	PDRY	EXPORT TO NORTH YEMEN	TOTAL
	m^3	m^3	m^3
Medical	1,200	600	1,800
Industrial	4,500	600-800	5,100-5,300

This level of output represents rather less than two weeks working every month on a three shift basis and for the remainder of the time the plant is shut down. Considering that the staff have so much spare time, one would have expected to find a rather higher standard of house-keeping than was apparent.

4.3.3 The oxygen plant uses about 15 m^3/hr of cooling water which is untreated, but is discharged to drain from the cooling pond about once a month. There is evidence of fouling of the heat exchangers and we would recommend the installation of a small water softening unit and a change in practice to a continuous bleed-off of cooling water to drain rather than a periodic flushing of the whole system.

4.3.4 The new Five Year Plan contains a provision of 300,000 YD for a new oxygen plant. Presumably the reasoning is that, after the failure of the Hungarian unit, the factory is working without a spare. However, the oil refinery has its own oxygen unit which is due for replacement in the near future and the army also possesses a mobile unit of 70 m^3/hr capacity. Therefore, it is unlikely that the country would find itself short of oxygen even if the existing Russian plant were out of commission. We find it difficult, therefore, to see any justification for a new plant.

4.3.5 The Acetylene unit has a capacity of 25 kg/hr of 92 per cent acetylene. The current monthly demand of 1,200 kg plus 200 kg exported to North Yemen indicates that this unit, also, is only operated for a few days a month. Bearing in mind that many welding jobs can be done using propane, which is available from the oil refinery at a much lower cost, it seems unlikely that there will be a sufficient increase in the demand for acetylene to warrant any further extension of the plant in the near future.

4.3.6 The factory has a small workshop, which deals mainly with valve and regulator maintenance and routine pressure testing of cylinders. At present cylinders are purchased for a number of sources which may be the cheapest solution, but we believe that, in the interests of safety, it would be better to have one standard specification for oxygen cylinders and another for acetylene and to ensure that the filling couplings are such that there is no possibility of filling oxygen into an acetylene cylinder or vice versa. Strict adherence to a cylinder colour code system is also vital.

4.3.7 The factory uses the following chemicals:-

Caustic soda	3.0 tons/annum
Silica gel	0.8 tons/annum
Calcium carbide	40.0 tons/annum
Acetone	3.6 tons/annum
Calcium chloride	1.0 tons/annum

Of these only caustic soda is a potential candidate for manufacture in PDRY.

4.4 Algundi Plastics Factory

4.4.1 This company, started in 1972, is engaged in the injection moulding of polypropylene, high-density polyethylene and polystyrene. There are two factories; the original one has five small East German injection moulding machines which are producing 31 different household articles up to a maximum unit weight of 515 gm. The new factory, which was officially opened during the team's visit, has one machine, also of East German origin, which is capable of producing large mouldings up to 4.8 kg. At present this is operating with only one mould producing vegetable crates, but a second mould for beer crates will be arriving shortly.

4.4.2 Both factories operate on three shifts, six days per week and the total number of employees is currently 63. The layout of the original factory is cramped, but in the new plant there is ample room for further development and, with labour being in short supply, the addition of a fork lift truck would be an improvement.

4.4.3 The quantities of polymers used in 1979 were:-

Polypropylene	350 tons
HdpE	100 tons
Polystyrene	34 tons

Purchases are subject to open tendering by the major manufacturers and, at present, the bulk comes from Italy. Colouring is done in the plant by addition of pigments although the management are keen to try Master Batches.

The only other purchases of raw materials are hydraulic fluids, lubricants and very small quantities of dosing chemicals required for the cooling water. This factory does not, therefore, provide any openings for import substitution of raw materials.

4.4.4 The installed power in the original factory is 150 KVA and in the new factory 200 KVA. The cooling water system operates on a closed circuit with a cooling tower. The make-up of about 10 per cent represents a very small volume.

4.4.5 The company sells its products direct to the market without going through the National Company for Home Trade. Customers collect their purchases from the factory and transactions are strictly on a cash basis (or LPO's in the case of Government purchases). The company therefore has no distribution costs and the absence of customer credit simplifies the book-keeping.

4.4.6 With 31 moulds the company manufactures a reasonable range of household products, but it finds difficulty in establishing what the market really wants and hence justifying the purchase of new moulds. In part, this is because customers are often not aware of the many new designs which are available in other countries, whilst at the same time, the company cannot afford the risk of buying expensive moulds on the off-chance that the product will prove a success. There would seem to be a good case for allowing the company to import trial shipments of mouldings which they do not currently manufacture for the purposes of test-marketing.

4.4.7 It is difficult to compete in overseas markets for small mouldings as most countries have injection moulding facilities of their own, but this does not necessarily apply to large mouldings where both the machinery and, more particularly, the individual moulds are exceedingly expensive. The company is, therefore, quite right to look for export markets for the new factory's production of vegetable boxes, beer and soft drinks crates. Contact has already been established with the brewery in Ethopia,and other outlets in East and Central Africa would appear to be worth further investigation. The intention appears to be to use PDRY's overseas embassies to foster foreign trade, supplemented by occasional visits by the company's management. Bearing in mind how competitive the market for mouldings can be, and the difficulties which all embassies experience in carrying out direct commercial transactions, we believe that the company would do well to consider the appointment of overseas agents.

4.4.8 There are no plans to increase the number of machines in the original factory, and, indeed, there is very little space available within the existing buildings. Development must, therefore, be in terms of variety of mouldings rather than increase in capacity. For the new factory, short-term development plans include the production of beer and soft drinks crates and plastic chairs. It is worth noting that the purchase of the beer crate mould for 34,000 YD has been justified on the basis of an initial order from the new brewery for 200,000 crates. As noted in Section 5.3.4 this quantity seems likely to be greatly in excess of the demand in which case the development of an export market will become all the more important.

4.4.9 The layout of the new factory leaves ample space for a second line and the current intention is to instal a Melamine moulding facility. Extrusion, blow moulding and film production lines are under consideration as a separate Plastics Complex which may eventually be sited adjacent to the Algundi Factory. These plans are considered further in Section 6.24 and Appendix V.

4.4.10 One of the company's most valuable assets is its stock of moulds and these must be properly cared for if they are to have a reasonably long working life. There appeared to be no provision for a proper mould store, nor is there anyone in the factory capable of refacing, grinding and polishing worn moulds. Whilst the maintenance and repair of moulds is a highly skilled operation, the provision of a separate mould store with racks and the greasing of moulds, which are not being used, to prevent rusting, is a matter of simple good housekeeping. Dust and sand laden with salt, together with a humid atmosphere can quickly ruin a high precision mould and it would be sensible to air condition the mould store or at least make sure that the doors and windows are close fitting.

4.5 The Polyurethane Foam Factory

4.5.1 This factory was established in 1973 and produces polyurethane foam mattresses, pillows and chair cushions in one section and metal furniture including beds, chairs and tables in another. In 1975, the output was 20 tons of foam products, 7,300 metal bedsteads and 300 chairs. There are 63 employees, 25 in the foam products section, 13 in the furniture section and 25 clerical and administrative staff. This is one of the few factories which operates a bonus scheme based on output and our general impression was that production was well organised and efficient. Other factories might do well to consider introducing similar bonus schemes.

4.5.2 The production of foam involves mixing Toluene Di-isocyanate (TDI) with a Polyol and a catalyst on a moving belt which is covered with Kraft paper. The foaming reaction between the two components is very rapid and at the end of the belt the thick layer of foam is cut to length and is then sliced into varying thicknesses. Any offcuts are shredded and used for stuffing pillows.

4.5.3 To run this section efficiently, it is important to pay close attention to weighing out the ingredients in exactly the right proportions and, although we have no evidence to suppose that there are any shortcomings, it would be advisable to institute a periodic check on the accuracy of the weighing machines. The only other matter for criticism is that the fire precautions are inadequate and need particular attention in view of the toxicity of the products of combustion. The fire resistance of polyurethane foam mattresses can be considerably improved by encasing them in a particular kind of plastic cover. There are several patents for this, the most recent being the one held by Dupont Company of the USA and we would recommed this as a product improvement which should not prove very expensive.

4.5.4 The raw materials used, namely TDI, Polyol, organometallic tim, triethylene diamine and silicones are not suitable for manufacture in PDRY.

4.5.5 Rigid polyurethane foams are increasingly being used for compression mouldings for furniture and this technology should be well within the capacity of the factory. The production of polyurethane shoe soles could also be undertaken provided that there is a sufficient market to justify purchasing the moulds.

4.5.6 The metal furniture section consists of manually operated pipe-bending, punching, drilling, welding and cutting units, whilst polishing is done with a wire brush. Current imports include 100 tons/annum of angle iron and 100 tons/annum of pipes as well as metal bed springs. There are plans to make metal cupboards, shelves and drawers when the current expansion of the factory allows more room.

4.6 Plastic Shoe Factory

4.6.1 This company was started in 1976 as a private sector enterprise, but now belongs to the Mixed Sector being 54 per cent Government and 46 per cent Private owned. It produces some 1.2 million pairs of plastic sandals per annum. The machinery originally came from China, but in recent years has been supplemented with new machines from Japan. The company employs 94 people working one shift per day for 6 days per week. The fixed capital is 300,000 YD.

4.6.2 The following raw materials are used in the factory:-

Synthetic Rubber (Poly-isoprene)	39	tons/annum
Stearic Acid	1	" "
Cross Linking Agent (1:3 bistertbutyl-peroxy-isopropyl benzene)	5	" "
Filler (Calcium carbonate)	99	" "
Blowing Agent (Azodicarbonamide Derivative)	19	" "
Pigments (Red Yellow Blue Green White)	8	" "
PVC Compounds	45	" "
Ethylene Vinyl Acetate(EVA)	160	" "

4.6.3 The only one of these for which local manufacture could be considered is the filler calcium carbonate. The specification calls for a product with an average particle size of 2.2 micron which all passes 325 mesh. This is in all probability a precipitated grade of calcium carbonate which would not be worth making on such a small scale in PDRY. However, if there is high quality limestone available it would be worth conducting a few small-scale grinding trials to assess whether a product could be made which, although not quite as fine as that called for in the specification, would nevertheless serve the purpose. The quantity of filler required by this factory is small, but if PVC pipes are to be manufactured in the new plastics complex, this quantity could rise substantially. (see Section 6.5)

4.6.4 Unlike the leather shoe factory this plant makes a product which, although variable in colour and sole thickness, is none the less relatively standard, functional and cheap. It is not so easily affected by changes in fashion and is therefore suitable for distribution by the National Company for Home Trade since market research and new models are not an important feature of the business.

4.6.5 The principal difficulty experienced in the operation and maintenance of the plant is in getting spare parts from China.

4.6.6 The method of hand feeding the mixer rollers is extremely dangerous even with trip bars situated over the machines. Although the management reported that they had never had an accident, the fact remains that the operators are taking a wholly unjustified risk which could easily be eliminated. Apart from this criticism, however, the factory obviously works well and is fulfilling the purpose for which it was intended.

As most neighbouring countries have similar plants, it is unlikely that any substantial export trade will develop so that this factory should not need much further investment in the next few years other than for the replacement of worn-out machinery.

4.7 Leather Shoe Factory

4.7.2 In 1972, UNIDO sponsored a training centre in Aden for leather working with the ultimate objective of making use of the output from the tannery. During the next four years, a number of key staff were sent for training overseas and UNIDO specialists were involved in the running of local courses. Eventually in July 1976, it was decided to convert the training centre to an operating company to be known as the Leather Shoe Factory. 120,000YD was spent on new equipment in 1978 and production rose rapidly from 29,000 pairs in 1977 to 96,000 in 1978. In 1979, 142,000 pairs were produced and the factory management estimate that, given sufficient demand, production could be stepped up by a further 70,000 pairs per annum. The factory has 120 employees working one shift per day for six days a week.

4.7.2 All raw materials are currently imported, the main items being leather and polyurethane soles. In theory, both of these could be produced locally. However, the poor quality of the leather produced by the tannery and the cheaper price of synthetic leather which is suitable for sandals, has persuaded the management, at least for the time being, to rely on imports. Complaints about the tannery's production include uneven thickness, too many flay cuts resulting in high wastage, and over-dry leather which produces surface cracking on the lasts. Whilst one can sympathise with a busy management which has enough problems of its own, not wanting the added complication of using local leather of doubtful quality, the temptation should be resisted to believe that everything imported is good and everything local is suspect. New machinery has been ordered for the tannery and it is hoped to engage foreign technicians to help improve the quality of local leather. When product quality improves as a result of these developments it will be important for the staff at the tannery to judge the success of their efforts by having a discriminating buyer close at hand. This, in turn, requires that someone in the shoe factory must be capable of selecting and purchasing suitable leather. If necessary additional training in this area may need to be provided.

4.7.3 Polyurethane soles could, in theory, be made at the Foam Factory provided it had a suitable injection moulding machine and used a slightly different formulation to that required for foam mattresses, but the main problem would be that changing fashions would require a constant supply of new moulds and it is doubtful whether the shoe factory's requirements would be large enough to justify the expense.

4.7.4 The only other input worthy of further consideration for local manufacture is shoe boxes, which could be produced by a local printing and packaging company, even though 140,000 boxes per annum would represent only a small order.

4.7.5 Any industry which is making fashionable goods inevitably has difficulty in judging what the market wants today and, just as important, what is is likely to require tomorrow. Until recently all shoe sales have been in the hands of the National Company for Home Trade which has resulted in a certain amount of inflexibility. On the one hand, the shoe factory was criticised for producing too many shoes which were unacceptable to consumers and which the Home Trade Company could not sell. On the other hand, the shoe factory claimed it was not being supplied with sufficient quantitative or qualitative market research data by the Home Trade Company and so was in a weak position to plan for new models. Such comments are not necessarily a reflection on the efficiency of either organisation, but stem from the fact that the two do not always have the same objectives. The Shoe Factory is in business to make a profit out of producing shoes while the Home Trade Company is concerned with supplying the market with a wide variety of products and it may well be that, with limited resources, it has to give higher priority to products other than shoes.

4.7.6 The same situation exists in the textile industry, and to some extent, with plastics products. In recent months the Government has very wisely allowed these industries to start marketing their own products at retail level, but, as the same time, has made it clear that these companies will be held reponsible henceforth for any errors of judgement that they may make in assessing their markets.

4.7.7 In our view, the Home and Foreign Trade Companies can provide a valuable service to new industries which are generally preoccupied with production and maintenance problems and may have little time to devote to marketing. However when the management reaches the point where it feels that it would be more advantageous to run its own marketing operation, it is obviously sensible to allow it to do so without hindrance.

4.7.8 Particularly in the case of fashion goods, it is always important for designers and management to know what is happening elsewhere in the world and regular visits to the Paris 'Semaine de Cuir' (Leather Week) by at least one person from the shoe factory and one from the tannery would be a thoroughly worthwhile investment. This exhibition, not only displays all the latest fashions in leather goods, but also demonstrates new machinery and production techniques for both tanning and shoe manufacture. It also provides an excellent opportunity to compare prices and qualities and to meet potential buyers and suppliers.

4.7.9 To set the local market into perspective, if PDRY has a population of 1.7 million and the Shoe Factory produces 140,000 pairs per annum, this represents only about one pair of shoes per person every eleven years. By contrast the rubber sandal factory produces 1.2 million pairs per annum. On might, therefore, expect to find 90 per cent of the population wearing sandals, but casual observation in the streets of Aden indicates that this is not the case for at least 50 per cent of the people wear leather shoes of one sort or another. Admittedly such observations do not represent a statistical sample, but it does support the contention that a large number of shoes are being brought into the country illicitly.

4.7.10 The factory has installed relatively simple equipment and has sent a number of management and technical staff on training courses overseas so that a satisfactory level of maintenance and quality control has been achieved and the number of reject shoes at roughly 2 - 3 per cent is not unreasonable.

4.7.11 The existing building which was not purpose-built is congested and short of space and most gangways were cluttered with intermediate products. It is doubtful whether production can really be increased substantially without operating a second shift and without a bigger storage area. If the management is successful in its marketing efforts, it will not be too long before the company will need new premises at which point the opportunity might be taken to improve the layout of offices, stores, maintenance shop and production lines.

4.7.12 This is another factory whose fire precautions should be reviewed for although the risk is not as high as in many others, the access is at times very congested and once a fire did start people might well find it difficult to escape.

4.8 The Aden Tannery

4.8.1 The tannery was started as a private enterprise, but is now in the public sector; it has been beset with problems ever since its inception and needs substantial further investment before it can become a profitable enterprise. There are 65 employees working a single shift, six days a week producing some 400 ft^2 of finished leather per day (80 per cent upper leather, 20 per cent lining) as well as 500 - 800 pickled or wet-blue skins. Finished leather is sold mainly on the local market for shoes and belts although, as already mentioned, none of the production is bought by the Aden leather shoe factory because they consider the quality inferior. Some lining leather is exported, but the bulk of the exports is in the form of pickled or wet-blue skins for which the average price is US $35 per dozen.

4.8.2 Some 1,500 skins per day are delivered to the factory which implies that around 700 are rejected as sub-standard and sold as dry-salted skins at a very low price of around US $2.35 per dozen. The loss of revenue which can be largely, though not entirely, attributed to careless flaying is thus of the order of

$$\frac{700 \quad (35 - 2.35)}{12} = \text{US } \$1,904 \text{ per day.}$$

Improvement can only be brought about through increased efforts in agricultural extension and at this price is clearly well worth pursuing.

4.8.3 Whilst the tannery cannot be held responsible for bad flaying, the fact remains that these rejects have a market value because someone is prepared to tan them (and presumably make a profit by doing so) which begs the question as to why the Aden Tannery cannot do it too. Ultimately the aim must be to sell only finished leather rather than to sell only semi-finished products which do not maximise the added value. An intermediate objective is obviously to provide sufficient good quality leather to satisfy the demands of the Aden Leather Shoe factory.

4.8.4 A detailed study has been made of the tannery's requirements for new machinery and, as a result, there are currently on order a sammying machine, a scudding machine, a new press and a toggling unit and drier. This will undoubtedly improve the situation but, bearing in mind that tanning is not something which can be learnt out of a book in a hurry, we would strongly recommend that the Ministry of Industry should request the services of one tanning and one finishing technician for a minimum period of two years. Short assignments by visiting experts are of very limited value in this particular industry.

4.8.5 We understand that effluent from the tannery is still finding its way into the Aden salt works despite the fact that the dangers of this have been pointed out in previous reports. This situation should not be permitted to continue.

The raw materials currently consumed by the tannery are as follows:-

	Tons/annum	
Salt	200	) Locally produced
Lime	50	)
Sulphuric Acid	5 - 10	
Sodium Sulphide	12	
Chromic Sulphate	10 - 20	
Mimosa Extract	10 - 15	
Synthetic Tannins	10	
Ammonium Sulphate	3 - 4	
Bating Agents	2	
Fat Liquors	10	
Pigments/Dyestuffs	2	

The water consumption is estimated to be about 4 m^3/hr and the installed power is 240 KVA.

Of these raw materials the only ones which might be considered for local production are sodium sulphide and sulphuric acid. (see Sections 4.1.9 and 5.4.)

4.9 Textile Factory

4.9.1 This company was established in 1972, the factory and all its equipment being supplied by the Republic of China. It was designed to produce 7.2 million m^2/annum of finished textiles using the medium staple fibre grown in PDRY. The main components of the factory are:-

20 Carding machines
12 Drawing machines
6 Split frame spinning machines
36 Ring frame spinning machines
14,688 Spindles
520 Looms (80 x 60", 440 x 50")
2 Sizing machines
12 Dyeing machines
4 Printing machines

4.9.2 The plant produces three types of yarn, 61/61, 68/68 and 34/34 counts and produces textiles of original design. Installed power is 1,200 kVA and water consumption approximately 35 m^3/hr. The total number of employees is 1,200 organised on a four shift system. This number includes some 270 maintenance personnel, most of whom have been trained on the job.

4.9.3 The maximum production which has yet been achieved was 4.8 million m^2 in 1977, but the forecast for 1980 is considerably lower at around 3 million m^2. Whilst the plant has difficulty in obtaining the spares they require from China and suffers from a considerable number of mechanical breakdowns and delays caused by power failures, the basic reason for not making fuller use of the plant capacity is the lack of demand for the company's products. But PDRY's overall requirement for textiles is well in excess of 7.2 million m^2/annum and the real problem is that the existing factory cannot produce the types and qualities that the market wants. There are indications that the market is looking for:

(i) blends of cotton and synthetic fibres

(ii) fine woven fabrics (either pure cotton or blends)

4.9.4 The factory as it stands is not capable of producing either of these. In addition, the clothing manufacturers complain of uneven cloth widths, lack of colour fastness and abnormal shrinkage. We were not able to ascertain whether these criticisms were justified, but certainly the lack of automatic controls on the finisher could well explain some of these faults.

4.9.5 A study is about to be undertaken which will examine in detail what modifications and additional plant are necessary to improve the quality of current production and to enable the factory to manufacture cotton/synthetic blends and also to utilise the long staple cotton which is grown in PDRY. Nevertheless, at this stage the following points should be made:

(i) In common with many other companies, the textile factory has yet to carry out any detailed market research into what their customers want. There is a design section which has produced some very attractive patterns, but casual observation in the streets of Aden did not give the impression that many people were wearing them. Since it is customary for men to dress informally, it is at least questionable whether fineness of weave is really so important if the material is both colour fast and of attractive design.

(ii) The problems of the textile factory should not be treated in isolation for they impinge on other important sectors of the economy. Thus the new study should establish what is the optimum ratio of long and short staple fibres which should be grown to satisfy both the textile factory and the export markets. These findings must then be balanced against the competition for water and arable land from other crops and for labour from other industries. The requirements of the ginnery both in terms of machinery and storage should also be considered and, perhaps more important, the needs of the new oil seed mill which is currently running well below its rated capacity because of the shortage of cotton seed.

(iii) It is curious that towelling is not being produced despite the relative simplicity of its production and we believe that this market should be investigated further.

4.9.6 The chemicals used by the textile factory excluding dyestuffs, which are highly unlikely to be produced in PDRY, are as follows:-

Chemical	Tons/Annum
Hydrochloric Acid	1.2
Sodium Hydroxide	60.0
Sodium Chloride	110.0
Bleaching Powder	3.7
Sodium Carbonate	1.2
Acetic Acid	3.0
Sodium Silicate	3.0
Hydrogen Peroxide	2.1
Sodium Sulphite	3.4
Wheat Starch	39.5
Red Oil	0.2
Sulphuric Acid	11.0

Of these sodium hydroxide, bleaching powder and hydrochloric acid could be produced by a local chloralkali plant, sodium silicate as an adjunct to glass manufacture and shulphric acid as part of the detergents complex. The local source of sodium chloride is of course already being used.

4.10 Soap Factory

4.10.1 This factory was a gift from North Korea and was commissioned in 1979. Its nominal capacity is 1000 tons/annum of toilet soap and 500 tons/annum of washing soap. Local expenditure on the project by PDRY has so far amounted to YD 254,000. By September 1979 it became apparent that the plant could not produce soap of sufficiently good quality to compete on the local market and the plant was closed down. The current position is that Tata Engineering of India have been invited to examine the plant in detail, recommend what should be done to put it right, and provide management for a period until it is seen to be working efficiently.

4.10.2 As the plant was shut down at the time of our visit and no drawings or project details were available our observations are somewhat subjective. Nevertheless the following points are worth making:-

(i) The three soap pans appear satisfactory but we consider softening of the process water is an important additional feature which should be provided. The cooling and drying rolls mounted under the pans appear most unsatisfactory. Both capacity and ability to retain the soap on the rolls and deliver uniform soap chips must be in doubt.

(ii) If, as we suspect, one of the major difficulties lies in the continuous production of the soap chips from the neat soap pan then we would recommend a continuous vacuum based method of chip production, using a proven system such as, for example, Mazzoni or Mechaniche Moderne in Italy.

(iii) The driers were said to be difficult to control, but this could be improved by installing steam control valves and adjustable ventilation. The effectiveness of the mixer-plodders and the subsequent milling rollers cannot be established without seeing the operation of the machines, but it seems improbable that they can work well unless the moisture content and size of the soap chips fed to them is properly controlled. The final screw press should work satisfactorily if a regular feed of satisfactory soap chips can be assured, but we have no details on the type of screw used, bearings, operating speed and drive.

(iv) The performance of the cutter and the stamper is unsatisfactory because of the difficulty of coordinating the timing of these operations with the moving soap strang which is to be cut. Because of design limitation it would seem advisable to replace these items.

4.10.3 When the factory has been put in proper working order, it would be worth considering an additional plant to recover crude glycerine although it is unlikely that a distillation unit to produce 40 - 50 tons/annum of pharmaceutical grade glycerine would be justified.

4.10.4 It is quite clear that there is no market for washing soap in PDRY where it is customary to use detergents and we consider that any further development work on this line should be terminated.

4.10.5 The raw materials which will ultimately be used by the plant consist of coconut oil, perfume, colouring, salt, caustic soda and tallow. Only the last three could be produced in PDRY. Assuming that the plant produces 1,000 tpa of toilet soap the likely requirement for these raw materials would be:-

	Tons
Salt	200
Caustic Soda	150
Tallow	300 - 600

Wrapping paper and cartons could also be produced by a local printing and packaging company.

4.11 The Vegetable Oil Seed Mill

4.11.1 The vegetable oil seed mill was designed and constructed with the assistance of the German Democratic Republic and came into operation in 1979. The capacity of the mill is rated at 40 tons/day working on cotton seed. The bulk of this seed is supplied by the ginnery in the Abyan Governorate between May and September. Two varieties of cotton are grown in PDRY namely long staple and medium staple and, whereas the seed from the former needs delinting, the latter is supplied as clean seed. The quality of seed is good; the oil content varies from 19 - 22 per cent with an average acidity of 2.5 per cent.

4.11.2 The process consists of seed weighing and cleaning, dehulling, hull beating, roller mills for the meats, three cookers and expellers, cake breakers and cake weighing and bagging. Oil is settled in a large tank, filtered and then neutralised in a batch vessel. No attempt is made to recover soap stock which is discarded to drain. A deodoriser and bleaching plant have been installed, but are not utilised, since the neutralised oil finds a good market without further treatment.

The equipment is laid out on three floors within a new building. The layout is spacious, and the machinery appears to be working efficiently. A small workshop and a store for spare parts have also been provided.

4.11.3 The only chemical which is likely to be required in any quantity is caustic soda of which about 10 - 15 tons/annum will be used when the plant is operating at full capacity. There is also a requirement for jute sacks, but there is no reason why polypropylene should not be used. The sacks are reuseable and revolve between the factory and the ginnery. Assuming that each sack lasts about three years, this would provide a market for about 100,000 sacks/annum.

4.11.4 The output from the mill is as follows:-

54% Expeller cake of 6-7% oil content	valued at	25 YD/ton
27% Husk of 1-1.5% oil content	"	40 YD/ton
15-17% Oil		530 YD/ton
		(equivalent to 95 YD per 44 galls)

There are 2 - 4 per cent losses (including moisture and free fatty acids which are discarded).

The average gross receipt from processing one ton of cotton seed is therefore:-

(0.54 x 25) + (0.27 x 40) + (0.16 x 530) = 109.1 YD.
The cost of the seed is 50 YD per ton which leaves a margin of roughly 60 YD per ton to cover processing costs.

4.11.5 Curiously the expeller cake is sold at a lower price than husk, which has a much lower oil content, and is therefore intrinsically less valuable. The explanation for this is that the cake is sold back to the cotton growers to feed their cattle at a 'concessionary price' whereas husk is sold on the open market.

4.11.6 The major problem facing this factory is the shortage of raw material. As was noted in Section 3.7.1 and Table IX, there has been a sharp decline in cotton production in PDRY in recent years and, whereas the capacity of the plant is 12,000 tons/annum actual deliveries in 1979 amounted to only 3,900 tons. Only 4,000 tons are expected in the current season.

4.11.7 The obvious solution of importing cotton seed is precluded by the high price of importing seed which is quoted at nearly 200 YD/ton. This is roughly twice as much as the gross receipts from the processed oil, cake and husk.

At the same time the Home Trade Company is annually importing into PDRY:-

Sesame seed	7,000 tons	@ 264 YD/ton
Sunflower/Corn oil	136 tons)	
Palm oil	5,000 tons)	@ 244 YD/ton
Coconut oil	200 tons)	(average)
Ghee	14,000 tons	@ 311 YD/ton

4.11.8 The imported sesame seed is currently processed, together with some 2,000 tons of locally grown seed, in a number of small expellers in the different Governorates which are certainly less efficient than the Aden plant in terms of the amount of residual oil left in the cake.

4.11.9 The GDR expellers which leave 6 - 7 per cent oil in the cake should be compared with the best European and American machines which can reduce residual oil to around 4 - 5 per cent. If, for the sake of argument, the existing expellers were changed then the outturn from one ton of seed would be :-

52.8% Cake @ 4.5% oil content	@ 25 YD/ton =	13.20 YD
27% Husk @ 1-1.5% "	@ 40 YD/ton =	10.80 YD
16-18% Oil	@ 530 YD/ton =	90.10 YD
		114.10 YD

4.11.10 The fact that the oil seed mill sells oil at 530 YD/ton whereas the Foreign Trade Company imports it for

244 YD/ton could be said to imply that either the Foreign Trade Company is making a handsome profit or the general public is subsidising an uneconomic plant.

4.11.11 We were not able to obtain details of capital and operating costs for the factory but for the purposes of illustration we have made the following rough estimates:

Capital cost	1 million YD
Operating costs:-	
Salaries and Wages	100,000 YD/annum
Maintenance	25,000
Utilities (Steam Water Electricity)	30,000
Overheads (incl Transport)	20,000
Depreciation (over 20 years)	50,000
TOTAL	225,000 YD/annum

If the plant has a throughput of 3,900 tons/annum this would give an operating cost of 58 YD/ton which is close to the figure of 60 YD/ton allowed for processing by the present price structure. This suggests that a price structure has been devised in order to provide the factory with a reasonable chance of making a "profit" even with its current low throughput. Certainly 60 YD/ton is an extremely high figure when compared to plants in other parts of the world.

4.11.12 If the plant were to operate at full capacity the costs of salaries and wages, maintenance and depreciation would remain relatively constant whereas utilities and transport costs would increase in direct proportion to the tonnage throughput. Under these conditions the figures become:

Salaries & Wages	100,000 YD/annum
Maintenance	25,000
Utilities	90,000
Overheads & Transport	55,000
Depreciation	50,000
TOTAL	320,000 YD/annum

If the throughput were 12,000 tons/annum this would imply a processing cost of 27 YD/ton and it is a simple matter to calculate the maximum price which could be paid for cotton seed under these conditions, assuming that the present price structure for expeller cake, husk and oil remains unchanged. This is given by the equation:

$$x = (\frac{17}{100} \times 530) + (\frac{53}{100} \times 25) + (\frac{27}{100} \times 40) - 27$$

x = 87 YD/ton (Equivalent to about US $306/ton)

4.11.13 The question which then needs to be put to the Ministry of Agriculture is whether increasing the price of cotton seed from 50 YD/ton to 87 YD/ton could provide sufficient incentive to persuade farmers to grow three times as much cotton as at present. Obviously this is only part of the problem since we have not taken into account what the effect would be on the production of other crops if the acreage under cotton were to be increased. A detailed review of both the agricultural implications and the effect on ginning costs and the operations of the textile mill needs to be made at the same time.

4.11.14 An alternative would be to modify the plant to make it capable of processing the 7,000 tons/annum of sesame seed which are currently imported. To do this would imply closing down a number of small presses in other parts of the country but we have no information as to what the economic and social implications of this would be.

4.11.15 Another possibility which would avoid any plant modification would be to import cotton seed. This is not a normal practice because:-

(a) the low oil content of the seed before dehulling makes freight costs expensive.

(b) cotton seed oil is chemically less stable than most vegetable oils and the free fatty acid content tends to rise during storage and shipment.

Nevertheless cotton seed is available in Kenya, Uganda, Ethiopia, Sudan and Egypt and it would be worth making enquiries about supplies.

4.11.16 Recent prices for cotton seed, oil and cake fob USA ports are of the order of $220, $805 and $190 respectively. If the assumptions made in 4.11.11 are substantially correct and the price paid for cotton seed could be raised to 87 YD/ton ($308/ton) provided the plant is fully loaded, then there would seem to be a good case for importing cotton seed if local supplies are not forthcoming.

4.11.17 It would also be worth investigating in more detail the possibility of importing groundnuts from Port Sudan since groundnuts have a much higher oil content (48 - 50%) than cotton seed, and freight costs from Sudan should be relatively low.

4.11.18 Finally we recommend that the Foreign Trade Co should investigate the possibility of importing sesame seed from Sri Lanka. The June 1980 delivered price (cif) Japan was US $800/ton whereas we were advised by the Foreign Trade Company that the price in May (cif) Aden was US $930/ton.

4.12 The Fish Meal Factory at Mukalla

4.12.1 At present the only fish meal plant in operation is a floating factory ship of Norwegian origin which has a nominal capacity of 500 tons/day. An older shore-based factory with a capacity of 150 tons/day has been closed down and some of its equipment will later be transferred to a new 500 ton/day plant which is currently under construction. The new plant has been beset with problems owing to the bankruptcy of the principal West German contractor but is now scheduled for completion in 1982.

4.12.2 The fishing season extends from November of mid-April and during the period of the S.W. monsoon from May to October when fishing stops essential maintenance work is carried out.

This year, from the 8th January to the 12th April 1980, 5708 tons of fish were processed by the floating factory, at an average output of approximately 57 tons/day or roughly 11 per cent of the quantity required to keep the plant at maximum output.

4.12.3 The fishmeal produced normally amounts to 17 per cent by weight of the fresh fish and has a residual oil content of 5-8 per cent. The oil recovered is said to be 7 per cent of the weight of the fresh fish. However the production figures for the Jan-April period of 850 tons fishmeal and 250 tons oil suggest that the true recoveries are :-

$$\frac{850}{5708} = 14.9 \text{ per cent for fishmeal, and}$$

$$\frac{250}{5708} = 4.4 \text{ per cent for fish oil}$$

4.12.4 The floating factory appears to be in good condition, except for the "blood water" evaporation unit which is badly instrumented and has blocked exchanger tubes. It is currently out of commission.

The process sequence and equipment is similar to herring processing; the fish are pumped from the fishing vessel into the factory ships' holds and from thence are conveyed into cookers and presses. The oil/water mixture passes through Sharples Decanters to settling tanks, and centrifuges. The oil goes to storage whilst the "blood water" is discharged overboard because of the problems with the evaporator unit. The meal from the presses is dried, milled and bagged in 50 kg paper sacks.

4.12.5 Both meal and oil are stored in barges, the meal in 600 ton lots and the oil in 400 ton tanks. Whilst the meal store is satisfactory, the oil storage barge has inaccessible holds which are extremely difficult to clean. This inevitably leads to the oil going rancid and fetching a low price. This point is well illustrated by the fact that in 1978 the Ministry of Fish Wealth obtained 126 YD/ton for fish meal and 72 YD/ton for fish oil whilst the 1979 world market prices quoted cif Hamburg were 147 YD/ton and 136 YD/ton respectively. The difference between the meal prices can be accounted for by freight charges and inflation, but the wide difference in oil prices can only be attributed to poor quality. The next time the tanks are emptied, larger hatches should be cut in the decks of the barge to allow easy access and the tanks must be scrupulously cleaned before next season. It is also important to check whether proper tank access has been designed for the storage tanks at the new factory.

4.12.6 Whilst we would normally recommend that the "blood water" evaporation unit should be repaired and put back into service, since it not only increases the weight of fish meal produced but also improves the protein content, it may well be that this is not an economic proposition if the floating plant is to be closed down when the new factory comes into operation.

4.12.7 The fish meal factory is supplied by a fleet of five trawlers and there are currently two others under repair in Aden. Two of the trawlers have a capacity for 200 tons of fish and have cooling systems which maintain the temperature in the holds at 5 - 10 °C which allows fish to be stored for up to four days. The remaining five vessels have a capacity of 90 tons each and have no cooling systems so that they are obliged to return to port every day. Their effective radius of operations is thus restricted to about 100 miles whereas the larger vessels can range up to 400 miles. Two more of the larger vessels are on order and will be in operation next season so that the total fleet will be made up of five large and five small ships.

4.12.8 In theory each vessel is supposed to catch 40 tons/day and there are occasions when this is achieved by individual trawlers but the average is very much lower. As we have seen, the average total catch in the first three months of 1980 was 57 tons/day or slightly less than 12 tons/ship/day and the most successful vessel, the Dop Dop, only caught 663 tons in February which is an average of 28 tons/day. To keep the 500 ton/day factory supplied therefore implies that the augmented fleet of 10 vessels will have to increase it productivity by a factor of four. In addition to long term research on the availability, distribution and life cycle of different species there are obvious short term improvements which can be made to the existing system which will help towards this end such as:-

(i) Using echo-sounding equipment to locate the fish.

(ii) Purchasing a large refrigerated vessel, to transport fish from the trawlers back to the factory which would allow the trawlers to stay at sea and keep fishing instead of returning to port every day.

(iii) Setting up a workshop in Mukalla capable of carrying out all but the most major ship repairs. At present all maintenance is done in Aden which inevitably causes long delays.

4.12.9 It is reasonable to expect that there will be an increase in productivity as crews become more adept at purse seine netting and as skippers become more familiar with distant waters. Nevertheless we find it hard to believe that a fleet of ten will be sufficient to keep the fish meal factory at full production and there will come a point where it is necessary to decide whether to invest in more trawlers or to run the factory deliberately below its rated capacity.

4.12.10 The basic problem is that the fish meal industry is not at the moment a very profitable one and it is difficult to see how any further investment in trawlers can be justified on economic grounds. We were not provided with any figures on the costs of operating either the trawlers or the fish meal factory, but to illustrate the problem we have made the following estimates:-

Assuming that the capital cost of the ten trawlers is 500,000 YD, and operating costs as follows -

Wages (200 men @ 35 YD/month)	84,000 YD/annum
Maintenance (10% of capital cost)	50,000
Fuel	75,000
Overheads	10,000
Depreciation (over 10 years)	50,000
TOTAL	269,000

The costs of the fish meal factory can be taken as roughly equivalent to the vegetable oil mill (see Section 4.11.11) and the processing costs assumed to vary between 200,000 and 300,000 YD/annum depending on output.

4.12.11 If the yields of fish meal and oil are 17 per cent and 7 per cent and their prices 126 YD/ton and 72 YD/ton respectively, the revenue derived from one ton of wet fish would be 26 YD/ton.

At the current production level of 12 tons/boat/day the total catch from 10 boats in the six month season (assuming a six day working week) will be:-

$$26 \times 6 \times 10 \times 12 = 18{,}720 \text{ tons}$$

and the cost of converting this to oil and meal will be:

$$\frac{269{,}000 + 200{,}000}{18{,}720} = 25 \text{ YD/ton}$$

4.12.12 This suggests that the whole operation is barely breaking even and insufficient profit is being generated to provide for new investment in trawlers.

Provided production can be stepped up to 50 tons/boat/day then the total catch in the six month period becomes 78,000 tons and the cost of production will be:

$$\frac{269{,}000 + 300{,}000}{78{,}000} = 7.3 \text{ YD/ton}$$

At this level there will be a surplus of 78,000 (26 - 7.3) YD or nearly 1.5 million YD/annum which appears to be a good return on investment.

4.12.13 However it must be pointed out that while the total production of sardines in PDRY in 1977 and 1978 was 90,000 tons and 62,000 tons respectively, the fish meal factory was kept short of raw material. The reason for this was that the open market price for sardines was 50 YD/ton (fresh weight) which is well above any price which the fish meal factory could have afforded. The question then arises as to whether a market exists for fresh or air dried sardines at a price of 50 YD/ton (fresh weight equivalent) either in PDRY or some other neighbouring country to which the trawler catch could be diverted. If such a market exists then the potential return of (78,000 x 50) - 269,000 = 3.6 million YD would be a distinct improvement on the yield from fish meal and oil even if oil is given its full market value. A survey of the market for air dried sardines should be carried out in the Arabian Gulf, and in East and North East Africa, before further investment in the fish meal project takes place.

4.13 The Fish Canning Factory at Mukalla

(Note. We were not permitted to inspect this factory and our information was obtained from an interview with the factory manager outside the premises.)

4.13.1 This is a new factory which started operations in December 1979 and is still in the process of working up to full output. It was designed and built by the USSR which is also supplying technicians to assist in the running of the factory for the first two years. The design capacity is 8.4 million cans/annum working on one shift/day, but the production planned for the first two years is 2.5 million and 5 million cans respectively.

4.13.2 Although the plant was originally intended for canning Tuna fish, catches were so small that production was switched to 70 per cent makerel and 30 per cent sardines. These are supplied by the cooperatives and also by the Ministry of Fish Wealth's vessels. Makerel are currently purchased at a concessionary price of 77 YD/ton as opposed to the market price of 142 YD/ton whereas sardines cost 50 YD/ton. This subsidy is presumably to help the factory in its early stages of development and should be removed when the output approaches design capacity.

4.13.3 In the process, the fish pass from the cold store to a defrosting section and are then degutted using disc machines. Because of their size and the fact that the plant is using small round tins, it is necessary to cut the fish into segments before packing. Filling of the cans with an average of 185 gm of fish is at present done by hand, but an automatic machine is due to be installed in September 1980 which will fill 45 cans/minute. Sardines are then blanched, which causes some shrinkage and means that whereas makerel (which is unblanched) needs only 10 gm of vegetable oil per tin, sardines sometimes take up to 35 gm/tin, thereby adding considerably to the cost. After the addition of oil and salt the cans are sealed, washed, retorted at 120° C (for 55 minutes in the case of makerel and 45 minutes for sardines), dried. labelled and finally packed in cartons containing 60 tins each. All waste material from the cutting and gutting section, which amounts to about 35 per cent of the total weight of fish, goes into a small fishmeal plant which has no connection with the other fish meal plants in Mukalla.

4.13.4 Apart from salt and vegetable oil the only chemicals required by the factory are about 4 tons/annum of detergents and 'a few' tons of caustic soda for cleaning purposes. There is also a requirement for labels, which is currently being met by the 14th October Printing Press, and for cartons which are imported. Cans are imported as flats and we do not foresee any chance of establishing an economic unit for making cans even allowing for the additional output of the other fish canning plant at Shukra and the tomato paste factory.

4.13.5 One interesting possibility would be to use refined, deodorised fish oil in place of vegetable oil. Assuming that the ratio of 70 per cent makerel:30 per cent sardines is maintained, and that these require 10 gm and 35 gm of oil/can respectively then, when production reaches 8.4 million cans the quantity of vegetable oil needed will be 147 tons/annum. Although this may be small by comparison with the planned production of fish oil, it does correspond fairly well with current production levels. It seems rather pointless to send fish oil from Mukalla to Singapore and bring vegetable oil back again if a straight substitution can be made. Certainly, the fish oil currently produced by the floating fish meal factory would need to be properly refined and deodorised before it could be used, but this is not a particularly difficult operation. It is unlikely that consumers would notice the change since the taste of the fish is much stronger than the taste of the oil. Nevertheless it would be wise to make the change by using blended fish/vegetable oil mixtures and gradually increasing the proportion of fish oil.

4.13.6 Although in the short term the Ministry of Fish Wealth is concentrating on supplying the local market, in the long run there seems every reason to suppose that fish canning in Mukalla will develop into a major export earner. At present there are logistical problems involved in getting the right quantity and quality of fish to the cannery at the right time, but it is as well to remember that 8.4 million cans/annum is equivalent to 1,550 tons/annum of fish which is only one per cent of the quantity required to keep the new fish meal plant at full production. On the other hand the profit from canned or frozen fish is considerably higher than selling it in the form of fish meal and it would be quite wrong to restrict the expansion of canneries because this might deprive the fish meal factory of some of its raw material. Once the new canning plant has settled down, the Government would do well to start thinking about expansion and development of an export market. This may entail some changes since most countries are not used to buying sardines in small round tins and normally expect to see whole rather than chopped fish. Nevertheless there are very large markets available and this appears to be on of the industries in which PDRY should be able to compete successfully.

4.13.7 Canned tomatoes and vegetables will always be restricted by the availability of land and water, but the supply of sardines and mackerel suffers from no such limitation. In our view, despite the manifold problems which beset this industry at present, it is the one which holds out most promise as a major earner of foreign exchange for PDRY and should be treated as such when considering the deployment of investment resources.

4.14 The Flour Mill

4.14.1 The Aden flour mill was designed and constructed by the GDR and started operations in 1975. Its nominal capacity is 200 tons/day and a rate of 185 tons/day is being achieved in practice.

4.14.2 The plant operates for 280 working days/annum which allows for two maintenance shutdowns of a fortnight each. The total outputs of flour and bran are 39,000 tons/annum and 13,000 tons/annum respectively and it is estimated that this satisfies 60 - 70 per cent of the demand for flour. Although about 10,000 tons/annum of wheat is produced in PDRY this is milled in the other Governorates; the Aden mill relies entirely on imports and operates on 40 per cent hard and 60 per cent soft wheat. The principal suppliers are Canada, USA, USSR and Australia and purchases are normally made in 200 - 500 ton lots. There are unfortunately no bulk handling facilities in the port area and the grain has to be bagged on the quayside before transferring to the mill which is 5 km away. Not only does this lead to losses and invite infestation from weevils, but it is also a waste of manpower. It is recommended that bulk handling and transport facilities at the docks, and underfloor conveyors at the mill should be given further study.

4.14.3 Although the plant has, in general, been well engineered the following points should be noted:-

(i) The grain washing system does not perform well and is constantly breaking down. The moisture content of the wheat is a crucial factor in obtaining good operational efficiency, the optimum figure being around 16 per cent. Frequently the wheat coming into the plant is at 12 per cent and without a reliable washing facility this is bound to cause trouble. We suspect that the drive unit is not up to the duty required of it, but this needs to be looked at in more detail.

(ii) The main switch room is in the centre of the building and the switch gear has become covered in flour dust. This constitutes a serious fire risk and it is recommended that:-

a. The switch room should be cleaned regularly once a week with a vacuum cleaner.

b. Double doors should be installed to provide an air lock between the plant and the switch room.

c. The room should be air-conditioned.

(iii) The weighing and bagging of flour is done manually and there is no provision for a fine feed system so that there is likely to be considerable variation in the true weight of the bags. Not only can this lead to genuine losses, or alternatively customer complaints but it also makes it extremely difficult to maintain accurate plant records.

(iv) It takes a considerable time for the mill to recover from an interruption to the electricity supply and this is one of the relatively few factories where consideration should be given to the provision of a standby generator.

(v) The mill has considerable problems with weevils but no fumigation of the grain silos has been carried out. We were unable to inspect the silos to see what problems this would create, but it is certainly a matter which needs to be pursued.

4.14.4 Despite these criticisms, which really stem from faults in design, we were impressed by the way the plant was being run and we recognise that under the difficult operating conditions, the continuous attainment of over 92 per cent of rated capacity represents a very creditable performance.

4.14.5 The mill does not use any chemical additives and only uses very small quantities of water treatment chemicals. On the other hand it sells flour in 60 kg polypropylene bags with polythene liners and 52,000 tons/annum represents a potential off-take of 867,000 bags.

4.15 The National Soft Drinks Company

4.15.1 Originally there were five soft drinks factories in Aden, all privately owned, namely, Coca-Cola, Pepsi-Cola, Canada Dry, Kota-Cola and Green Spot Cola. The combined out-put was 280 crates per hour (one crate holding 24 x 8½oz bottles). Three factories were destroyed at the time of Independence, leaving the Canada-Dry and Coca-Cola factories with a joint output of 160 crates per hour.

4.15.2 In October 1979 work began on the installation of West German equipment for a new 1100 crate/hour plant on the site of the old Canada Dry factory. This is due for commissioning in 1980 and, once it is running smoothly, the old Coco-Cola plant will be closed down. The products which will be made include:-

Tonic Water
Soda Water
Pineapple Juice
Orange Juice
Spot Cola
Champion Cola
Stim Cola
High Spot Lemon

4.15.3 The operation of an 1100 crate/hour plant for 8 hours/day and 26 days/month represents an output of roughly 5½ million bottles/month which is nearly seven times the existing production. Whilst this may seem a rather massive increase, it still represents a consumption of slightly less than one bottle/day for every person in the Aden Governorate, not counting any of the population further afield, and therefore it seems likely that the plant will soon reach full capacity. Nevertheless it should be noted that the price of soft drinks is currently controlled at 33 fils/bottle whereas in all probability the production cost on the new plant will be over 50 fils/bottle. Should the Government raise the present price in order to provide the company with a reasonable rate of return there may well be some consumer resistance.

4.15.4 The principal raw materials used by the factory are proprietary concentrates, sugar, citric acid, water and water treatment chemicals, carbon dioxide, glass bottles, crown tops and plastic crates. Of these, the first three will have to be imported and need not be considered further.

4.15.5 The water requirement of the plant will be quite high, at around 100 m^3/shift, and we would recommend that the factory management should check the likely frequency of water restrictions with the Water Corporation and then recalculate whether their five water storage tanks will be adequate. The total dissolved solids (TDS) of the water is too high for both the boiler plant and for bottling, and a Reverse Osmosis unit has therefore been installed. The following chemicals will be required for water treatment:-

Calcium Oxide
Sodium Carbonate
Sodium Aluminate
Ferric Chloride
Sulphuric Acid
Sodium Hexametaphosphate
Chlorine

The quantities required, however, are relatively small.

4.15.6 Carbon dioxide will be generated by burning diesel oil and scrubbing the exhaust gases. It is common practice to collect the CO_2 produced during fermentation in a brewery and to use it for soft drinks production and this could well be considered in Aden where a new brewery is being built quite close to the soft drinks plant. The question which will need further study is whether the cost of a compressor, storage tanks and pipeline will outweigh the cost of fuel which is required by the existing system. In any event the soft drinks factory will need to retain its CO_2 generator to deal with those occasions when the brewery is shut down.

4.15.7 At present the company purchases about 1.5 million bottles/annum for a factory with an output of 160 crates/annum and, if the same breakage rate applies in the new factory, the likely demand will be 10 million bottles/annum. Allowing three bottles per kg of glass, this represents a demand for about 11 tons/day of glass. At the present time even the smallest glass bottle-forming plant on the market has a rated output of about 30 tons/day. This is an instance where cooperation between North and South Yemen could bring benefits to both sides for neither, on its own, is likely to be able to justify a glass bottle factory and yet both suffer from the fact that importing glass bottles is extremely expensive. A brief outline of a small glass plant is given in Appendix X.

4.15.8 Crown tops are imported in bulk; the cost however is small and there appears to be little reason to manufacture locally, although there is said to be some Hungarian equipment already in PDRY which could be used for this purpose. All raw materials would have to be supplied from abroad and there would be no means of recycling the offcut waste. This aspect together with the problem of balancing orders for the correctly printed sheet suggests that the benefits would be very marginal.

4.15.9 The old 160 crate/hour plant uses a stock of 6,000 crates which means that on average each crate spends 4½ days in circulation before being refilled. Scaling up for the 1,100 crate/hour plant gives a figure of 41,250 crates but, bearing in mind that the distribution network will cover the whole country whereas, at the moment, the majority of sales are in Aden, it would not seem unreasonable to double the time in circulation and hence the stock of crates. The current position is that the factory has imported 100,000 crates for the new plant and is considering ordering another 50,000. Whilst 100,000 does not appear unreasonable it is difficult to see the justification for an additional 50,000 since the rate of deterioration of the crates is very low. The Algundi Plastics Factory is anxious to manufacture crates, but has not yet obtained the necessary mould. In these circumstances it would be sensible to delay the purchase of further crates until such time as the Algundi factory is in a position to supply them.

4.16 Dairy Products Factory

4.16.1 This is a new factory which only started production in June 1979. It consists of six sections: preparation, pasteurising, sterilising (UHT), yoghourt, cheese and laboratory. Current production is some 20 tons/day of pasteurised and sterilised milk as well as some yoghourt. The capacity of the plant is quoted as:-

Pasteurised milk	30 tpd (operating on 1 shift)
Sterilised milk	10 tpd
Yoghourt	2 tpd
Cheese	3 tpd

4.16.2 Pasteurised milk is sold in 'Tetrapaks' whilst the sterilised milk which will keep for three months is sold in 'Prepaks' (similar to Tetrapaks, but with a polythene lining). Yoghourt is sold in containers which are produced automatically from plastic film strip and the top is sealed with pre-printed aluminium foil.

4.16.3 The factory receives some 5 tpd of fresh milk from the State farms and the balance is made up from imported milk powder and fats.

4.16.4 A considerable effort has been made to see that those responsible for running the plant have been properly trained, and we were impressed by their obvious concern to keep the plant tidy and hygienic, and to ensure that the finished products are up to standard. Our only slight reservation is that the plant is well automated with quite a number of instruments but there did not appear to be anyone in the factory who knew how to maintain them. At the moment, whilst the plant is brand new, this is not a problem, but it would be advisable to be prepared. It would also be worth paying particular attention to the maintenance of the three refrigerated delivery lorries which are probably the most vulnerable machines belonging to the factory. If it has not been done already, the Italian contractors should be asked to draw up a planned maintenance schedule for the whole plant.

4.16.5 The management are obviously keen to expand their turnover and have already organised a trial consignment to North Yemen, and in the future will try to develop markets in Somalia, Djibouti and Ethopia.

The production of fruit flavoured yoghourts and cheddar cheese are also being considered. Given sufficient enthusiasm there seems no reason why these developments should not prove successful and we feel they should be given every encouragement.

4.16.6 Apart from milk powder and fats the plant requires very little in the way of chemical raw materials apart from small quantities of caustic soda (about 5 kg/day) and Nitric Acid (3 kg/day) which are used for sterilising, and salt which is used for regenerating the water softener. The production of Tetrapaks might well be considered as part of the output of a printing and packaging company and at a later stage it might be worthwhile for the Algundi Plastics Company to manufacture the plastic crates which hold 18 Tetrapaks each. However for the moment if the production reaches 30 tpd in ½ litre Tetrapaks this would require

$$\frac{30,000}{0.5 \times 18} = 3333 \text{ crates/day}$$

and if these are returnable after two or three days the number in circulation will only be about 10,000 which would not be sufficient to justify the purchase of a mould.

4.17 Yemen Company for Perfumes and Cosmetics

4.17.1 This small company, which operates from a former garage, was started in 1974. It currently employs 40 people working one shift/day, six days/week and production is in the region of 20,000 - 40,000 litres/annum. Previously the company sold a wide range of alcoholic perfumes and also blends of essential oil concentrates but in the last year it has reduced its range to 10 of the former and 8 of the latter. All raw materials including alcohol, essential oils, bottles and packaging materials are imported. The company has licensing arrangements for the production of certain perfumes and is currently negotiating another licence to enable it to produce 100,000 tubes/annum of tooth paste and 75,000 bottles/annum of shampoo. There are also plans to make hair cream, shaving cream, talcum powder and prickly heat powder.

4.17.2 The equipment used for perfume production is very simple since the only operations involved are weighing, mixing, filtering and packing. Since this is not a high-speed line, packing is done by hand and there are therefore no real maintenance problems.

4.17.3 Our only criticism of the factory is the fact that the fire precautions are totally inadequate, bearing in mind the amount of alcohol which is stored on the premises.

4.17.4 The company owns one shop but the majority of its products are sold to merchants. In theory it has a monopoly of the market but it has been estimated that 75% of the perfumes consumed in PDRY have been imported into the country through irregular channels. This does not imply that the company's products are in anyway inferior but reflects:-

(a) The prejudice, which is not unique to PDRY, that anything imported is 'good' whereas anything made locally is inferior.

(b) The power of advertising and novelty.

4.17.5 The company obviously cannot afford to spend large sums on glossy advertising and has recognised the futility of trying to match every passing change of fashion. We agree with their policy of reducing the product range to a relatively small number of perfumes which sell well and of trying to build up the production of the cheaper range of cosmetics such as shampoos and hair cream, where the volumes are larger and the sales more consistant.

4.17.6 The raw materials required by the factory consist of:-

Alcohol
Essential Oils
Bottles
Boxes

4.17.7 Whilst in theory it would be possible to make 20,000 - 40,000 litres of alcohol in PDRY, the cost and security problems involved in doing so, make this an unattractive project. To the best of our knowledge there are no essential oils grown commercially in PDRY despite the many historical references to 'the perfumes of Arabia' and the fact that to the Romans Arabia Felix was a well known source of perfumes and frankincense. In view of the high price of essential oils and the fact that it would make an attractive small scale agro-industrial project, it might be worth encouraging the agricultural research station to set out a few trial plots.

4.18 Hempel Paints Factory

4.18.1 This company began manufacturing both decorative and marine paints under licence in 1970. The volume of production in the last three years has been as follows:-

1977	140,000 US galls
1978	374,000
1979	384,000
1980 (budget)	412,000

The capacity of the plant is theoretically 600,000 US galls/ annum assuming 1 shift/day six days/week. 1 gall paint tins are manufactured on site from imported flats. Marine paints are sold to the National Dock yard Company or directly to ships and, in the past, there have been some exports to Somalia (20,000 US galls in 1977). The household paints are sold through the Home Trade Company or direct to customers at the factory gate.

4.18.2 Since this is a very simple factory there are few mechanical problems and our overall impression is that the company is fulfilling its purpose reasonably efficiently. The storage of raw materials and finished products is however very untidy and the standard of house keeping should be improved. The position should be eased when the new storage area is completed.

Bearing in mind the high fire risk associated with paint factories, the existing fire fighting facilities should also be re-examined.

4.18.3 The principal raw materials used by the plant are as follows:-

Alkyd resins	700 tpa
Titanium Dioxide	200
White Spirit	90
Poly Vinyl Acetate	300
Drying Oil	30
Water	1800

In theory it would be possible to produce alkyd resins in PDRY and perhaps make use of the glycerol fraction which could be produced by the soap factory. However it seems unlikely that this would be a viable venture for the following reasons:-

(i) Apart from glycerol, all raw materials such as phthalic anhydride and cotton seed oil would have to be imported (on the assumption that PDRY will never be able to produce surplus cotton seed oil)

(ii) The glycerol fraction from the soap factory could not be used direct but would have to be purified which is itself an expensive operation if carried out on a small scale.

(iii) Although alkyd resins can be produced in relatively small batches 700 tpa still represents a very small output.

(iv) The paint licensor (Hempels) might object to the use of alkyd resins which are not manufactured under its own control.

Although alkyd resin manufacture is not recommended at the present stage of industrial development of PDRY it is a project which should be kept in mind for the future. The other paint raw materials offer no prospects for local manufacture.

4.19 The Yemen Auto Batteries Co

4.19.1 This company began in 1974 by importing 'Chloride' batteries from the UK and in 1977 set up a production line under licence from the Swedish firm, Noaek. Thirteen different sizes are manufactured, suitable for both cars and heavy commercial vehicles.

The factory employs 30 workers and in 1978 and 1979 produced 23,000 and 19,200 batteries respectively. The estimate for 1980 is 19,700.

4.19.2 The assembly line has been well laid out and the plant appears to work quite efficiently. However the whole operation is hampered by the fact that it is tied to one supplier of components. Without the ability to 'shop around' it seems likely that the cost of a locally produced battery will be higher than that of an imported one. One way of mitigating this problem would be to start reconditioning old batteries which are currently thrown away. Normally it is the plates which need to be replaced whilst the casing and the lead link bars, which together make up a fair proportion of the total cost can usually be recovered. Consideration should be given to the installation of a small muffle furnace for recovering lead from used plates. Whilst we would not recommend trying to use this recovered lead to make new plates, it could perfectly well be used to make new link bars.

4.19.3 The total quantity of sulphuric acid used in batteries in PDRY amounts to roughly 300 tons/annum which is really too small to justify local manufacture. However this could be considered when the sulphonation unit of the detergent plant is being designed. (see Section 5.4.3.)

4.20 National Cigarette and Matches Industries

4.20.1 This company, which employs 400 people, started as two separate enterprises, the first being the match factory, which began in 1970 followed by the cigarette factory in 1973. The original match-making machinery came from Japan but a completely new line has recently been installed which consists of Swedish match-making and West German packing machinery. The new plant was being commissioned at the time of our visit and consequently it was still suffering from some inevitable teething troubles. There appears to be some mismatch between the rate of production and the rate of packing and it seems inevitable that one part of the plant will have to run on one shift whilst the other works two shifts. It is expected that production will settle down to about 2,000 - 2,500 gross of boxes per day.

4.20.2 There is an obvious need to move the initial feed hopper and sorting machine so that it will feed direct into the match making machine and this is already in hand. Likewise the final packaging of the boxes into cartons could be automated further.

4.20.3 We were impressed by the efficiency with which this plant was being run. It was clean and tidy and there were no heaps of unwanted raw materials or faulty products lying around. The management was well aware of the dangers of the chemicals being handled and was making sure that shift teams were trained to cope with emergencies.

4.20.4 The chemical raw materials required to produce 2,000 gross of boxes/day for 300 days/annum are:-

	Tons/annum
Calcium Chlorate	48.0
Potassium Dichromate	1.25
Gelatine Glue	10.0
Sulphur Powder	6.25
China Clay	2.5
Talc Powder	2.25
Casein	2.25
Manganese Dioxide	5.75
Glass Powder	19.0
Paraffin Wax	15.5
Hide Glue	0.5

These tonnages are too small to be considered for local production. The possible exception is animal hide glue which might be produced as an adjunct to the tannery. The more interesting possibility is the local production of the cardboard strip (both printed and plain) which is used for the boxes, the wrapping paper for cartons and the labels all of which might form part of the output of a local printing and packaging factory.

4,20.5 The cigarette factory makes two brands, Radfan and Pall Mall the latter under licence from Rothmans. Tobacco is all imported although the Ministry of Agriculture is undertaking experiments on the production of Virginia tobacco (Local tobacco is suitable for Hookahs but apparently not for cigarettes.) Blending is done in a separate plant, which we did not visit. New machinery is being installed there which will allow for the blending of approximately double the quantity currently required for cigarette manufacture which is about 100 tons/month.

4.20.6 There are no chemical additives used in the cigarett- apart from very small quantities of adhesive and inks, and once again, the only real possibility for import substitution, other than growing suitable tobacco, lies in the packaging.

4.20.7 At the moment the company sells about 15 million packets of Pall Mall and 45 million packets of Radfan every year. The former are only produced in flip-top packets whilst the latter is produced in both flip-top and soft packets.

4.20.8 The licensing arrangement with Rothmans extends to the provision of training courses and certainly the machinery gives every appearance of being well maintained. There were none of the usual complaints about difficulties in getting spare parts.

4.20.9 Although North Yemen has its own cigarette factory at Hodeida there may well be export opportunities in Ethiopia and Djibouti and indeed in many of the Gulf States which, for religious reasons, will not contemplate indigenous production of cigarettes. No doubt the export of Pall Mall will be restricted by the licensor, but there is no obvious reason why this should apply to Radfan and particularly if the experiments with locally grown Virginia tobacco are successful, this could well become a valuable export for PDRY.

4.21 Gil Bawazir Gypsum Factory

4.21.1 Work began on this project in 1976 and it is hoped that the factory will finally be commissioned in 1980. It is being built under a bilateral agreement with Hungary, and is designed to produce 750 tpa of gypsum, 600 tpa for use as building plaster and 150 tpa for blackboard chalk for schools. Some Plaster of Paris for medical use will also be made.

4.21.2 There are four quarries in the neighbourhood of Gil Bawazir and, according to the Geological Survey Department, there are reserves of around six million tons of good quality gypsum in the area. The project envisages two men to dig gypsum by hand, four men to transport it by lorry to the plant and fifty-five men to operate the process which consists of sorting, crushing, screening, firing, grinding (hammer mill plus rod mill for the fine grade material), colour mixing, moulding, cutting and packing.

4.21.3 It has been estimated that the requirement for blackboard chalk is 10 million pieces per annum which we consider to be rather exaggerated. The plant, however, is designed to run five batches per day with each batch giving 30,000 pieces so that the annual production requirement will be achieved in three months.

4.21.4 The layout of the plant leaves much to be desired. No attempt has been made to install conveyors or to group machines in such a way that one feeds into the next. The explanation for this is that the project was conceived at a time when it seemed necessary to create employment. However, since it now appears that there is no shortage of job opportunities in the area, the problem remains as to what should be done with the factory. In our opinion no attempt should be made to produce building plaster because if 59 men are employed to produce 750 tons of plaster in 9 months and their monthly earnings average 35 YD the labour cost alone will be :-

$$\frac{59 \times 9 \times 35}{750} = 24.8 \text{ YD/ton}$$

which would make it an extremely expensive product. The scale of operations should be limited to producing school chalk and medical Plaster of Paris. Since the basic plant will then have excess capacity, it could be run as a batch operation with a much lower labour requirement. If two elevators were purchased to feed the kiln and the batch mixer, a gang of say four men could be organised to spend a week quarrying gypsum and moving it to the plant, the following week they would move on to crushing and screening, and then the next week they would operate the furnace and so on. Whilst this clearly makes inefficient use of capital equipment, since each section of the plant is inactive for most of the time, the fact is that since the factory was supplied as a gift from Hungary there are no fixed capital charges and the important thing is to make the most efficient use of labour.

4.21.5 There will undoubtedly be those who will argue the opposite case, that by modifying the plant to increase output it should be possible to bring the labour costs down and make the production of building plaster viable.

This is true, but this plant was always intended to be on a small scale and if high output is required it would be much cheaper to start again with a properly designed plant. In particular a proper furnace should be supplied rather than trying to modify the existing one. In Section 6.26 it is suggested that the manufacture of gypsum building panels, would be worth further study in which case this should be combined along with a proper unit for making building plaster.

4.22 Shemosa Lime Plant

4.22.1 This plant consists of nine shaft kilns built in the traditional manner some 20 kilometers west of Mukalla where there are extensive limestone deposits close to the main road to Aden and within easy reach of the sea. Limestone is extracted with pick axes and hammers and transported to the kiln by lorry. Here it is graded by size and carefully built up inside the kilns in such a way as to allow a reasonable through draught. The kilns are then fired with wood, most of which appears to be date palm costing 170 YD per lorry load. After firing the kilns are unloaded by hand and the lime is slaked with sea water and then packed in 50 kg jute bags.

4.22.2 Each kiln is fired about four times a year and yields about 1400 x 50 kg bags of slaked lime so that the overall production is in the region of 2500 tpa. The price per bag collected from the site is 2.5 YD. Although there appears to be plenty of demand for lime, further expansion is limited by the difficulty of getting labour and the shortage of fire wood.

4.22.3 Taken in isolation this is a most attractive plant which is using traditional skills and local resources to create products of value to the community and one should be cautious about recommending radical changes to a business which is so obviously successful. Nevertheless it is not difficult to see that mechanised quarrying together with a modern oil-fired shaft kiln and a proper slaking and bagging plant could produce lime in much greater quantity and at a lower cost than the existing factory. Some details of such a plant are given in Appendix VI. The question which needs to be resolved is whether it would be more economic for PDRY to have a single lime plant situated adjacent to the new cement works, which would have all the advantages of shared infrastructure and in particular a shared quarry, but would imply high transport charges to the Hadrahmut region, or to have two smaller plants in which case it could be worth modernising the Shemosa site.

4.22.4 This question cannot be resolved without a detailed study of the building requirements in the different Governorates which is beyond the scope of this report but is an area which should presumably have been covered in the Cement Plant Feasibility Study.

4.22.5 It is interesting to note that the lime is slaked with sea water which in a temporate climate would inevitably result in lime plastered walls becoming discoloured with salt bloom. Presumably the atmosphere is so dry in PDRY that this process does not take place.

Should a lime plant be established close to the cement works, attempts should be made to discover if there are sufficient quantities of brackish water available to slake the lime rather than use scarce supplies of potable water.

Finally jute sacks are in short supply, and are expensive, and should a polypropylene sack factory be established in PDRY, lime would provide another outlet for them.

V REVIEW OF FEASIBILITY STUDIES

5.1 Fertilizer Factory

5.1.1 A brief study was carried out in 1974 by a team from the Indian Ministry of Petroleum and Chemicals. Their conclusion was that in the absence of any indigenous supplies of oil or natural gas a nitrogenous fertilizer plant in Aden, which would have to rely on imported feedstocks, would be uneconomic. They also pointed out that because of the very small local market for fertilizers, it would be necessary to export the vast bulk of the production and therefore the project should be abandoned.

5.1.2 Whilst there have been considerable changes in the economics of fertilizer production since that report was prepared the conclusions are undoubtedly still valid because:-

(i) There has been a very sizeable increase in the production of ammonia from associated natural gas in most of the oil producing countries which has led to the closure of many plants based on naphtha feedstocks.

(ii) The current price of a 1000 tpd ammonia and 1500 tpd urea plant which is the normal economic size of plant now being installed is around 60 million YD which represents more than twice the total amount of money allocated to the industrial sector under the next Five Year Plan.

(iii) In 1979 the market for nitrogenous fertilizers in PDRY was approximately 6,000 tons which represents only one week's production from such a plant.

(iv) The requirement of around 3 million gallons/day of fresh water, although not impossible would create considerable strain on the available resources.

5.1.3 The position could alter radically if natural gas were discovered but no development should be contemplated until adequate reserves have been proven. As noted in Section 4.1.4, a number of neighbouring countries have been persuaded to install small naphtha based plants usually producing around 180 tpd of ammonia. These plants have normally been purchased on the basis that they were of strategic importance and that the economics were of secondary significance. To date all those countries which have embarked on such projects have come to regret their decision.

5.2 Building Materials

5.2.1 Cement

The new Five Year Plan includes an allocation of 14.7 million YD for a cement plant. It was not made clear to us what size of plant is being considered, but this size of investment would suggest a plant of between 100,000 and 150,000 tpa. We did not see the feasibility study on the cement project, nor any demand forecasts, but it is difficult to see how such a large tonnage can be utilised in PDRY. The import figures for cement for the years 1973-77 are as follows:-

1973	110 Thousand tons
1974	63 "
1975	28 "
1976	50 "
1977	70 "

Although imports may have been restricted artificially, it still seems likely that there will remain a substantial surplus for export.

5.2.2 If the plant is to be sited in the Abyan Governorate, it is doubtful whether cement can be exported economically bearing in mind:-

(i) That the site is a considerable distance from the port of Aden.

(ii) 150,000 tpa, although large in terms of the PDRY market, is relatively small compared to the output of many modern plants and production costs will not show the advantages which can be derived from large scale operations.

(iii) Bulk loading facilities at Aden would be extremely expensive to instal because of the lack of deep water berths.

5.2.3 As in other cases, simple industrial logic would suggest a combined project with North Yemen which is also currently investigating the feasibility of a cement plant and has yet to reach a final decision. However, if this is not a viable option, then it is important to investigate in detail the relationship between plant capacity and production costs under the conditions ruling in PDRY. Often there are mis-conceptions in evaluating what constitutes the minimum economic size of plant and in this instance it could well be more prudent to design a small plant with relatively high operating costs than to buy a large efficient plant whose output could only be exported at a loss. There are many countries besides the PDRY which face precisely the same problem and to meet this need research work is currently being carried out in UK on the re-development of small shaft kilns which could provide a more realistic solution to the problem. If, as we suspect, the true demand for cement in PDRY is nearer 100,000 tpa than 150,000 tpa, then we would strongly recommend that this alternative be given serious consideration before the Government comes to a final decision on such an extremely important subject.

5.2.4 Bricks

We remain unconvinced by the feasibility study for a brick industry which contain some basic assumptions about levels of demand without carrying out any subsequent check on their accuracy. Our casual observation suggests that bricks are rarely used in PDRY. This may be because they are not readily available, but it could equally well be a consequence of the shortage of skilled labour.

5.2.5 The Ministry of Construction appears to favour prefabricated buildings for new housing projects and has three plants for making prefabricated panels awaiting erection. The private sector on the other hand appears to favour the traditional stone built houses.

5.2.6 We believe that before any irrevocable decisions are taken it would be advisable to carry out a sectoral study of building materials as a combined exercise between the Ministry of Industry and the Ministry of Construction. This is a case where local knowledge of building traditions, the likely demands for housing and industrial buildings in different areas and the ability of the public and private sectors to meet these demands, is far more important than technical expertise in brick or cement manufacture. This study should, therefore, be undertaken by young Yemeni graduates rather than UNIDO experts.

5.3 Brewery Project

5.3.1 Two reports on breweries were available, the second being an appraisal of the first. Both had been undertaken with the assistance of UNIDO. The main report (M.R. Awad PDY/74/006) was based on the return of various offers to construct a new Brewery.

5.3.2 As far as can be ascertained the offers were prepared without any indication of either capacity or specification and therefore were not directly comparable.

Country making offer	Annual Capacity h/l
Yugoslavia	30,000
GDR	15,000 - 30,000
Czechoslavakia	20,000 - 40,000
Lebanon	100,000

The appraisal report recommended the offer from the GDR as being the most acceptable and suggested an initial capacity of 18,000 h/l per annum.

5.3.3 Construction of the Brewery has now started and 1,266,000 YD has been provided for it in the current Five Year Plan.

5.3.4 The following points should be noted although at a late stage:

(i) No detailed study of the market potential for beer appears to have been undertaken and the plant capacity is based on import figures. Bearing in mind that imports may have been restricted because of problems with foreign exchange it is doubtful whether these figures give a true picture of the potential market.

(ii) It is suggested that the barley grown in PDRY would be unsuitable for malt production and, given the climatic conditions, this is almost certainly true. However, even if this were not so, the requirement for say 300 tpa of malt would hardly justify building a plant and the sensible course is to import it.

(iii) The report recommends that fresh hops should be used, but we consider that hop extract would ensure greater consistency of flavour besides being very much easier to handle. There is no possibility of growing hops in PDRY.

(iv) No provision was made in the study for treatment of the incoming water supply, but no doubt this will be taken care of in the actual project. As in the case of the nearby soft drinks plant, adequate storage of water on site must be provided to cope with interruptions to supply.

(v) No provision has been made for stand-by generators. Although this is one of the cases where considerable loss of product can result from prolonged power cuts, it is not necessary to provide full standby power and a careful study should be made of which drives are essential to protect the product and which are not.

(vi) The report suggests that the fermentation tanks should be made of vitreous enamelled mild steel, whereas the normal practice is to use stainless steel. This, of course, is designed to keep the cap˙tal costs down but with it comes the risk of serious corrosion and loss of product quality if, by any mischance, a crack develops in the enamel.

(vii) The original UNIDO report pointed out that there were already many bottles in the PDRY and estimated that a further 600,000 x 0.5 L bottles would be required in the first year. It is certainly true that a great number of beer bottles have been imported into PDRY, but most of these seem to be of the non-returnable type which would not be suitable for re-use. It is highly unlikely that 600,000 bottles can be produced economically in PDRY and it is a mistake to think that this output can simply be added to the requirement for soft drinks bottles and, therefore, help to justify a glass bottle factory. In practice two different machines are required.

(viii) Brewing is a continuous operation and the plant will have to be operated seven days a week and not six as indicated in the report.

(ix) If the circulation time for beer crates is similar to soft drinks, the likely requirement for crates will initially be 18,000 - 20,000, but annual replacement will be small. (see Section 4.4.8.)

5.4 Detergents

5.4.1 The report prepared by Eng. Dhia Jawad Amely is both well presented and thorough. The market study is as good as can be achieved without doing extensive field work and the conclusion that the demand will rise from 4000 tpa to 8000 tpa by 1993 appears not unreasonable. According to the Foreign Trade Company imports of detergents are currently running at around 5000 tons/annum which is slightly ahead of Eng. Amely's forecast.

5.4.2 A plant with a capacity of 9000 tons/annum is proposed and it is assumed that excess production can be exported until such time as the local market has caught up.

The product recommended is a heavy-duty detergent composed of:-

1. A non-biodegradable alkyl-benzene sulfonate,	(about 28 per cent of the powder)
2. Sodium tripoly phosphate	(about 27 " " " ")
3. Sodium sulphate	(about 14 " " " ")
4. Sodium silicate	(about 8 " " " ")
5. Sodium perborate	(about 8 " " " ")

Other ingredients are toluene sulphonate, sodium carboxymethylcellulose, fluorescent agents etc.

The composition is similar to the Chinese "White Cat" detergent powder now widely used in PDRY.

Biodegradeable detergent could be produced at a later stage in the same plant if this should be required.

5.4.3 The processing scheme proposed, includes sulphonation in a continuous plant with SO_3, generated on site from elemental sulphur. The ingredients are mixed and dried in a spray drier. Packing is in polythene bags and cartons.

Apart from the alkyl benzene sulphonate some of the other compounds could be produced locally, in particular:-

(i) Sodium silicate could be produced from sand and caustic soda. The requirement would be for 840 tons for 9000 tons of detergent powder. This represents a very small offtake but could form an adjunct to a small glass factory.

(ii) About 400 tons per annum of caustic soda would be required for 9000 tons of detergents.

(iii) If SO_3 is being produced it could be worth having a small sulphuric acid unit to supply battery acid, (Section 4.19.3), the refinery (Section 4.1.12) and the tannery (Section 4.8.5) which together account for some 350 tpa.

5.4.4 The report works out operating costs in great detail, but before any decision is taken it will be necessary to obtain fresh data on raw material, labour and utility costs.

Some of these will turn out to be much higher than in the report. In particular raw materials derived from oil such as alkyl benzene and toluene have increased substantially. It cannot be automatically assumed, that costs of imported detergent powder will rise in proportion.

5.4.5 The break-even point is calculated at about 25 per cent of full capacity, and the internal rate of return is given as 14.65 per cent. This figure is arrived at after inclusion of taxation. By recalculating at full capacity and omitting taxation, the I.R.R would rise to about 25 per cent. The operating costs per ton of powder amount to about 165 Y.D., the sales revenue per ton is about 268 Y.D. which leaves a gross profit of about 39 per cent.

5.4.6 The weakest argument in the study is that excess production can be exported until such time as the local market has caught up. North Yemen has its own detergent plant and there are no obvious outlets for surplus production in what amounts to a highly competitive market. Whilst it may be true that the break-even point is 25 per cent of full capacity, it might nevertheless be prudent to wait a few years until the home market can be relied on to take a higher proportion of the total production. Nevertheless, we believe that this is a good project which would be worth reviewing in the near future.

5.5 Ghee Production by Hydrogenation of Fish Oil

5.5.1 This study by W S Atkins of UK investigates the replacement of imported ghee by hydrogenated fish oil, blended with 20 per cent of imported palm oil. The various chemicals, flavouring, vitamins etc are also imported, but represent a relatively minor expenditure.

5.5.2 The study recommends a plant for the hydrogenation of fish oil which would start by using 11,850 tons/annum of oil in 1982 and increase to 13,515 tons/annum by 1987. The corresponding output of ghee would be 13,150 tons/annum in 1982 and reach 15,000 tons/annum by 1987.

5.5.3 Both the technical and the economic analysis are well presented and represent a thoroughly professional job. However, the study is based on a number of assumptions, which may have seemed reasonable at the time of the study (1977 to early 1978), but which are less so today.

5.5.4 The assumptions made in developing the project, which now seem open to question, are as follows:-

(i) Availability of fish oil well in excess of 10,000 tons/annum seems unlikely in the immediate future. In the last part of the present season (8 January to 12 April 1980) about 570 tons of oil was produced. The total figure for this year (1979/80) will be well under 1,000 tons of oil.

Improvements are under way, but it would be unwise to proceed with the project until the catch has increased very substantially to around 70,000 tons/annum of sardines. Further consideration should not be given to the project until higher output is actually being achieved, and additional studies by the fisheries research laboratory on maximum sustainable yields (MSY) have been carried out.

(ii) Oil yield of the fish last season was given by the Ministry of Fish Wealth as about 7 per cent, and not the 8 per cent assumed in the study. 193,000 tons of fish would be required at the lower oil content for the plant to run at full capacity.

As production of fish increases, a careful study of oil content will be required.

(iii) The study assumes that ghee based on 80 per cent hydrogenated fish oil is acceptable to the market. This may well be true, but we would suggest a programme of test marketing before any firm decision is taken to proceed with the project.

(iv) It is assumed that 150,000 m^3/annum of oxygen, produced in the electrolytic hydrogen unit can be sold at $3.8 per NM^3, giving a revenue of $570,000 per annum.

Since the medical oxygen unit in Aden is only working for 2 weeks a month, we do not consider it wise to credit the sales revenues with this amount. Cash flow calculations and "break-even point" would be significantly affected.

(v) The study bases its working capital requirements on two months supply of vegetable and fish oils and two weeks production of finished goods.

If the present method of working is maintained, work starts on 1 October and finishes at the end of April, amounting to 30 weeks, whereas the study assumes 45 weeks. Working capital requirements will therefore be correspondingly higher and this will have a marked effect on the IRR.

(vi) Changes in the fish catches from year to year are impossible to forecast, but it would be prudent to investigate whether there is a risk of occasional bad seasons with poor catches and, if so, to make allowance for this in the profitability calculations.

5.5.5 If it should ultimately transpire that PDRY can make a better overall return by selling canned or dried sardines rather than fish meal then clearly the whole basis for this project would be nullified.

VI SUGGESTIONS FOR NEW CANDIDATE INDUSTRIES

6.1 General

6.1.1 The most striking feature of industry in PDRY is that, with the exception of the refinery and one or two other enterprises, all have been started during the 1970's. This has placed considerable strain on the available trained manpower and, as we have tried to point out, this shows up in a variety of different ways such as a lack of maintenance planning, overmanning, poor accounting, lack of market research, etc. This is neither surprising nor is it by any means unique, for most developing countries face the same problems and PDRY appears to be dealing with them considerably better than most. Our subjective impression is that there is a need for a period of consolidation during which improvement in the efficiency of existing industries should take priority over the establishment of new ones. Sections 4.1.13 to 4.1.19 outline one way of solving the problem of providing effective maintenance.

6.1.2 The three-man UNIDO team in the Ministry of Industry is doing useful work in setting up cost accounting systems in the different factories and it is important that this work should continue. We understand that there is a possibility that this team may be disbanded in 1981. In our opinion, this woud be a mistake, for the introduction of accounting systems and the training of a nucleus of people in cost accounting and the keeping of proper plant records is inevitably a slow task, but is nevertheless essential.

6.1.3 Overmanning in a country which is short of labour is merely a symptom of inexperienced management who may not have given sufficient thought to ways and means of making jobs easier or may be hampered by lack of foreign exchange from investing in labour saving machinery. In most developing countries there is a surplus of labour and there is little incentive to reduce numbers and in this respect PDRY is unusual. It would, therefore, not be inappropriate to suggest that UNIDO might provide an expert to train a small group in Work Study techniques.

6.1.4 The lack of market research stems from the fact that too many industries have been relying on the Home Trade Company to solve all their sales problems. The recent change in strategy whereby many industries have become responsible for their own marketing is a welcome move, but again it will take time for individual managements to learn the techniques.

6.1.5 We are not advocating a complete stoppage of new projects, but merely that some of the less attractive ones should be postponed for a year or two. There are few projects where the potential returns are so good that they cannot be delayed. In many cases the justifications for a project will be improved by the fact that in the interim period, the market has expanded or become more firmly established.

6.2 Chlorine/Caustic Soda Plant

6.2.1 The quantities of chlorine and caustic soda which are being used at present in PDRY are as follows:-

Caustic Soda		Chlorine	
Refinery	242 tpa	Refinery	75 tpa
Textile Mill	60 tpa	Textile Mill (Hypochlorite)	4 tpa
Soap Factory	150 tpa		9 tpa

The problem with chloralkali plants in nearly all developing countries is the lack of sufficient demand for chlorine. As noted earlier, we believe that insufficient chlorine is currently being used for water treatment, but even making allowance for this application can exceed 250 tons/annum.

6.2.2 Apart from making chlorine or sodium hypochlorite it is, of course, possible to produce hydrochloric acid from a cell plant by reacting the chlorine with the hydrogen gas released at the cathode. At present, there appears to be little demand for hydrochloric acid, but this could alter as time goes by and a demand builds up for a general purpose acid. In particular, hydrochloric acid is used in quite large quantities for clearing accumulated calcium carbonate deposits from the bottom of oil wells and if substantial quantities of oil should be discovered this would have a significant effect on the viability of a small chloralkali plant.

6.2.3 In theory the by-product hydrogen could be used for fish oil hydrogenation, but in practice the quantity generated by the chloralkali plant discussed in Appendix VII would be about 40 tpa which is less than half the amount required by the hydrogenation plant. Furthermore since it would not be practical to transport this quantity of hydrogen in cylinders, the only way of making use of it would be to site the chloralkali and hydrogenation plants adjacent to one another. This in turn would imply either shipping salt to Mukalla or fish oil to Aden neither of which appears to be attractive.

6.2.4 A team of experts provided by the Indian Government wrote a report on the possiblility of having a chloralkali plant in PDRY and, quite rightly, concluded that at the time it was not justified. This is probably still true, but it is worth pointing out that there are now quite small chloralkali plants on the market which are package units and are designed to produce as little as five tons/day of chlorine. Whilst we would not recommend this as an immediate project, it is one which is worth reviewing occasionally and we have, therefore, included an outline of such a plant in Appendix VII.

6.3 Polypropylene Sack Plant

6.3.1 PDRY currently imports jute sacks for packing salt and lime, kraft paper bags for fish meal and cottton bags for flour. In addition, there are an unknown quantity of bags used for storing agricultural produce such as wheat, maize and sorghum, and for transporting cotton seed between the ginnery and the vegetable oil mill.

6.3.2 Making the following fairly conservative assumptions:-

(i) An export of 50,000 tpa of salt in 50 kg sacks

(ii) An export of 5,000 tpa of fishmeal in 50 kg sacks.

(iii) An internal movement of 52,000 tpa of wheat flour in 60 kg sacks with each sack lasting on average three journeys before being discarded.

(iv) An internal movement of 12,000 tpa of cotton seed in 20 kg sacks with each sack lasting an average of six journeys.

The total annual requirement for sacks would be in the region of 1.5 million.

6.3.3 In Appendix II we have included an outline of a plant capable of producing 3,000,000 sacks per annum, assuming three shifts working. This is about the smallest viable unit available and would appear to be about the right size for the PDRY bearing in mind that there are many other users for polypropylene sacks in general agriculture and that the output of fishmeal if supposed to increase well beyond the figure which has been assumed.

6.4 Printing and Packaging Company

6.4.1 It is clear from the reviews of the different industries in Section 4 that many of them have a requirement for boxes, cartons and labels, but that nearly all of these are being imported. For example, the cigarette and match factory imports cigarette packets in the form of preprinted flat cardboard sheets and, likewise, match boxes are made up from preprinted rolls. Shoe boxes, cartons for sardine tins and soap are a few other examples. At the moment salt for domestic consumption is packed in polythene bags, but would look considerably more attractive in a cardboard carton if this were available.

6.4.2 The 16th October Printing Works, which unfortunately we were not able to visit, does some printing of labels, for example for sardine tins, but has no machinery for dealing with cardboard. We are not in a position to judge whether it would be sensible to expand this business to take in packaging as well as printing or whether it would be better to set up a new company.

6.5 Calcium Carbonate Filler

6.5.1 As noted in the review of the Algundi Plastics factory, there is a requrement for calcium carbonate for plastics - the quantity required being dependant upon the type of product being made. This can vary from about 10 per cent in domestic holloware to around 40 per cent in PVC pipes.

6.5.2 As noted in Section 4.6 the normal practice is to use 'precipitated' calcium carbonate for this purpose because a greater uniformity of particle size can be obtained. However, 'finely ground' calcium carbonate can be used, provided that the finished article is not subject to high stresses. Other possible uses include pesticide dusting powders and as an ingredient in toothpaste. The quantities involved are not large, but since there are deposits of high grade limestone near the proposed site for the cement factory, a small fine grinding mill would make a very simple addition to the facilities. The best type of mill for this purpose is a glass bead mill and manufactureres such as Bachofen Maschinfabrik of West Germany are normally prepared to carry out laboratory trials on samples of limestone.

6.6 Lime Kiln

6.6.1 Despite the fact that the lime kilns near Mukalla are obviously thriving, there is little doubt that lime could be produced considerably cheaper by using a more modern oil-fired plant. Details of one such plant are given in Appendix VI This could form a part of the proposed cement complex in the Abyan Governorate, or if transport costs prove to be excessive, it might be more economic to have two smaller plants, one adjacent to the cement works and the other on the existing site at Shemosa.

6.6.2 The quantity of lime required still seems very uncertain as far as the building industry is concerned, nor has the Ministry of Agriculture indicated whether the farmers would have any substantial need for it if the price were low enough. The best estimate given by the Ministry of Construction was in the region of 20,000 tpa.

6.7 Fish Oil Refining and Deodorising

6.7.1 As noted in Section 4.12 the fish oil currently produced in Mukalla is fetching a very poor price, largely because it is stored in a barge which cannot be cleaned properly, which leads to the oil going rancid.

Apart from improving this aspect, it would also be worth considering refining and deodorising the oil to bring it up to accepted international standards. The techniques are the same as with vegetable oil and indeed since the deodorising plant, which has been installed at the new vegetable oil factory, is not being used, it is possible that this could be used for fish oil.

6.7.2 We recommend that the vegetable oil factory should undertake some laboratory trials with fish oil. If these are successful then it would be worth test marketing:-

(i) tinned sardines packed in fish oil

(ii) a series of blends of vegetable and fish oils in different proportions to be used for cooking purposes.

The objective in both cases would be to use the maximum quantity of fish oil within PDRY and thereby reduce the import of vegetable oil.

6.8 Sodium Silicate

6.8.1 Sodium silicate is made by fusing sand and soda ash, and is a raw material used in the manufacture of detergents where it acts as a filler. A different grade of this material also has some use as a cheap adhesive, particularly for paper and cardboard. Whilst the feasibility study on detergents suggests that sodium silicate should be manufactured locally, the smallest economic size plant is usually around 5,000 tpa which is well beyond the quantity of 850 tpa required for the detergent plant.

6.8.2 Several neighbouring countries such as Jordan, Saudi Arabia, UAE and Egypt all have plans to produce sodium silicate and will like PDRY be looking for export markets. In these circumstances it might seem unlikely that this would make a viable project were it not for the fact that sodium silicate is chemically related to glass and a single furnace could be used both for sodium silicate production and for glass making. Thereafter of course the sodium silicate has to be dissolved and requires different handling equipment but the capital cost of this section is small in comparison to the cost of the melting furnace. Since the smallest glass furnace that is likely to prove viable produces about 20 - 30 tpd and this is more than can be absorbed by the local market for glass bottles and fibre glass, sodium silicate production would make a usefu adjunct and this would also lead to some saving in the cost of producing detergent.

6.9 Lube Oil Blending Plant

6.9.1 This is essentially a mixing and blending operation and should not be confused with a lube oil refinery. Whilst it would be necessary to import all the raw materials, it is known that the oil companies make a considerable margin on lubricating oils. For this reason it may well be profitable to import in bulk and then blend and pack into small plastic containers, which could also be produced locally.

6.9.2 To establisn a plant of reasonable capacity, it would be important to supply lubricants to the armed forces, whose requirements may be somewhat different, and they should be consulted before embarking on a full feasibility study.

6.9.3 We also recommend that an investigation should be undertaken on the possibility of establishing a small plant to refine used engine oils. Rural electrification schemes are currently being effected by diesel generators and, together with the centralisation of vehicle servicing, supplies of used oil should be readily available. The cleaned oil would be suitable as a base for the blending plant.

6.9.4 The successful production of lubricating oils requires strict adherence to quality standards for the results of incorrect blending can be disastrous. We would, therefore, recommend that if this project is approved, it should become the responsibility of the Aden Refinery whose laboratories would then take care of quality control.

6.10 Pesticide Blending Plant

6.10.1 Since kerosene is available from the refinery, there should be a good case for a small pesticide blending plant which would dilute imported concentrates and pack them in suitably sized plastic containers. This project would also provide a new product for the Algundi Plastics factory.

6.10.2 Likewise it would be relatively simple to produce dusting powders by mixing the pesticide concentrate with a suitable local filler, such as finely ground calcium carbonate, talc, kaolin or pumice.

6.10.3 We were unable to obtain any figures on the quantities of insecticides currently being made in PDRY, but in any case we suspect that one of the reasons for the decline in cotton production may be that insufficient insecticide is being applied. Furthermore it is almost certain that the losses of dried fish caused by insect damage would be cut very considerably by using a pyrethrum based insecticide either as a dip or as a spray.

6.11 Galvanising Plant

6.11.1 The Ministry of Construction did not have any figures for the quantity of galvanised pipe being used in PDRY, but it is possible that this mi ht be sufficient to warrant a general purpose galvanising plant which could be used for such other items as lighting poles and sections of overhead cable towers.

6.11.2 Galvanised sheet is normally produced in a continuous strip and, as the output of even a small plant would be of the order of 60,000 tpa, this is not worth considering.

6.12 Foundry

6.12.1 There are many heaps of scrap metal in Aden and the complete hull of a wrecked coaster in Mukalla harbour, but we have no information about the rate at which it is being generated. Nevertheless, there would appear to be a good case for establishing a small foundry of about 2,000 tpa capacity which could be used for the production of simple agricultural implements and cast iron pipes and fittings. Details of such a plant are included in Appendix

6.13 Reinforcing Bars

6.13.1 There is undoubtedly an increasing demand for reinforcing bars and although no figures were available for the quantities imported it is not unreasonable to use a ratio of 1 ton of bars to 4 tons of cement so that the figures in Section 5.2 would suggest a market for 30,000 tons of rebars. The problem about having a rolling mill in PDRY is the lack of sufficient scrap metal and we are of the opinion that the little which is generated would be better employed in a foundry. Nevertheless the possibility of a steel rolling mill was mentioned on several occasions during our visit and whilst we would not recommend this as a suitable candidate industry we have nevertheless included an outline of a 30,000 tpa mini steel mill in Appendix IV.

6.14 Wire Products

6.14.1 This includes such items as nails, nuts and bolts, barbed wire, wire mesh and chain link fencing. All these can be manufactured in relatively small plants which do not require massive capital investment.

6.14.2 A small wire drawing plant would in turn lead to secondary industries producing such household items as pins, needles, kitchenware, wire brushes , hooks and strainers . Because of the shortage of scrap metal the raw material would be imported rod.

6.15 Cosmetics and Toiletries

6.15.1 The Yemen Company for Perfumes and Cosmetics (see Section 4.17) has plans to diversify into the manufacture of toothpaste and haircream; for both products there seems to be a good market. We believe that consideration should also be given to setting up a small aerosol filling line for the production of household insecticide sprays, air fresheners, shaving cream, hairsprays, deodorants etc.

6.15.2 The plant is very simple and is easily operated by women who make up the majority of the present labour force. The tins, nozzles, dip tubes and chemical ingredients would have to be imported. Kerosene, which is used to dilute insecticides, and water for air fresheners are obviously available locally. The propellant would be Freon 11. Preparation only requires a simple mixer and filter whilst a small manually operated can-filling and closing machine can produce about 200 cans per hour.

6.16 Mixed Fibre Textile/Fine Yarns

6.16.1 We understand that a new study is to be commissioned to examine in detail and report on all aspects of this subject. Therefore, we have not delved into the matter in any great depth. Whilst there is clearly a demand for mixed fibre textiles which the present factory is not equipped to meet, the case for producing fine yarns appears to depend less upon satisfying a local demand and more on getting a better price for the long staple cotton which grows well in PDRY. Cotton production over the last few years has declined sharply and it is obviously vital to reverse this trend if any substantial investment in fine spinning machinery is to be justified.

6.16.2 We also feel that the study of the cotton based industries should include the marketing and production problems associated with the production of towelling and cotton wool.

6.17 Polyurethane Foam

6.17.1 In Western Europe the market for polyurethane foam is made up as follows:-

Furniture and Bedding	40 per cent
Automotives	20 per cent
Building	11 per cent
Refrigerators	6 per cent
Shoes	4 per cent
Textiles	6 per cent
Coatings	5 per cent
Others	8 per cent

So far the foam factory has concentrated on bedding and furniture but, given the climate in PDRY there should be good opportunities for building insulation either by the production of rigid panels or by the injection of polyurethane into cavity walls.

6.17.2 The danger with polyurethane is that it is highly imflammable and the products of combustion are toxic. Nevertheless, it is the most efficient thermal insulator and could go a long way towards reducing the seemingly inexorable increase in the power required for air conditioning.

6.17.3 Fire resistance of mattresses and furniture can be improved by using a liner made from a thin cellular layer of neoprene elastomer, which goes between the polyurethane and the mattress cover and is very effective against dropped cigarette ends.

6.17.4 Likewise, wall panels are normally protected against fire by making the polyurethane the central core of a sandwich, the outer layers of which are covered by a less imflammable plastic, plaster board, asbestos or sometimes aluminium sheet. In the case of foam which has been injected into cavity walls, it is naturally protected by the walls themselves. We note however cavity wall construction seems the exception rather than the rule in PDRY.

6.17.5 Whilst there is an obvious market for polyurethane shoe soles, it is unlikely that it is big enough to support an injection moulding machine, unless the output of the leather shoe factory expands very considerably. Even then the constant changes in fashion would mean buying new moulds probably every two or three years which would be extremely expensive.

6.18 Waste Paper Recovery and Processing

6.18.1 No statistics were available for the quantity of paper being imported, and no estimates are available on how much of this could be recovered. However we understand that a study is being made of refuse disposal in Aden and it is possible that this will provide some indication of the tonnage of waste paper. If this proves sufficient, it would be worth considering the production of such low quality items as egg trays for this can be done on a cottage industry scale and, contrary to popular belief, the process does not require large volumes of water.

6.19 Sodium Sulphide

6.19.1 The refinery produces 150 tpa of hydrogen sulphide (H_2S) as a waste stream which could in theory, converted into sodium sulphide (Na_2S) and sodium hydrosulphide ($NaHS$). This has limited use in the tannery (12 tons/annum), but most of PDRY's neighbours in Africa have much larger tanneries and none of them produces sodium sulphide.

6.19.2 The economics of such a small plant are not likely to be particularly attractive and this is not a project which should be given any high degree of priority.

6.20 Bitumen

6.20.1 The requirement for bitumen for road surfacing in PDRY is around 10,000 tpa and as discussed in Section 4.1 it is possible that a small unit could be incorporated if the introduction of a new Vis Breaker provides a suitable feedstock. The local cost of bitumen is 75 YD per ton cif whereas the value of the raw material in the refinery is likely to be around 55 - 58 YS. There is the added advantage that bitumen delivered from the refinery would be carried in tankers which would do away with the need for drums and for reheating. The running costs of such a unit would be relatively low since it would not require more than two men/shift and the utility consumpion is small. Details of a small bitumen unit are given in Appendix IX.

6.21 Adaptation of Oil Seed Mill to Process Sesame Seed

6.21.1 This subject is discussed in Section 4.11, dealing with the vegetable oil mill. At present the new mill which was designed to process cotton seed is short of raw material and it has been suggested that the spare capacity should be used to process sesame seed which is currently being pressed in a number of small and less efficient expellers. The problems associated with modifying the plant were made the subject of a special investigation and our member of the team paid a second visit to PDRY to discuss the subject in more detail. The conclusions are summarised in Appendix VIII.

6.21.2 If the answers are satisfactory the problem is a minor one, but if not then considerable expenditure of the order of 100,000 - 125,000 YD may be required to fit new presses capable of dealing with both cotton seed and sesame seed.

6.22 Glass Fibre

6.22.1 The smallest unit for producing glass fibre economically has a capacity of 250 tpa.

6.22.2 Such a plant would produce enough glass fibre to make approximately 50 kilometres of 8" GRP (glass reinforced plastic) pipe which roughly corresponds with the requirement estimated by the Ministry of Construction. In addition GRP has other applications such as roofing panels, water tanks, irrigation channels and boats so that there seems to be a good case for further investigation

6.22.3 An outline of a small plant for producing the fibre is given in Appendix XI . This project would mean importing polyester resins which currently cost around 650 YD/ton and represent about per cent of the weight of a pipe. It is therefore necessary to balance the cost of this against the technical advantages of GRP and also take into account that the replacement of asbestos cement pipes by GRP would represent a reduction in the potential market for locally manufactured cement.

6.23 Tyre Retreading

6.23.1 This is a small scale industry which could be of great benefit not only to the Balance of Payments, but also to the increase in public safety. The capital equipment required is inexpensive, and casual observation suggests that there should be a good market. A separate mould is required for each size of tyre and where casings have become excessively worn they can no longer be retreaded. Nevertheless, we believe that this is a worthwhile project which should be given every encouragement.

6.24 Plastics Complex

6.24.1 We are given to understand that a new plastics complex is already under active consideration, but no feasibility study for this was made available. Since at present there are only injection moulding facilities available in PDRY it seems likely that there will be a good case for adding a plant for blow moulding of small containers such as bottles for water, shampoo, vegetable oil, lubricating oil, fruit squash, and other items such as water coolers, toys and floats for fishing nets.

On the other hand, there is unlikely to be a sufficient market to justify a plant to produce large blow mouldings such as 40 gallon drums; the machinery required for this is both sophisticated and expensive.

6.24.2 There is also likely to be a requirement for a pipe extrusion plant for making electric conduit and small diameter water pipes for both household and agricultural purposes. If the Ministry of Agriculture decides to use trickle irrigation in some areas this could very quickly absorb the output from an extrusion line. For the larger diameter pipes, the cost of PVC increases rapidly and asbestos cement or glass fibre pipes which are mentioned in Section 6.21 are more economical. GRP pipes which are still relatively new have the considerable advantages of lightness, ease of fabrication and jointing, while buried pipes are less liable to cracking than asbestos/cement in the event of minor subsidence.

6.24.3 Other outlets for plastic extrusions which should be examined in further detail are Venetian Blinds and wall skirting. A wide sheet extrusion line which would be needed to produce wall panels is less likely to be justifiable in view of the limited size of the building program.

6.24.4 The market for blown plastic film is rather more doubtful; the Algundi plastics factory had in line for the production of polythene bags, but closed it down although it was not clear whether this was because of lack of demand or because the product, which was based on imported film, was too expensive.

As the standard of living rises it is a common experience in most countries for the expenditure on packaging to rise for, whereas people may now be content to bring their own containers to a shop to fill up with sugar, flour, or cooking oil, in the future they will expect all these products to be prepacked in handy sized containers. Consumers may even expect fruit and vegetables to be prepacked. There will be a demand for plastic shopping bags and a wish to see new clothes kept in polythene bags; the applications are numerous.

Refuse collection in black polythene bags can also be expected to grow, particularly in Aden. There may also be a use for black polythene sheet for horticultural purposes. In other words, in the long run it will almost certainly be possible to justify a blown film plant, but this may require some years. An outline of the requirements for pipe extrusion film and blow moulding facilities are given in Appendix V.

6.25 Glass Bottles

6.25.1 As already noted in Section 4.15 the total demand for glass bottles in PDRY when the new soft drinks factory comes into production is equivalent to 11 tons/day, which is not sufficient to support the smallest bottle making plant which is currently on the market. However, it is conceivable that PDRY may be able to come to an arrangement with North Yemen over the production of bottles, and as already mentioned there is the possiblility of using the same glass furnace for making glass film and sodium silicate. We have therefore included an outline of a 30 ton/day plant in Appendix X.

6.26 Gypsum Building Panels

6.26.1 Gypsum plaster board consisting of gypsum sandwiched between two layers of paper is normally made in large high speed units and it is unlikely that PDRY will ever have a sufficiently large market to justify such a plant. However, an alternative which is proving very; successful in Dubai is to make hollow block panels which are suitable for partition walls and are easy to erect and join together. The process involves producing plaster by heating gypsum in a rotary calciner and then mixing it with water and pouring into panel-shaped moulds through which run tapered plastic pipes. These are withdrawn when the mould has set thereby giving the panel a hollow core. Panels are joined by using a special adhesive.

The advantages of this system are:-

(i) Dry construction which reduces construction time.

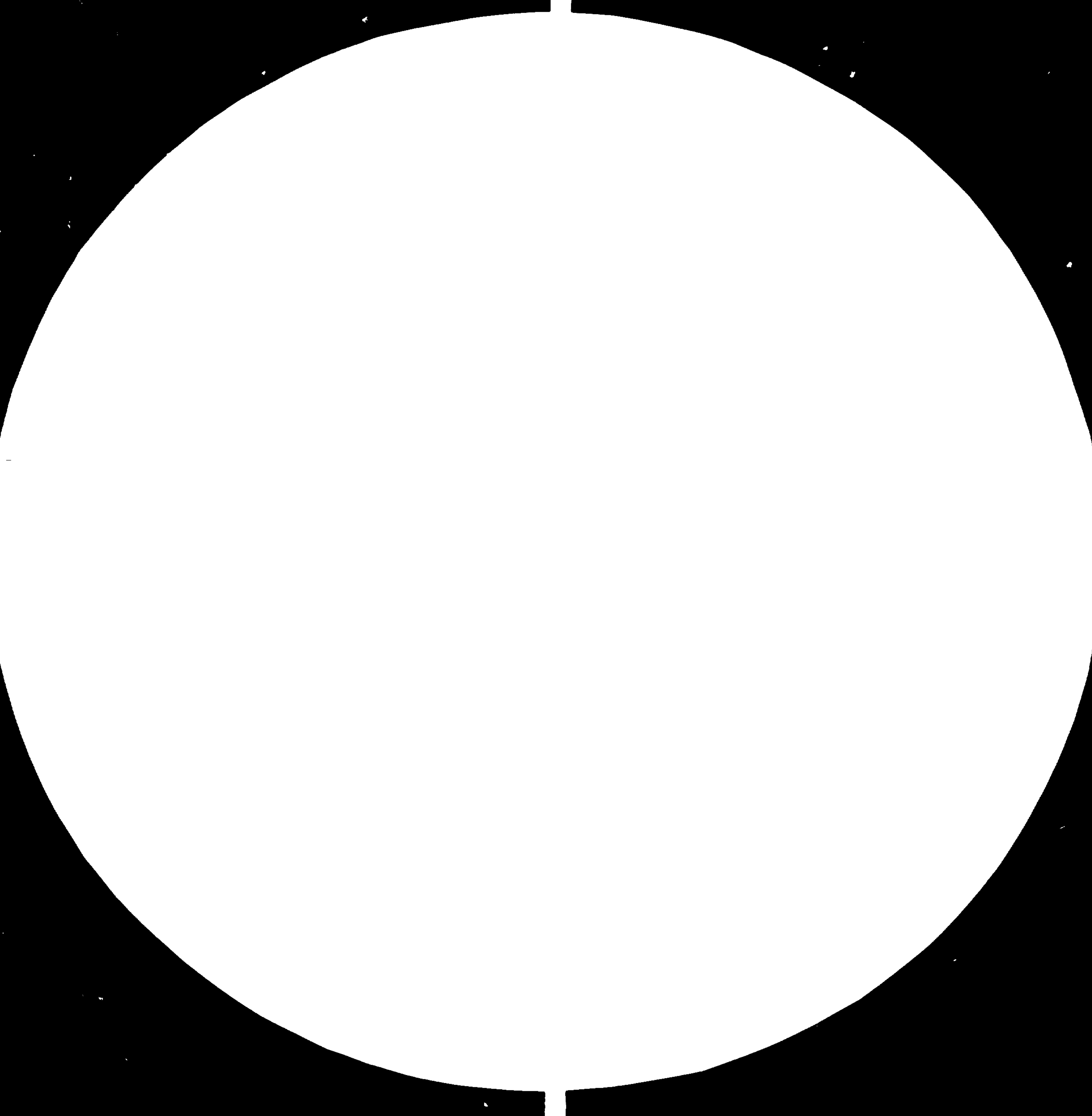
(ii) Smooth faces save additional plastering.

(iii) Good fire resistance, as well as heat and sound insulating properties.

(iv) Panels are rigid and allow fixing of sanitary and kitchen elements. Shock resistance is as good as any other plastered surfaces.

(v) Ceramic tiles can be glued on the surface of panels if required.

Unfortunately in the time available we have not been able to trace the manufacturer of the Dubai plant and have therefore not included an Appendix on this topic. However bearing in mind that PDRY has large reserves of excellent quality gypsum and that this system has proved successful under similar climatic conditions, there seems to be a good case for making further enquiries from the Islamic Bank (Dubai) who sponsored the original project.



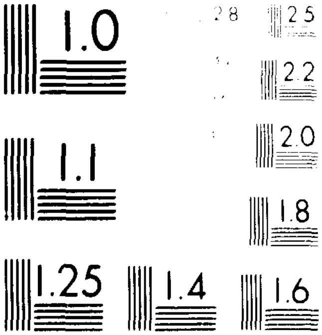

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Table I FIVE YEAR PLAN (1980-85)

		'000s YD
Ministry of Industry Total		25,899.6
Total Public Sector		23,452.0
New Projects	(i) Industrial Park	597.0
	(ii) Brewery	1,266.0
	(iii) Soft Drinks	1,033.0
Dev. of Existing Factories	(i) Spare parts factory	42.0
	(ii) Agricultural implements	77.0
	(iii) Plastic factory	205.0
	(iv) Oxygen/Acetylene factory	300.0
	(v) Tannery	156.0
	(vi) Salt Works	2,713.0
	(vii) Automatic Bakery	834.0
New Projects	Cement factory	14,770.0
	Trico	410.0
	Childrens clothes	544.0
Projects under Study	Cans	
	Cotton yarns	
	Construction Materials and Glass	
	Fertilizers (compost)	
	Detergents	
	Plastic complex	
	Industrial areas	500.0
	Construction unit	
	Training centre for textile industry	
	Small scale industries complex	
	Biscuits	
	Metal furniture	
	Carpets	
	Automatic bakeries	
Total Mixed Sector		2,005.2
Existing factories	Aluminium Utensils	100.0
	Perfumes shampoo and toothpaste	13.7
	Paint	136.1
	Matches	91.4
	Cigarettes	966.0
	Polyurethane foam	201.0
	Pipe extension	497.0
Total Private Sector		441.9
	Plastic sandals	42.4
	Clothing	43.7
	Clothing	46.0
	Clothing	40.0
	Synthetic (Trico) and clothing	101.0
	Belts and Bags	6C.0
	Nails	35.0
	Kraft paper bags	17.0
	Ice cream/Ice/Insecticides	56.8

TABLE II

SUMMARY OF NATIONAL ACCOUNTS (YD MILLION)

	1973	EST 1977	PERCENT CHANGE
Population (mill)	1.59	1.73	8.8
GDP (Current Market Prices)	84.2	150.3	78.5
(Agriculture and Livestock)	(12.3)	(14.7)*	19.5
(Fisheries)	(5.5)	(12.1)*	120.0
(Aden Refinery)	(4.7)	(1.9)*	-59.6
(Other Manufacturing)	(4.3)	(12.1)*	181.4
(Economic Services)	(11.9)	(27.1)*	127.7
(Financial Services)	(23.2)	(36.5)*	57.3
GDP Constant 1974 Prices	93.1	123.2	32.3
GNP (Current Market Prices)	92.2	202.0	119.1
GNP Constant 1974 Prices	97.7	154.2	57.8

*1976

Source: Central Statistics Organisation/IBRD

TABLE III. COMPOSITION OF IMPORTS, 1973-1977

(YD Thousands)

	1973	1974	1975	1976	1977
Food and live animals	16,709	25,307	21,940	22,235	28,450
Live animals	790	552	820	1,504	1,746
Ghee	775	1,833	1,912	1,610	3,542
Wheat and wheat flour	3,566	7,250	3,606	5,398	6,051
Rice	2,401	5,841	4,673	3,072	3,315
Refined sugar	2,685	4,291	4,757	2,349	2,882
Coffee	261	355	794	1,277	502
Tea	1,343	673	923	1,531	2,223
Spices	574	567	472	457	966
Other	4,314	3,945	3,983	037	7,223
Beverages and tobacco	1,118	1,098	955	1,242	1,312
Crude materials, inedible, (except fuel)	1,393	2,591	1,970	2,531	2,928
Hides and skins	7	51	47	14	11
Sesame seeds	829	1,292	666	1,270	553
Wood	296	914	861	978	1,840
Other	261	334	396	269	524
Petroleum products	3,157	14,428	11,641	21,189	22,082
Animal and vegetable oils	328	896	683	730	1,222
Chemicals	1,616	2,447	2,785	3,221	3,488
Manufactured goods classified chiefly by materials	6,105	8,615	10,602	11,368	15,182
Textiles	2,608	3.016	1,363	1,462	3,428
Cement	410	1,424	959	974	844
Other	3,087	4,175	8,280	8,932	10,910
Machinery and transport equipment	2,958	8,257	10,316	20,103	42,231
Machinery	1,263	3,113	4,490	8,689	5,829
Passenger vehicles	222	340	273	1,149	1,977
Trucks	91	1,182	1,324	2,623	10,067
Other	1,382	3,622	4,229	7,642	24,358
Miscellaneous manufactured articles	2,598	1,985	1,198	2,393	4,434
Clothing	943	646	288	517	1,480
Footwear	248	200	161	372	364
Other	1,407	1,139	749	1,504	2,590
Unclassified items	18	40	54	95	—
Qat	—	—	7	80	—
Other	18	40	47	15	—
TOTAL	36,000	65,664	62,144	85,107	121,329

Source: Central Statistical Organization

Table IV: COMPOSITION OF EXPORTS AND RE-EXPORTS, 1973-1977

(YD Thousands)

	1973	1974	1975	1976	1977
Food and live animals	2,577	2,832	2,592	5,640	7,527
Dried fish	225	241	182	123	23
Fresh fish	1,382	1,997	1,472	3,907	5,844
Rice	—	—	—	—	—
Wheat and wheat flour	—	—	3	—	—
Refined sugar	231	—	—	—	—
Coffee	495	380	669	1,170	1,209
Tea	1	—	—	—	—
Other	243	214	266	440	451
Beverages and tobacco	57	38	65	112	183
Crude materials (except fuel)	3,044	970	1,021	4,301	1,963
Hides and skins	328	289	226	222	179
Cotton linters and seeds	2,139	231	472	3,565	1,263
Salt	117	181	52	99	193
Metal scrape	108	73	15	—	—
Other	352	196	256	415	328
Petroleum products	131	54	24	5,262	5,807
Animal and vegetable oils	2	—	6	34	8
Chemicals	57	40	24	28	4
Manufactured goods	561	250	75	39	18
Textiles	383	139	13	3	—
Other	178	111	62	36	18
Machinery and transport equipment	77	32	21	6	230
Passenger cars	13	6	5	2	—
Trucks	3				217
Other	61	26	16	4	13
Miscellaneous manufactured articles	273	170	59	70	30
Clothing	191	89	22	13	11
Footwear	8	2	1	—	—
Other	74	79	36	57	19
Unclassified items	104	—	19	4	3
TOTAL	6,883	4,386	3,906	15,496	15,773
Memorandum					
Re-exports	2,095	1,088	1,050	6,786	
Food and beverages	678	376	732	1,116	
Industrial supplies	782	487	229	346	
Consumer goods	340	148	28	9	
Other	295	77	61	5,265	

Source: Central Statistical Organization

Table V : PRODUCTION OF MAJOR INDUSTRIES, 1973-1977

	Unit	1973	1974	1975	1976	19
Cotton linters	Tons	4,266	3,597	3,979	2,900	1,8
Electric power (Aden)	Million kwh	136	134	141	153	1
Water	Million litres	17,344	16,293	17,051	16,170	17,0
Ships built or repaired	Number	326	350	363	415	3
Soft drinks	Million bottles	15	18	19	24	
Vegetable oils	Thousand kgs.	5,267	4,681	3,256	3,956	2,5
Vegetable cake	Thousand kgs.	14,648	10,138	9,217	6,134	[illegible],1
Salt	Tons	42,815	34,270	6,876	36,502	100,6
Matches	Thousand gross	191	231	192	358	3
Paints	Thousand litres	229	398	461	508	6
Shirts	Thousands	247	280	356	418	6
Dairy products	Thousand litres	656	787	2,901	4,538	5,9
Cigarettes	Millions	137	318	487	678	7
Leather products (Tannery)	Number	114,012	93,771	151,359	134,085	34,6
Paper bags	Tons	407	301	217	261	4
Machinery spare parts	Value in dinars	67,841	88,387	89,736	95,736	331,3
Plastic household utensils	Tons	19	33	58	69	1
Tiles	Hundreds	5,853	2,700	4,180	11,160	9,4
Aluminum utensils	Tons	127	139	250	373	3
Sewing	000 piece	247	280	356	418	6
Batteries liquid	000 battery	-	-	-	-	11.
Fish canned	Ton	-	-	-	-	3
Fish meal	Ton	-	-	-	-	156.
Fish oil	Ton	-	-	-	-	4
Footwear (plastic)	000 pairs	202	358	590	800	9
Nails	Ton	119	91	111	224	1
Spongy product	Ton	-	35	162	295	4
Perfumes	000 liter	-	-	-	10.3	27.
Tomato paste	Ton	-	-	-	-	111.
Bags	000 bag	37	27	84	130	2
Leather shoes	Number	-	-	6,290	46,833	75,5

Source: Central Statistical Organization

Table VI

Estimation of area and crop production of the republic for 1974/1977

(Area in acres)

(Quant. in tons)

Year / Crop	1974			1975			1976			1977		
	Area	Quant.	Yield	Area	Quant.	Yield	Area	Quant.	Yield	Area	Quant.	Yiel[illegible]
Cotton	33550	10327	0.308	28022	10804	0.386	26701	9340	0.350	13059	4857	0.37[illegible]
Sesame	5769	1200	0.208	7752	2000	0.258	11142	1649	0.148	200[illegible]	2926	0.14[illegible]
Coffee	1500	810	0.540	1500	810	0.540	1500	810	0.540	1500	810	0.54[illegible]
Tobacco	1813	1200	0.662	2182	1200	0.550	1648	1200	0.728	1278	1200	0.9[illegible]
Wheat	13910	9000	0.647	18553	10000	0.539	15198	10000	0.658	17460	9114	0.5[illegible]
Cereals	97925	47200	0.482	63452	25000	0.394	103942	30559	0.294	127639	41355	0.32[illegible]
Tomato for Industry	-	-	-	1402	4208	3.001	1795	4866	2.711	2495	7485	3.0[illegible]
Vegetables	3920	12335	3.147	6585	19603	2.977	8648	30345	3.509	8280	28632	3.45[illegible]
W.Melon& S.Melon	1557	5250	3.372	1364	5718	4.192	2046	9013	4.406	2681	9798	3.6[illegible]
Fruit	2668	9617	3.604	2951	13604	4.610	2890	16738	5.791	2574	12934	5.0[illegible]
Dates	8593	20000	2.234	8953	20000	2.234	6977	15000	2.150	5974	15000	2.5[illegible]
Al-hinna	170	100	0.587	170	100	0.587	170	100	0.587	170	100	0.5[illegible]
Qat	-	935	-	-	1063	-	-	1323	-	-	1321	-
Fodder	18499	137000	7.406	19410	162500	8.372	23292	182000	7.814	23863	157952	6.61
Total	190234			162296			205949			227014		

Source: Central Statistics Organisation

(Area in acres)

(Quantity in tons)

Table VII

Estimation of area and crops production in co-operative and state farms during 1973/1974 - 1976/1977

Crops	1973/1974			1974/1975			1975/1976			1976/1977		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Cotton	29844	9667	0.324	27231	10737	0.394	25723	8998	0.350	12610	4830	0.383
Tobacco	975	645	0.662	940	517	0.550	1043	759	0.728	739	694	0.939
Sesame seed	2196	456	0.208	5598	1444	0.258	6102	905	0.143	6595	965	0.146
Other tech. crops	150	88	0.587	61	67	1.098	111	157	1.414	296	150	0.507
Wheat	10639	6880	0.647	11624	6271	0.539	11468	7541	0.658	11817	6764	0.572
Barley	258	149	0.578	416	179	0.430	335	100	0.299	386	68	0.176
Sorghum	10276	4880	0.475	19962	8658	0.434	13859	5411	0.390	23071	5121	0.222
Maize	717	188	0.262	2613	859	0.328	4162	1174	0.282	5932	2238	0.377
Millet	3388	1321	0.390	3389	1372	0.405	3978	1295	0.326	5328	1956	0.367
Other cereals	3967	1894	0.477	4726	1211	0.256	13910	2670	0.192	5029	3479	0.692
Fodder	2023	14982	7.406	4483	37530	8.372	4791	37436	7.814	5468	36194	6.619
Potatoes	21	70	3.333	63	206	3.270	1099	5153	4.689	875	4114	4.702
Tomatoes/household consumption	410	1611	3.929	1361	3953	2.904	2049	6744	3.291	2406	8812	3.663
Tomatoes for industry	-	-	-	757	2959	3.909	1234	4037	3.271	1970	6732	3.417
Onion	694	2061	2.970	542	1194	2.203	713	2359	3.309	996	2820	2.831
Other vegetables	1159	3300	2.847	2299	6690	2.910	3585	12118	3.380	2892	9161	3.168
Gourds	135	571	4.230	244	767	3.143	334	1215	3.638	335	1122	3.349
Sweet & Water Melon	608	2320	3.816	1101	4615	4.192	1796	7913	4.406	2437	8908	3.655
Bananas	1099	4714	4.289	1149	7357	6.403	1853	12833	6.926	1765	10650	6.033
Papaya	178	355	1.994	184	591	3.212	182	527	2.896	140	469	3.350
Dates	-	2864	-	1929	4310	2.234	1939	4169	2.150	1929	4844	2.511
Total	69045			91207			100663			93451		

Table VIII

(Area in acres)
(Quantity in tons)

Agriculture - Private Sector

	1974			1975			1976			1977		
	Area	Quantity	Yield	Area	Quantity	Yield	Area	Quantity	Yield	Area	Quantity	Yield
Cotton	3706	660	0.178	791	67	0.085	978	342	0.35	449	27	0.06[illegible]
Sesame	3573	744	0.208	2154	556	0.258	5040	744	0.148	13446	1961	0.146
Coffee	1500	810	0.540	1500	810	0.540	1500	810	0.540	1500	810	0.540
Tobacco	838	555	0.662	1242	683	0.550	605	441	0.729	539	506	0.939
Wheat	3271	2120	0.648	6929	3729	0.538	3730	2459	0.659	5643	2350	0.416
Cereals	79319	38768	0.488	32346	12721	0.392	67698	19909	0.294	87893	28493	0.324
Tomatoes for Industry	-	-	-	645	249	1.936	561	829	1.478	525	753	1.434
Vegetables	1636	5293	3.23	2320	7560	3.259	1202	22899	19.05	1113	21463	19.28
Water & Sweet Melons	949	2930	3.087	263	1103	4.194	250	1100	4.40	244	890	3.64
Fruit	948	3334	3.517	839	4226	5.037	124	1440	11.613	-	-	-
Dates	8953	20000	2.234	7024	15690	2.233	5038	10831	2.15	4045	10156	2.51
Al-hinna	170	100	0.587	170	100	0.587	170	100	0.587	170	100	0.587
Fodder	16476	122018	7.406	14927	124970	8.372	18501	144564	7.814	18395	121758	6.61[illegible]
Total	121339			71150			105397			133962		

(Quantity in tons)

(Value in Dinars)

Table IX

Estimation of production and values of crops of the republic for 1974-1977

Crops \ Year	1974			1975			1976			1977		
	Quant.	Value	Price	Quant.	Value	Price	Quant.	Value	Price	Quant.	Value	Price
Cotton	10327	798,277	77.300	10824	878365	81.300	9340	788,287	84.399	4857	407,986	84.000
Sesame	1200	150,000	125.000	2000	260000	130.000	1649	272,615	165.321	2926	426,026	145.600
Coffee	810	356,400	440.000	810	356400	440.000	810	372,600	460.000	810	372,600	460.000
Tobacco	1200	330,000	275.000	1200	348000	290.000	1200	360,000	300.000	1200	360,000	300.000
Wheat	9000	630,000	70.000	10000	750000	75.000	10000	750,000	75.000	9114	865,830	95.000
Cereals	47200	3304,000	70.000	25000	1750000	70.000	30559	2139,130	70.000	41355	2894,850	70.000
Tomato	-	-	-	4208	105200	25.000	4886	170,310	35.000	7485	261,975	35.000
Vegetables	12335	567,410	46.000	19603	784120	40.000	30345	1213,800	40.000	28632	1145,280	40.000
Water melon & Sweet melon	5250	84,000	16.000	5718	91488	16.000	9013	144,208	16.000	9798	156,768	16.000
Fruits	9617	211,574	22.000	13604	302009	22.200	16738	371,567	22.199	12934	287,135	22.200
Dates	20000	1500,000	75.000	20000	1600000	80.000	15000	1350,000	90.000	15000	1350,000	90.000
Al-hinna	100	17,000	170.000	100	23000	230.000	100	26,000	260.000	100	29,000	290.000
Qat	935	359.000	383.957	1063	472000	444.966	1323	483,000	365.079	1321	485,000	367.000
Fodder	137000	1307,000	9.540	162500	1544000	9.502	182000	1729,000	9.500	157952	1500,544	9.500
Total		9,614,661			9,204,582			10,170,517			10,542,996	

Source: Central Statistics Organisation

Table X: PRODUCTION OF THE ADEN REFINERY 1969-1977

(Million Long Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Gasoline	0.6	0.7	0.4	0.5	0.5	0.5	0.2	0.2	0.3
Jet fuel	0.9	0.9	0.6	0.4	0.3	0.3	0.3	0.2	0.2
Fuel oils	4.6	4.6	2.4	2.5	2.0	1.8	1.1	1.2	1.3
Other products	0.2	-	-	-	-	-	-	-	-
TOTAL PRODUCTION	6.2	6.2	3.4	3.4	3.4	2.8	2.6	1.6	1.8

Source: Central Statistical Organization.

Table XI

Utility Requirements of Petrochemical Industries

PLANT	AREA ha	CAPACITY '000 tpa	POWER kw	COOLING WATER m^3/h	FRESH WATER m^3/h	FUEL kcal/h x 10^6	PERSONNEL
1,1,2 Trichloroethane	1.0	15,000	315	182	12.0	2.5	30
Vinylidene Chloride	1.0	12,000	333	22	7.0	-	30
Polyvinylidene Chloride	1.0	14,000	600	75	6.0	-	25
Vinyl Chloride	4.0	60,000	1,935	1,640	9.6	0.1	75
Ethylene Dichloride	3.0	50,000	3,622	820	2.3	-	40
PVC	8.0	60,000	1,807	450	27.5	0.9	185
Polystyrene	4.0	60,000	1,524	262	2.62	2.3	100
Butadiene	2.0	50,000	19,600	5,840	371.0	45.2	50
Polybutadiene	3.0	15,000	2,086	619	8.0	8.7	85
Acrylontrile	4.0	50,000	5,043	2,500	39.0	-	80
ABS Resins	1.0	20,000	1,410	143	6.0	2.0	18
SAN Resins	1.0	5,000	63	36	7.0	0.6	12
Propylene	4.0	50,000	4,900	1,400	112.0	5.7	50
Polypropylene	5.0	40,000	2,517	1,000	15.0	8.2	110
Cumene	4.0	35,000	228	86	3.86	7.3	25
Phenol) Acetone)	2.0	25,000) 15,000)	962	1,280	13.0	7.5	40
Bisphenol A	2.0	10,000	60	118	2.0	2.0	30

Table XI continued /....

PLANT	AREA ha	CAPACITY '000 tpa
Polycarbonate Resins	1.0	7,000
Epichlorohydrin	1.0	6,000
Epoxy Resins	1.0	6,000
Carbon Black	3.0	20,000
SBR	4.0	40,000
Cyclohexane	3.0	45,000
Cyclohexanone	1.0	41,000
Caprolactam	2.0	45,000
Nylon 6 Chips	0.5	40,000
Phthalate Plasticisers	0.5	16,000
Phenolic Resins	1.0	18,000
Alkyd Resins	1.0	15,000
Phosgene	1.0	20,000
Maleic Anhydride	1.0	3,000
Methyl Methacrylate	4.0	18,000
TDI	1.0	15,000
Polyurethane	1.0	20,000
Toluene Diamine	1.0	10,000
Ethanolamines	2.0	5,000
Formaldehyde	2.0	20,000
Pentaerythritol	2.0	4,000

POWER kw	COOLING WATER m^3/h	FRESH WATER m^3/h	FUEL kcal/h x 10^6	PERSONNEL
977	107	1.0	4.2	30
900	175	33.0	3.4	40
500	257	42.0	3.4	15
300	-	150.0	-	120
2,750	720	32.0	6.2	48
188	45	0.45	-	60
6,780	3,895	52.0	39.0	46
10,650	6,187	78.0	23.0	150
500	800	13.5	0.5	36
250	41	0.6	0.6	20
733	178	8.0	2.9	16
500	100	1.1	0.1	15
104	150	5.0	-	25
450	75	18.75		45
600	871	28.0	7.2	16
1,221	384	4.0	5.6	40
165	25	0.5	1.0	35
732	767	19.0	6.3	16
46	210	12.1	2.35	16
450	100	2.0	28.0	20
1,840	235	2.35	3.9	30

Table XI continued/.......

PLANT	AREA ha	CAPACITY '000 tpa
Urea Formaldehyde Resins	1.0	20,000
Melamine	2.0	10,000
Xylene Separation	2.0	30,000
Terephthalic Acid	2.0	94,000
Polyethylene Terephthalate	2.0	70,000
Polyethylene Terephthalate	1.0	50,000
Phthalic Anhydride	2.0	15,000
Polyvinyl Acetate	1.0	20,000
Polyvinyl Alcohol	1.0	15,000
Chloroacetic Acid	1.0	1,500
Carbonxymethyl Cellulose	1.0	5,000
2-Ethyl Hexanol	2.0	40,000
N-Butyraldehyde)	2.0	52,000)
N-Butanol)		5,720)

POWER kw	COOLING WATER m^3/h	FRESH WATER m^3/h	FUEL kcal/h x 10^6	PERSONNEL
320	392.0	24.0	2.9	15
1,236	62.5	13.1	6.92	50
1,215	45.0	1.5	18.0	50
3,401	1,839.0	62.0	9.31	60
2,429	550.0	17.5	57.4	50
1,735	393.0	12.5	41.0	40
1,570	150.0	8.5	0.1	20
1,725	240.0	11.0	0.8	20
10,000	4,500.0	165.0	60.5	20
1,200	250.0	2.7	0.5	20
1,000	200.0	2.7	1.1	25
1,540	1,900.0	19.0	18.0	40
800	510.0	5.0	5.6	40

LIST OF APPENDICES

APPENDIX I

TERMS OF REFERENCE

1. Examine the present production and set up of the existing chemical industries in the country;

2. Assess the domestic demand for the various types of chemical products and the rate of growth of the demand for such products, taking also into consideration the demand in external markets, particularly in neighbouring countries;

3. Look into the production of the existing BP refinery and consider products and byproducts which can provide suitable raw materials for possible chemical industries and consider other indigenous raw materials and raw materials which can be economically imported to feed such industries;

4. Work out proposals for economic units to produce locally various types of chemical products and prepare a list of such units and examine the possibility of setting up integrated units for the production of various chemical products;

5. Prepare complete techno/economic feasibility studies for the production units selected, indicating the capacity of each, the location and the types and quantities of the products to be manufactured, the type of plant to be installed, the raw materials and process routes to be used as well as estimates of the capital investment and operational costs required in each of the suggested units;

6. Indicate the priorities to be followed in the implementation of the units which prove their viability;

7. To submit a final report with recommendations.

APPENDIX II

POLYPROPYLENE WOVEN SACK PROJECT

I Proposed Project

1.1 To establish a plant to produce 3.5 million woven sacks a year from pelleted polypropylene feed stock.

1.2 The specification of the bags would be as follows:

To contain 50 kgs of flour etc	
Sack width (gusseted)	51/60 cms
Sack length	94.5 cms
Cut length/sack	97.0 cms
Warp tape	1,000 denier @ 2.5 mm wide x 50 microns thick
Weft tape	1,000 denier @ 2.5 mm wide x 50 microns thick
Warp tape density	5 tapes/cm
Weft tape density	4.5 tapes/cm
Type of weave	Plain
Weight of tape/sack	125 grms
Weight of sewing twine	0.4 grms
Total sack weight	125.4 grms

1.3 In order to achieve this output, the plant would work three eight hour shifts for 300 days per annum (ie 7,200 working hours).

II Process Description

2.1 Raw polypropylene feed stock is passed through an extruder to produce the filament. Weaving is undertaken by a circular unit which produces the fabric in tube form.

2.2 In order to achieve the high level of output required and to reduce labour, a fully automatic sack making line has been proposed together with an automatic two colour printing unit.

2.3 The equipment is robust, but requires a high standard of maintenance.

III Capital Costs

3.1 The following calculations are used to define the equipment to be supplied.

3.2 (i) Tape Output Required

3.5 million sacks/year of 7,200 working hours,

Sacks/hour 487

Tape required $\frac{487 \times 125 \text{ grms/sack}}{1{,}000}$ = 61.00 kilos/hr

Plus: 5% Allowance for waste over weaving and conversion (this can be recycled) = 3.00

Total requirement of 1,000 denier tape sufficient to support the above sack output 64.00 kilos/hr

(ii) Machinery Required — First quality tape in package form

One 21" die granule to tape unit with 66 winders will produce: 75 kilos/hr @ 1,000 D.

Therefore, quantity of units required: 1

3.3 Production of Tubular Woven Cloth

(i) Output Required

Output per TF4 Unit -

$\frac{500 \text{ picks/minute}}{4.5 \text{ weft tapes/cm}} \times \frac{60 \text{ minutes}}{100 \text{ cms}} \times \frac{85}{100}$ = 56.6 m/TF4/ hour

Average cut length = 97 cms

Average output per TF4 Unit = $\frac{56.6 \text{ metres}}{0.97 \text{ cms}}$ = 58 sack lengths/hr

(ii) Machinery Required

Units required = $\frac{487 \text{ sacks/hour}}{58 \text{ sack length/hr}}$ = 8.3

a) Say, 10 - HIGH SPEED TF4 UNITS (ie 9 operating + 1 for maintenance cover)

b) 1 - 4 SECTION CREEL UNIT required per TF4 Unit Therefore 10 Units required.

c) 1,440 WARP END CAPS required per TF4 Unit. Therefore 10 x 1,440 = 14,400 required.

d) 5 - Warp Package Trucks) for transporting the tape packages from winding
e) 3 - Weft Package Trucks) units to the TF4 Unit

3.4 Conversion into Sacks

(i) Output Required

487 sacks/hour

(ii) Machinery Required

When processing 60 cm wide cloths (double thickness lay flat) a highly automated Fabric to Sack Conversion Unit will handle, on average 800 - 1,000 sacks/nour.

This Unit incorporates motions for -

Cloth let-off
Measuring
Cutting
If desired - Printing in line (1,2, or 3 colour on one side)
Base Sewing
Counting and Stacking

Units required - $\frac{\text{487 sacks/hour}}{\text{Average 900 sacks/unit/hour}}$ = 54

ie 1 - FABRIC TO SACK CONVERSION UNIT

(This machine is fitted with in-line 2 Colour Printing

3.5 Ancillary Equipment

(i) Machinery Required

a) 1 - MANUALLY PROPELLED FORK LIFT STACKER TRUCK:

For transporting the cloth reels from the TF4 Units to the Fabric to Sack Conversion Unit.

b) For Baling of Sacks - A 25 Ton Pressure Hydraulic Up-Stroke Baling Press will handle up to 3,000 sacks per hour in bales of 750 to 1,000 sacks per bale. We therefore propose:

1 - 25 TON HYDRAULIC BALING PRESS with 1 Loading Truck

c) For Quality Control:

1 - SET OF LABORATORY TEST EQUIPMENT

3.6 Waste Recovery

1 - GK 75 Flaker for the initial treatment of waste film tape and fabric with fan and cyclone separator.

1 - Plastic Film Compacting Machine for the production of free flowing granules from flaked polypropylene film tape and fabric.

1 - Barrelling Unit for tumble blending recovered material with new polymer.

3.7 Compressed Air Services

Compressed Air Requirements @ 100 lbs per square inch pressure
CFM - Cubic Feet per minute

For - 1GT LINE-MAXIMUM DEMAND AT START UP Reducing to 50 CFM during normal running		360 CFM
10 TF4 Units @ 1.0 CFM		10 CFM
1 FABRIC TO SACK CONVERSION UNIT		35 CFM
	TOTAL	405 CFM

2 AIR COMPRESSORS (1 RUNNING AND 1 STANDBY) EACH WITH A CAPACITY OF 424 CFM

3.8 The cost of all items of plant including buildings of 1800 m^3 together with site development is US $4,030,200. The detailed cost breakdown is set out in Table A.

IV Operating Costs

4.1 Operating costs are set out in Table B from which it will be seen that the major cost is polypropylene granules.

4.2 In order to maintain through-put, we consider that it is essential to provide stand-by generator capacity, although this has not been provided for in the costings. The total connected load is 555 KW, with a running load of 350 KW.

4.3 The estimated cost of production is 40 US Cents per sack, which compares very favourably with jute sacks at 97 US Cents per sack. The major demand will be for fish meal, flour, salt, cotton seed and other agricultural products. The woven material can also be cut into lengths suitable for wrapping baled cotton.

V Conclusion

5.1 This project would lead to significant savings vis a vis the import of jute sacks although it is doubtful whether the local cost of production could match the price of polypropylene sacks imported from major producers such as Taiwan. Nevertheless, the domestic added value of home production would be significant and we believe that this is a worthwhile project which should be pursued.

TABLE A

Estimated Capital Cost of 3.5 million Polypropylene Woven Sack Plant

		US $
A Direct Costs		
(i) Plant and Equipment		
Fabric Production		
1 - 21" GT Line with 66 Winders	368,300	
10 - TF4 Weaving Units	366,500	
10 - Gussetting Motion	4,100	
10 - TF4 Creel	35,000	
5 - Warp Transport Trucks	2,400	
3 - Weft Transport Trucks	1,800	
1 - Fabric to Sack Conversion Line with 2 Colour Printing Press	147,500	
Ancillary Equipment		
1 - Manual Fork Lift Truck	3,100	
1 - Baling Press 25 Ton Capacity	26,900	
1 - Baling Press Loading Truck	2,200	
1 - Laboratory Equipment	18,000	
Waste Recovery		
1 - Compacting Unit	23,800	
1 - Waste Flaker	11,100	
1 - Barrelling Unit	2,700	
Accessories		
10 - Loom Platform	60,700	
1 - Platform Lift	15,200	
2 - Compressors	82,800	
1 - Set Pipework inside Compressor House	1,400	
9,000 - Warp Cores	13,400	
1,800 - Weft Cores	2,800	
Freight	300,000	1,489,700
(ii) Installation of Equipment		50,000
(iii) Electrical Installation		50,000
	c/f	1,589,700

			US $
		b/f	1,589,700
(iv)	Building 18000 m^2		1,728,000
(v)	Spares etc		112,500
(vi)	Site Development		100,000
(vii)	Service Facilities		100,000
		TOTAL DIRECT COST	3,630,200
B	Indirect Costs		
(i)	Engineering Supervision		150,000
(ii)	Construction		250,000
		TOTAL INDIRECT COST	400,000
		TOTAL CAPITAL COST	US $4,030,200

TABLE B

Estimated Annual Operating Costs of 3.5 million Polypropylene Sack Plant
(7,200 Hrs per Annum, 3 Shifts of 8 hrs for 300 days)

					US $
A	Variable Costs				
	Raw Materials	Unit Cost	Usage per Hour	Cost per 1,000 Sacks	Annual Cost
	Polypropylene granules	US $ 772/ton	0.064 T	101.68	355,892
	Sewing Twine	US $1,400/ton	204.5 gm	0.59	2,062
	Printing Inks	US $ 5/litre	0.19 l	1.93	6,750
	Utilities				
	Electricity	0.013/kWH	293.23 kWH	7.84	27,447
B	Fixed Costs				
	Operating Labour	45 men @ US $2,000/ man-year		25.71	90,000
	Operating Supplies	6% of operating labour + US $2.98 per 1,000 sacks		4.52	15,830
	Supervision and Indirect Payroll	20% of operating labour + 1 Supervisor at US $20,000 per annum		10.86	38,000
	Repair Labour and Supplies	2% Fixed Investment		23.03	80,604
	Plant Overhead	5% Fixed Investment		57.57	201,510
	Depreciation	10% Fixed Investment		115.15	403,020
	Interest on Capital	9% on 50% of Fixed Investment		51.82	181,359
				400.71	1,402,474

40 cents each

APPENDIX III

IRON FOUNDRY

I Proposed Project

1.1 To establish a foundry to be fed from scrap metal available in PDRY.

The proposal is based on the following conditions:

(i) 1,000 tpa of finished steel castings
(ii) One shift working
(iii) 250 working days a year
(iv) Three taps per day

1.2 The proposed product range and estimate of production are set out below:

Product	Dimensions (cm)		Weight (kg)		Total N^o^	Total
	Min	Max	Min	Max	(pa)	(tpa)
Wheels and Pulleys	50øx25	60øx30	25	50	15,000	450
Pressure Valves	2" (150 psi)	8" (300 psi)	6	180	6,000	90
Linings	30x30x5	90x80x10	6	120	1,200	120
Various Small Castings	10x6x3	40x30x25	1	30	2,000	30
Grinding Balls	5ø	10ø	8	45	11,700	310
					TOTAL (PER ANNUM)	1,000

II Project Description

2.1 The following equipment would be required:-

(a) Stockyard

1 x 2 ton mobile magnet crane
1 x 2 ton platform weigher
1 x transfer bogie
3 x sets of arc cutting equipment

(b) Meltshop

1 x 2 ton electric arc furnace
2 x scrap charging buckets
1 x set of ladles
1 x 2 ton gantry crane
1 x emission control system

(c) Foundry

1 x mould/sand system
1 x new sand addition plant
1 x core shop system
1 x 2 ton gantry crane
1 x shotblasting machine
1 x cut-off machine
2 x 1 ton jib crane (column mounted)
1 x heat treatment system

(d) Services

2 x compressors
2 x 1 ton forklift
1 x electrical distribution network

(e) Maintenance

1 x lathe
2 x pedestal grinders
1 x drilling machine
1 x set of assorted compressed air operated and electric tools
1 x set of assorted hand tools

(f) Laboratory

1 x spectrophotometer
1 x set of physical metallurgical testing equipment
1 x set of sand testing equipment

2.2 Raw Materials

In order to meet the required finished castings output, a supply of assorted scrap such as automotive parts, machine turnings and other general ferrous items must be found.

The quality of scrap available is assumed to be poor quality and, therefore, all calculations on refining time and melting rate have been based on this.

2.3 Services

The following requirements have been calculated based on the assumptions already mentioned.

Power	1,500 kVA	
Water	20 m^3/Hr	(make-up)
Air	200 m^3/Hr	(provided by internal compressor)
Oxygen	10 m^3/Hr	@ 180 psi

Oxygen will only be required when the furnace is being lanced and this operation will only be carried out for a maximum of three times per day for ten minutes each.

2.4 Site Size and Buildings

The total area required for the plant is one hectare. All the equipment mentioned in Section 2.1 can be housed in one building split into a number of bays ie Meltshop, Stockyard, Moulding, Maintenance etc and the overall dimensions are likely to be approximately 40 x 15 metres.

2.5 Manning Requirments

Stockyard	3
Meltshop	4
Foundry	14
Services	4
Maintenance	3
Laboratory	2
TOTAL	30 per shift

III Capital Costs

3.1 The capital costs have been estimated as follows:

			US $
A	**Direct Costs**		
(i)	Plant and Equipment		
	Stockyard	37,000	
	Meltshop	569,000	
	Foundry	2,640,000	
	Services	592,000	
	Maintenance	82,000	
	Laboratory	101,000	
	Freight	400,000	4,421,000
(ii)	Installation of equipment		300,000
(iii)	Pipework		100,000
(iv)	Electrical Installation		75,000
(v)	Building 600 m^2 (Estimated)		576,000
(vi)	Site Development		150,000
(vii)	Service Facilities		250,000
	TOTAL DIRECT COSTS		5,872,000
B	**Indirect Costs**		
(i)	Engineering and Supervision		200,000
(ii)	Construction		250,000
	TOTAL INDIRECT COSTS		450,000
	TOTAL FIXED CAPITAL COSTS		US $6,322,000

3.2 The cost of US $6,322,000 should only be taken as a guide of the likely investment. Final cost will depend on the range of products to be made which can only be determined by a market study.

IV Operating Costs

4.1 These can only be arrived at with any accuracy when the product range has been defined in more detail. However the following may be taken as a general guide.

	Unit Cost US $	Usage/ton of castings	Yearly Cost (US $)
<u>Variable Costs</u>			
Raw Materials			
Scrap	85.0 /ton	1.1 tons	92,400
Additives	600.0 /ton	13.0 kg	7,800
Electrodes	3,350.0 /ton	5.5 kg	18,400
Utilities			
Electricity	0.013/kWH	600.0	7,800
Water	0.1 /m^3	2.0	200
		Sub Total	126,600
<u>Fixed Costs</u>			
Operating Labour	30 men @ US $2,000/man year		60,000
Supervision and Indirect Payroll	25% of Labour cost plus one Supervisor @ US $20,000 pa		35,000
Maintenance Labour and Materials	4% of Fixed Investment		252,880
Plant Overheads	5% of Fixed Investment		316,100
Depreciation	10% of Fixed Investment		632,200
Interest on Capital	9% on 50% of Fixed Investment		284,490
		TOTAL US $	1,707,270

With an output of 1,000 tons/annum this gives an average cost of about US $1,700/ton.

V Conclusion

This project obviously requires further definition to establish

(a) the quantitiy and quality of scrap which is being generated;

(b) the optimum range of products.

Nevertheless we consider that this should be a viable scheme which will benefit the Balance of Payments as well as using a local raw material which if not utilised will become an increasing nuisance.

APPENDIX IV

<u>Outline of a mini-steelworks to produce 25,000/30,000 tpa re-bar and light section</u>

1 Production: 30,000 tpa based on 3 shift/day working in the steelworks and 2 shift/day working the rolling mill.

Rounds Ø 6-32 mm
Angles 20-50 mm
Flats 20-40 x 4-10 mm
Channels, Squares and Hexagons of similar dimensions.

Description:		Cost (US $)
	Steelworks:	
	15/17 T capacity Electric Arc Furnace 2 Strand Continuous Casting Machine Ancilliary Plant, 1 year's operational Spares and Engineering of Equipment	3,564,000
	Rolling Mill:	
	Reheat furnace, cross country mill train, electrical equipment, spares for 1 year's operation and engineering of equipment	6,271,200

2 Estimated Engineering Costs:-

(a) General engineering, basic civil designs and site supervision including start up		738,000
(b) Turnkey, main contracting engineering		1,230,000
(c) Total civil works including buildings		3,278,400
(d) Total services and ancilliaries		3,000,000
	Sub-total	18,081,600
Allow contingency of 10%		1,808,160
	TOTAL	19,889,760

Steel Melting

3 a) Estimated unit quantities per ton– Approx cost £UK

Scrap	1,108.00 kgs	27 - 35/tonne
Additions	13.00 kgs	225 - 250/tonne
Anthracite	2.25 kgs	40/tonne
Limestone	18.00 kgs	5/tonne
Lime and spar	17.00 kgs	150/tonne
Electricity	600.00 kw	
Electrodes	5.50 kgs	1,390/tonne
Refractories	44.20 kgs	350/tonne
Water	441.00 gals	

b) Labour - per shift

Foreman - furnace and casting	1
Melter	1
Helpers	2
Crane Operators	3
Bricklayer	1
Helper	1
Scrapyard	1
Casting Machine Operators	3
Billet Yard	1
Maintenance	2
Helpers	2
TOTAL	18

Rolling Mill

4 a) Estimated Utilities

Electricity	2,700 Kw
Water (Circulation)	240 m^3/hr
Water (Make-up)	12 m^3/hr
Fuel	Nominal

b) Labour - per shift

Foreman	1
Roller	1
Helper	1
Furnaceman	1
Guideman	1
Helper	1
Rollturner	1
Helper	1
Operators	5
Floormen	8
Maintenance	2
Helpers	2
TOTAL	25

c) Area required for melting and rolling) 1 hectare

Raw material and finished production)
Access roads and parking area) 2 hectares

APPENDIX V

PLASTICS COMPLEX

1 As a plastics complex is already under active consideration by the Ministry of Industry, we have not attempted to duplicate their work but this Appendix merely provides some basic information which can be used for comparative purposes.

As noted in Section 6. there are at present no facilities for blow moulding small containers, extruding plastic pipe or producing film for bag making and the first two at least seem likely to find a ready market in PDRY. The following notes describe three separate small factories although clearly considerable savings could be make in both capital and administrative costs by combining the operations.

Plastic Blow Moulding Plant

A single blow moulding machine which will produce containers up to a capacity of 2 litres will normally have an output of 800 units/hour. Working 300 days/annum on three shifts gives a theoretical output of 5.76 million, but allowing time for breakdowns and product changes a reasonable target would be 5 million units/annum.

Assuming that plastic bottles will be required for:-

(a) Vegetable oil - say 3,000 tons/annum packed in 1 litre PVC bottles (the remainder being in the traditional 4 gallon tins)

(b) Lubricating oil - say 1,000 tons/annum packed in 1 litre bottles

(c) Mineral water - say 1,000,000 bottles/annum

then there should be sufficient demand to keep one machined fully occupied. The essential requirements for a small blow moulding plant are as follows:-

Building Area:	Materials Store	200 m^2
	Blow moulding machinery /plus injection moulding of caps/	300
	Quality control/Tool store	120
	Buffer store	50
	Packaging & despatch	150
	Office	80
	Amenities	100
	TOTAL	1,000 m^2

To take account of future expansion up to 4 blow moulding machines allow 1,200 m^2.

Personnel:	Managerial/Administrative	7
	Blow moulding	1 per shift
	Injection moulding (of caps)	1 per shift
	Packing and labelling	2 per shift
	Maintenance	1 per shift
	Quality control	1 per shift
	Raw materials, handling and despatch	4 day workers
	TOTAL	29 employees
Equipment:	Blow moulding machine	US $188,000
	Chiller	15,600
	Grinder and hopper loader	15,600
	Tools, 2 x 1 litre) 1 x 2 litre)	105,000
	Injection moulding machine	72,000
	Labelling machine	3,000
	Fork lift truck) Quality control equipment) Maintenance tools) Furniture & Fittings)	60,000
	TOTAL	US $459,200
Utilities:	Electricity	250 kw installed
	Water	1 m^3/hr

Plastic Pipe Extrusion Plant

The output of pipe from an extruder will vary with diameter and thickness and also with the type of plastic, but a standard machine will produce approximately 200 kg/hr which is equivalent to about 100 m/hr of 4" - 6" pipe. Working 6 days per week this is equivalent to an output of aobut 700 tons/annum which should be more than adequate for immediate purposes. It would be sensible therefore to start with a single line, but to leave room for later installation of a second one. A machine for making sockets would also be an essential feature.

The essential requirements for a pipe extrusion plant are as follows:-

Building Area, to include:

Raw materials store) Finished product store) & despatch) 2 Extrusion lines) 1 Socket making machine) 1 Band Saw and Grinder for) scrap reclaim) Tool store/Quality control) Maintenance shop) Offices) Amenities)	1,800 m^2

Personnel:	Managerial	7
	Extrusion machine	1 per shift
	Socket machine/regrinding of scrap	1 per shift
	Raw materials and finished products handling	2 per shift
	Quality control	1 per shift
	TOTAL	22 employees
Equipment:	1 Extrusion Machine & Control Cabinet	US $114,000
	Dies & Adaptor Rings	21,600
	Vacuum sizing and cooling	21,400
	Sleeves for vacuum sizing	27,000
	Haul Off mechanism	31,800
	Flying saw	22,200
	Tip table	5,400
	Socket making machine	66,000
	Socket tooling	10,000
	Grinder & scrap recovery) Forklift truck) Quality control) Maintenance tools) Furniture & Fittings)	60,000
	TOTAL	US $379,400
Utilities:	Electricity	650 kW (which allows for a second extrusion line)
	Water	2 m^3/hr

Film and Plastic Bag Plant

A small film blowing plant will process 100 kg/hr which is the equivalent of approximately 4,000 bags/hr. However, a small unit for making carrier bags from this film will normally produce 12,000 bags/hr. Since the demand for bags in PDRY is likely to be nearer 4,000/hr than 12,000/hr, it will be necessary to run an unbalanced plant with continuous running of the film blowing plant but only intermittent use of the bag making machinery. Another point which needs to be made is that colour printing is also a high speed operation and even a small unit costs in the region of US $100,000 so that this is unlikely to be an economic proposition and should be avoided unless it is essential from the marketing point of view.

The essential requirements for a film blowing plant and related bag manufacturing facilities are as follows:-

Building Area, to include:

Raw materials store)	
Finshed product store)	
1 Film blowing unit)	
(6 m x 3 m))	
1 Carrier bag unit)	
(12 m x 4 m))	
1 Trash bag unit)	1,000 m^2
(3 m x 3 m))	
1 Scrap reclaim unit)	
Tool store/Quality control)	
Maintenance shop)	
Offices)	
Amenities)	

Note that unlike other plastics processing plant, the film unit requires 10 metres headroom.

Personnel:	Managerial & Administrative	6
	Film production unit	1 per shift
	Carrier bags unit	1 per shift
	Trash bags unit	1 per shift
	Raw materials & finished products, handling and scrap recovery	1 per shift
	Maintenance	1 per shift
	TOTAL	21 employees
Equipment:	1 Film blowing unit	US $120,000
	1 Carrier bag unit	72,000
	1 Trash bag unit	48,000
	Ancilliaries	60,000
	TOTAL	US $300,000
Utilities:	Electricity	300 kW
	Water	1 m^3/hr nominal

APPENDIX VI

LIMEKILN PROJECT

I Proposed Project

1.1 To achieve an annual output of 20,000 tpa of quicklime, suggests a kiln with a daily output of 70 - 100 tons. This is a small plant, but is, none the less, an economical size. As fuel economy is of crucial importance, it is likely that a vertical shaft kiln will prove the most suitable for local conditions. It is flexible in operation, and can deal with a grain size of up to 200 mm diameter and a size ratio of up to 1:4.

1.2 By varying the temperature, soft, medium or hard burned lime can be produced. To economise on fuel consumption without limiting operating flexibility, heat recovery is essential. The simplest and most effective way is to use the limestone bed itself for this purpose. This is achieved in the "Parallel Flow Regenerative Limekiln", on which the budget costs are based. This system achieves a fuel consumption of 100 kg fuel oil per 1,000 kg of quicklime produced. Diagram 1 shows the principle of operation.

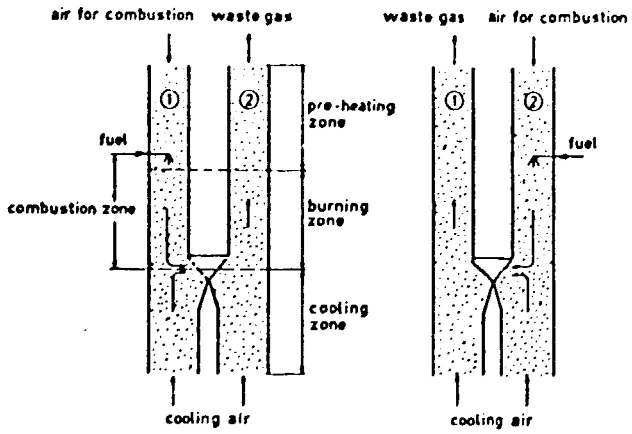
II Project Description

2.1 Basically, there are two shafts with two separate charges, discharging into the same hopper, being fired in turn. Cooling air is blown in from below into both shafts, but leaves with the combustion gases only through the section which is not being fired at the time. Combustion air is added from above to the fired section only. On a 20,000 ton plant this operation would require a twelve minute cycle.

2.2 Metering and control devices include a kiln programmer to control the correct sequence of the operating cycle. Flaps and vents are actuated hydraulically.

2.3 The overall operation is as follows:

The limestone arrives in the storage area by dumper truck. It is picked up by a frontloader, and charged into the crusher feed bin, and crushed. The crushed stone goes by conveyor to the limestone surge hopper with two weighbins mounted at ground level, which weigh a charge each. A skip hoist picks up the charge and lifts it into the feed bin on top of the kiln. After being fired and cooled in the kiln, the limestone passes through the discharge hopper out to a conveyor to the slaking, grinding and screening unit. The slaked lime is weighed in a weigh-bin and packed into 50 kg sacks.



Direction of flow in PR-Kiln

Diag 1

III Capital Costs

3.1 The estimated capital costs are set out in Table A and amount to just over US $5.1 million for the complete plant.

IV Operating Costs

4.1 The operating costs have been based on the following assumptions:

Daily Production 80 tons (24 hours)
Annual Production 300 days, 24,000 tpa
Fuel 1 million k cal/tonne quicklime (100 kg fuel oil)
Power 115 kWH/tonne quicklime.

4.2 We estimate that the cost of production at US $93.70 excluding the cost of the limestone. Raw material costs will be composed of the costs of extraction and transportation. Depending on purity, one ton of quicklime (equivalent to 1.3 tons of slaked lime) will require just under two tons of raw limestone.

V Conclusion

5.1 The cost of slaked lime at the Shemosa plant is 2.5 YD per 50 kg bag (50 YD/ton). The price of lime based on a modern plant is US $97.96 per ton of quicklime, equivalent to 22.5 YD (US $74) per ton of slaked lime. This of course does not include the cost of quarrying the limestone or transporting it to the plant, but nevertheless the difference between 50 YD and 22.5 YD is obviously ample to provide for this and leave a very substantial profit.

TABLE A

Estimated Capital Cost 70/100 tpd Limekiln

			US $
A	Direct Costs		
	(i)	Plant and Equipment	
		- Limestone crusher	376,000
		- Feedbin conveyors etc	235,000
		- Limestone surge bunker, weigh hopper, skip hoist, kilns, casing, refractory lining, reversing and energing valves, oil heating and pumping equipment, blowers, control control panel etc	2,115,000
		- Slaking/grinding/screening equipment	164,500
		- Forklifts, limestone trucks	164,500
		- Freight	352,500
	(ii)	Installation of Equipment etc	587,500
	(iii)	Civil Works, Stores etc	399,500
	(iv)	Service Facilities	423,000
		TOTAL DIRECT COSTS	4,817,500
B	Indirect Costs		
	(i)	Engineering and Supervision	150,000
	(ii)	Construction	150,000
		TOTAL INDIRECT COSTS	300,000
		TOTAL FIXED CAPITAL COSTS	US $5,117,500

TABLE B

Estimated Operating Costs 70/100 tpd Limekilns 300 days/ann 24,000 tpa

A Variable Costs

Utilities	Unit Cost (US $)	Usage per ton quick lime	Cost per ton quick lime	Yearly Cost (US $)
Fuel	0.068/kg	100.0 kg	6.80	163,200
Electricity	0.013/kWH	115.0 kWH	1.50	35,800
Water	0.10 /m^3	0.5 m^3	0.05	1,200
Sacks	1.63 each	20.0	33.75	809,952

B Fixed Costs

Operating Labour	12 men/shift, 3 shifts per day, US $2,000 per man year	3.00	72,000
Operating Supplies	6% of operating labour plus US $1/ton quicklime	1.18	28,320
Supervision and Indirect Payroll	25% of operating labour and 1 Supervisor US $20,000 pa	1.58	38,000
Repairs, Labour and Supplies	4% Fixed Investment	8.52	204,700
Plant Overheads	5% Fixed Investment	10.66	255,875
Depreciation	10% Fixed Investment	21.32	511,750
Interest on Capital	9% on 50% of Fixed Investment	9.60	230,287
	TOTAL OPERATING COSTS US $	97.96	2,351,084

APPENDIX VII

CHLOR ALKALI PROJECT

I Proposed Project

1.1 To establish a plant to manufacture five tons/day of Chlorine with an equipment capacity (chlorine basis) as follows:

Brine Saturation and Treatment	5 tons/day
Electrolysis	5 tons/day
Bleach Manufacture	5 tons/day
Hydrochloric Acid (32 per cent solution) Manufacture	5 tons/day

II Process Description

2.1 Locally produced solid salt will be delivered in bulk and fed to the saturator. The brine will be treated with caustic soda and soda ash to precipitate calcium, magnesium and other metal ions. The brine will be further purified by the addition of phosphoric acid and its final pH adjusted before being fed to the electrolysers.

2.2 Brine flow rate is based on a depleted brine concentration of 260 gpl NaCl and a feed brine strength of 305 gpl with a maximum hardness concentration of 3 ppm.

2.3 Chlorine will be produced in 40 monopolar membrane cell electrolysers. The cells operate at a current density of 3.1 kA/m^2 at 3.9 volts to provide 91 per cent current efficiency.

2.4 Chlorine and hydrogen gas from the cells are sent to the HCl burner/absorber where they combine to form hydrochloric acid. Part of the chlorine and caustic soda are also reacted to form Sodium Hypochlorite.

2.5 The caustic will either be sold directly at 30 per cent by weight concentration, or combined with chlorine to form Sodium Hypochlorite. Caustic evaporation is not included. The excess hydrogen is vented to the atmosphere, equipment has not been provided to utilise its fuel value.

III Capital Costs

3.1 The capital cost of the plant is US $3,225,000 (Table A) including development of the site and erection of plant. It has been assumed that water and power are available or site and the cost of an electrical substation and water purification are both included.

3.2 The indirect costs include engineering design and supervision and a contingency of 3 per cent has been allowed.

IV Operating Costs

4.1 The operating costs set out in Table B are based on the following assumptions:-

Raw Materials:

Salt	- solar salt delivered in bulk
Hydrochloric acid	- to be purchased and not taken from production

Utilities:

Power	- electric consumption of the cells based on 91 per cent caustic current efficiency. AC to DC rectification efficiency 95 per cent giving an overall power consumption of 3,090 kWH (AC) per ton of chlorine. The auxiliary supply is required for pumps, lighting, instrumentation etc.
Water	- sea cooling water has been assumed as potable water is liable to be too expensive.
Operating Labour:	- a flat rate of US $2,000 pa has been charged although there will be variations in the individual wages paid.
Operating Supplies:	- the cost of labour and materials routinely consumed during plant operation eg membranes.
Supervision and Indirect Payroll:	- includes estimate of supervision directly associated with the plant. Also provides for employees fringe benefits.
Repair Labour and Supplies:	- general plant maintenance etc.
Plant Overheads:	- includes all plant expenses, technical staff, plant management, accounting, purchasing, taxes, insurance, general maintenance, store room and laboratory.
Depreciation:	- charged over 10 years.

4.2 The output production cost of chlorine at US $631/ton is based on 300 days a year operation. The production cost would fall to about US $550/ton if 350 days a year were worked. This would increase output from 1,500 tpa to 1,750 tpa.

V Conclusions

The limiting factor for this project is the use that can be made of the chlorine which at the present moment is confined to water treatment. On the basis of existing plans for expansion of water supplies, we estimate that the total demand for chlorine will be in the region of 200 - 250 tons by 1983 which includes some 75 tons used for dosing the Aden Refinery cooling water system. On this basis, we can see little chance of this project succeeding unless it can be undertaken as a joint venture with the North Yemen. This position could however alter rapidly if oil is discovered in significant quantities and hydrochloric acid is required for well cleaning.

TABLE A

Estimated Capital Cost of 5 tpd Chlor Alkali Plant

				US $
A	Direct Costs			
	(i)	Plant and Equipment		
		Onsite systems	1,570,000	
		Storage tanks	150,000	
		Other equipment and freight	275,000	1,995,000
	(ii)	Installation of equipment		200,000
	(iii)	Pipe work		120,000
	(iv)	Electrical installation		40,000
	(v)	Building 250 m^3		240,000
	(vi)	Site development		100,000
	(vii)	Service facilities		200,000
		TOTAL DIRECT COSTS		2,895,000
B	Indirect Costs			
	(i)	Engineering and supervision		150,000
	(ii)	Construction		180,000
		TOTAL INDIRECT COSTS		330,000

TOTAL FIXED CAPITAL COSTS US $3,225,000

TABLE B

Estimated Annual Operating Costs 5 tpd Chlor Alkali Plant (300 days per annum)

A	Variable Costs:		Usage per ton of Chlorine	Cost per (US $) ton of Chlorine	Yearly
	Raw Materials	Unit Cost			
	Sodium Chloride	30/T NaCl	1.75	52.50	78,750
	Hydrochloric Acid	250/T HCl	0.06	15.00	22,500
	Phosphoric Acid	500/T H_3PO_4	0.002	1.00	1,500
	Soda Ash	300/T Na_2CO_3	0.024	7.20	10,800
	Utilities:				
	Electricity cells	0.013/Ac kWH	3090 Ac kWH	40.17	60,255
	Electricity aux.	0.013/Ac kWH	140 Ac kWH	1.82	2,730
	Cooling water	0.10 /M^3	40 M^3	4.00	6,000
B	Fixed Costs:				
	Operating Labour	US $2,000/man year 12 men per year		16.00	24,000
	Operating Supplies	6% of Operating Labour + US $12/ton Chlorine		12.96	19,440
	Supervision and Indirect Payroll	30% of Operating Labour + 1 Supervisor at US $20,000 pa		18.13	27,200
	Repair Labour and Supplies	2% Fixed Investment		43.00	64,500
	Plant Overhead	5% Fixed Investment		107.50	161,250
	Depreciation	10% Fixed Investment		215.00	322,500
	Interest on Capital	9% on 50% of Fixed Investment		96.75	145,125
			TOTAL	631.03	946,550

APPENDIX VIII

THE EDIBLE OIL SUPPLY IN THE P.D.R.Y. - AN ABBREVIATED STUDY OF THE PRESENT POSITION AND FUTURE OPPORTUNITIES

Table of Contents:

1. Summary of the Present Position

a) Edible Oil Supply

No detailed market studies are available, but the recent import statistics and statistics on local oilseed production, together with the forecasts by the Ministry of Agriculture and the Foreign Trade Corporation, give sufficient information for planning purposes.

i) Sesame Seed

Imports	1979:	10 000 Tons
	1980:	8 000 Tons
	Future	10 - 12 000 Tons

Local production

1979/80	1670	Tons (estimates)
1980/81	2520	Tons (confirmed plan)

ii) Sesame Oil

The oil is at present produced locally from seed in a large number of inefficient and unhygenic mills, each producing about 8-10 Tons of oil per annum, on average. On the basis of residual oil in the cake from these mills of 25%, we arrive at an oil recovery from seed of about 28%. If indeed the government decides to continue supplies of sesame seed to these mills, they would produce 3 360 Tons per annum of oil from 12 000 Tons of seed, which probably pictures the present position. (Efficient double expelling would only require 7600 T of sesame seed to produce this amount of oil).

iii) Liquid Oils

Imports of liquid oils amount to another 5000 to 5500 Tons per annum. The oil is believed to be largely refined palm oil, together with various other oils.

iv) Vegetable Ghee

Imports of vegetable ghee in 1980 are estimated at 14 000 Tons.

v) Fish Oil

This oil is at present exported, but amounts are in hundreds rather than in thousands of Tons. We shall assume say 600 Tons.

vi) Cotton Seed

Long staple seed cotton production was in:

1978/79	4680 Tons	
1979/80	3390 "	(estimates)
1980/81	5880 "	(unconfirmed plans)

This would give a maximum of about 3900 Tons of cotton seed for processing.

Medium staple seed cotton

1978/79	2520 Tons	
1980/81	2970 Tons	(not confirmed)

About 1900 Tons of medium staple type cotton seed would be available for processing, but this would require "Delinting", since it contains about 15% of linters after ginning. At present this seed is fed directly to cattle, and is lost to human consumption (as oil).

On the basis of the 1980/81 unconfirmed plans, the long staple seed would give:

546 Tons / annum of cotton seed oil (unrefined),

and the medium staple seed:

304 Tons per annum of unrefined oil.

The present contribution is based on long staple seed only, and the Al Mansura mill should have produced in the region of 400 Tons of neutralised oil from the 1978/79 crop if all was supplied to the plant.

b) <u>Economic Value of Seeds and Oil Products.</u>

To obtain a picture of the amounts involved, and the financial significance of any processing improvements developed below in this report, we are listing the relevant quantities assumed for this study, in Tons per annum and Y.D.

i)	Sesame seed, 12,000 T 12,000 x 900/3.3 =	3,272,727.-
[ii)	Sesame oil from 12,000 T of seed, present operation 3,360 x 2000/3.3 =	2,036,363.-]
iii)	Imported liquid oil 5,000 x 560/3.3 =	848,485.-
iv)	Vegetable ghee 14,000 x 1090/3.3 =	4,624,242.-
v)	Fish oil (exported) 600 x 480/3.3 =	87,274.-
vi)	Cotton seed oil (long staple) 546 x 680/3.3 =	112,509.-
	[Cotton seed oil (medium staple) not now processed] [304 x 680/3.3 =	62,642.-]
Total (excluding items in brackets)		8,945,237.-

In addition, oil cake would be produced as follows:-

Sesame cake	
8,640 x 230/3.3 =	602,182.-
Cotton seed cake (long staple)	
2,145 x 230/3.3 =	149,500.-
Cotton seed as animal feed	
1,900 x 230/3.3 =	132,424.-
Or total animal feed	884,106.-
(excluding fish meal)	

(Note: International prices have been used)

The total consumption amounts to just under 10 Million Y. Dinars.

The bulk of this figure represents imports, and is comparable to the total value of agricultural production in the P.D.R.Y. in the year 1977, for instance.

Clearly, the most important task is to reduce the imports of sesame seed, and of vegetable ghee.

The problem is twofold, more efficient processing or part processing in the P.D.R.Y., by local industry, on the one hand, and increased agricultural production especially of sesame seed, on the other. Very large increases of cotton seed would be required to make a substantial impact on the situation.

A decision to discontinue sesame seed or oil imports would equally result in substantial savings, but this report assumes that a supply of sesame oil amounting to, say, 3360 Tons will still be required.

Locally produced sesame seed has been ignored in this study, since it has been assumed that an equivalent amount will be used directly as seed in various food preparations. However if larger amounts could be produced locally, this would decrease the imports required for oil production.

More efficient processing is the primary subject of this report, and very substantial savings can be made in this area.

c) Oil Seed Processing

Of three existing factories, only one at Al Mansura, is now operating, but it suffers from lack of raw materials. This is due in part to the shortage of cotton seed produced in the country, partly to the inability to process medium staple seed, and, to the unavailability of imported (or local) sesame seed, which goes to the small and very inefficient small local mills.

The mill with its present equipment could process some 5 000 Tons of sesame seed and much of the available cotton seed, at moderate efficiency.

The second mill, at Al Kod, is in good condition, and some equipment there could be used to increase the capacity of the Al Mansura mill. The third mill located at Maalla, is old and few items are still useful.

2. Scope of this Study

The study arose from a request of the P.D.R.Y. Ministry of Industry, to give a somewhat broader coverage to vegetable oil seed processing, in addition to the study prepared by the consultants on the "Development of Chemical Industries and Industrial Survey of P.D.R.Y.", carried out on behalf of UNIDO for the government of the P.D.R.Y. No written terms of reference were available, but the subjects to be studied resulted from discussions at the Ministry of Industry were:

a) Imported and local raw materials, their availability and cost,
b) Improvements and extensions at the Al Mansura Oil Mill, as part of an assessment of the viability of the mill.
c) Assessment of local and imported oil product costs.

Since the available time was extremely limited, about three weeks in total including the consultant engineers visit to P.D.R.Y. for this purpose, the study was in fact concentrated on providing the elements for decision making by the P.D.R.Y. on the following questions:

a) Should imports and processing of sesame seed continue in the present manner.
b) What improvements can be achieved by policy decisions.
c) What improvements can be achieved by moderate additional investment in existing mills.
d) Is substantial new investment justified, for instance a Solvent Extraction plant.
e) Can other savings be made in the edible oil supply of the P.D.R.Y. by import changes or local processing.

In the short time available, this study attempts to answer these questions clearly. However more detailed and prolonged studies are desirable in several areas. These cover the P.D.R.Y market, and precise technological decisions relating to the oil mills, and to vegetable ghee production proposed below, as well as edible refining and hydrogenation.

3. What to do next. A Summary of Options and Recommendations

A. The Al Mansura Oil Mill

The mill should remain the basis of oil seed processing in the P.D.R.Y. Its management should be reinforced, if necessary by expatriate managers.

Three stages of improvement are possible:-

i) Imported sesame seed should be diverted from the small mills immediately to be extent of 4000 - 5000 T per annum.
New seed cleaners, and 2 additional expellers from the Al-Kod mill could be installed at this stage.

ii) New expellers for final pressing should be installed as soon as possible (Rosedown type 3 b, 2 expellers, as an example). Two stage expelling should make the operation efficient for economic operation.

iii) Delinting equipment should be considered for processing of medium staple cotton seed, limited delinting is also required for the present long staple seed processing.
If equipped in this way, the mill could process all the sesame seed imported (say 7600 Tons per annum) and all the locally produced cotton seed (about 5800 Tons) including medium staple seed, (see section 4).

A pre-requisite of this improvement would be a crucial decision, with the following choices:-

a) to continue sesame seed imports

b) to close the old traditional mills. This would save the import of 4400 Tons per annum of seed, worth about 4 million Y. Dinars per annum without reduction in oil supply.

B. Solvent Extraction Plant

Solvent Extraction is not recommended for the relatively small amounts of seed involved. Capital expenditure and operating costs would be excessive. Insufficient funds would be generated to retain the skilled staff required for safe and efficient operation. The improvement in liquid oil recovery over the double expelling plant would be relatively small. (see section 5).

C. Protein Concentrates for Animal Feed

If a policy decision is made to substantially increase the amount of protein concentrate in the form of oil meal or cake supplied to cattle, a solvent extraction plant could be reconsidered.
About 44 000 Tons of cake or meal could possibly be absorbed in the P.D.R.Y.
An additional import of say 46 000 Tons of soya beans would meet the requirement, and produce about 8000 Tons of liquid soya bean oil, more than enough to replace imported liquid oils.
In the field of cattle feed, substantial further studies are required to replace the preliminary assumptions made in this study. (see section 5).

D. Vegetable Ghee

A study is proposed for the local manufacture of ghee from imported palm oil, hinged around technical and market studies.

If the results of the proposed studies are favourable, substantial import savings could be made at moderate capital cost. No hydrogenation plant or perhaps quite a small unit would be required. Palm oil should remain in plentyful and increasing supply.

The difference of cost between ghee and palm oil is about 500 US$ per Ton, enough to pay for a simple plant and chemical additions in a short time. (see section 6).

E. Fish Oil

Fish oil refining and deodorising on an experimental scale is proposed, to test the market for this product. (see section 7).

F. Continuous Refining Plant

A continuous refining plant is particularly useful for cotton seed oil, and could result in much better yields. Unfortunately, not enough cotton seed is available to make this plant worthwhile considering.

Liquid oils at present imported consist largely of palm oil, and there is no application for a continuous plant, since this oil is imported already neutralised.

If a Solvent Extraction plant is eventually built, substantial quantitiy of soya bean oil would be produced, and a continuous refining plant could be justified.

G. Oil Seed Crop Growing

Whilst an agricultural evaluation of the most profitable crops to be grown is outside the scope of this study, and is being undertaken by the responsible authorities, it is suggested that any decisions on agricultural planning should take into account plans relating to the edible oil and oil cake and meal producing industries.

4. Development of the Al Mansura Vegetable Oil Mill

a) Immediate Action Recommended

i) Supplies of Seed and Costs

3900 Tons of cotton seed could perhaps reach the mill after the 1980-81 campaign, enough for less than 80 days operation. Meanwhile, it is suggested that say 4000 Tons of sesame seed be diverted from the small private mills to Al Mansura, even before major policy decisions are taken.

The income from cotton seed should be:-

Oil 546 x 532 =		290,472.- YD
Cake 2145 x 25 =		53,625.-
Husk 1092 x 40 =		43,680.-
Total		387,770.-
Seed 3900 x 60 =		234,000.-
	Cash return	147,770.-
Operating Cost except Labour		
7 x 3900 =		27,300.-
		120,470.-

For sesame seed, the efficiency of recovery at 11% residual oil would be 41.5%.

International prices have been used for the cost calculations below:-

Oil 0.415 x 4000 = 1660 Tons		Y.D.
Oil 1660 x 2000/3.3 =		1,006,061
Cake 2340 x 260/3.3 =		184,364
		1,190,425
Seed 4000 x 900/3.3 =		1,090,909
Surplus		99,516
Operating costs 7 x 4000 =		28,000
	C/F	71,516

	B/F	71,516
Cotton seed		120,470
		191,986.-
Annual Labour Costs		200,000.-
	Loss	8,014

The extra oil recovered would be 540 Tons, when compared with the small private mills. This represents an import saving of 1929 Tons of sesame seed or Y.D. 525,974.-

The mill would almost pay its way in international terms and make a healthy profit on the inflated internal prices.

ii) Equipment

The purchase of sesame seed cleaners would become essential. The Al-Kod equipment is probably too small. This would be a minor item, with an installed cost of the order of 30 000 YD. An additional filter press should be transferred from Al-Kod.

b) Early Reequipment Recommended

i) Supplies of Seed and Costs

As soon as practicable all sesame seed should be diverted to the Al Mansura Mill.

The mill would be moderately reequipped as below under ii) for double pressing with modern Expellers. All 7 600 Tons of sesame seed are to be diverted to the mill, which will now be able to recover 44.5% of the oil present, assumed to be 48%.

For sesame seed, the return could be calculated as follows:-

		YD
Oil 3360 Tons		
3360 x 2000/3.3		2,036,364
Cake 4240 x 260/3.3		334,061
		2,370,425
Seed 7600 x 900/3.3		2,072,727
		297,698
Operation 7600 x 8		60,800
	Surplus	236,898
Cotton seed surplus		120,470
	Total	357,368
Labour		200,000
Operating profit		157,368

This is healthy profit, justifying moderate capital expenditure. No account has been taken of the improved return for cotton seed in the new presses, which should add another 20,000 DA approximately.

ii) <u>Equipment needed</u>

		Installed Cost, YD
Sesame seed cleaners		30,000
Roller mill in prepared position		40,000
Transfer of 2 presses from Al Kod into prepared but modified positions say		10,000
Transfer from Al Kod of a further Filter press		3,000
Further handling equipment		40,000
2 modern expellers Rosedowns type 3 D or equivalent (Andersons, Speichim, French Oil Mills, Mechaniche Moderne)		182,000
	Total	305,000.-

The estimate is approximate, but it shows that two years extra income on a basis on international prices would cover the expenditure.
Home grown seed is more expensive at 500 YD per Ton, but so is the local price of sesame oil.
Home grown seed would be available for consumption as a seed.

c) Extension to Process Medium Staple Cotton Seed Recommended as Final Expansion Stage

i) Seed Supply and Costs

2970 Tons of medium staple seed could be provided according to the unconfirmed estimate for 1980/81.

This would provide about

	YD
Oil 1900 x 0.15 = 285 Tons	
285 x 532 =	151,162
Cake 740 x 25 =	18,500
Husk 721.6 x 40 =	28,865
Lint 190 x 60 =	11,400
Total	209,927.-
Seed Cost	
1900 x 60 =	114,000
Surplus	95,927
Operating Cost	
1900 x 8	15,200
	80,727
Extra Labour	10,000
Operating profit	70,727.-

ii) Equipment

The main addition would be one seed cleaner and 5 linters and accessories. This would be needed for delinting, and to cope with the additional seed.

Seed cleaning	40,000
Delinting installed	
Cost (without building)	160,000
Additional transport equipment	30,000
Total	230,000.-

A building of about, 170 M^2 would be needed.

Pay-back would be about 3.25 years, which still seems attractive. Better use of the domestic cotton seed could be made, depending on the actual achievement of the agricultural targets.

Some delinting is also required for good operation of the long staple cotton seed processing.

It may be possible to use the delinting machines at the Maalla factory.

5. Solvent Extraction Plant, Limitations and Benefits

a) Small Plants

With plants of 100 Tons input or less on a seed basis, operating costs would be high in relation to the profit. Utility and Hexane consumption, processing and labour costs per Ton of seed are high.
Even with this capacity, other seeds have to be processed to obtain full utilisation.
We have assumed that in addition to sesame seed and cotton seed of both varieties, soya beans will be processed, although it would be possible to process groundnuts or for instance Canadian (low erucic acid) rape seed.

Processing Costs

17 400	Tons of soya beans and
7 600	Tons of sesame seed =
4 820	Tons of cake
3 900	Tons of long staple cotton seed
2 465	Tons of cake
1 900	Tons of medium staple cotton seed
893	Tons of cake

This represents 25 578 Tons of feed to the solvent extraction plant.
The benefit of solvent extraction against double expelling is highlighted below:

	YD
Long staple cotton seed	
Extra Oil 3900 x 1.82/100 = 71 Tons	
71 x 532 =	37,772
Medium staple seed	
Extra Oil 1900 x 1.44/100 = 28 Tons	
28 x 532 =	14,896
	52,668
Cake loss 99 x 25	2,475
	50,193

Soya beans (271 $/Ton)	
Oil 2959 Tons (610 $/Ton)	
Oil 2959 x 610/3.3	546,966
Meal 14260 x 238/3.3 =	1,029,202
Total	1,576,168
Soya beans	1,429,238
	146,930
Cotton seed and soya bean Surplus	197,123
Operating cost including extra Labour	108,667
Operating profit	88,456
Fixed capital	1,200,000.-

This corresponds to a 14 years pay-back, which is not attractive given the uncertainities of the local seed supply situation.

b) Larger Plant based on Projected Oil Meal Demand

Estimates of oil meal or cake demand in the P.D.R.Y. will depend on government policy. Should it be decided to provide protein concentrates to supplement local and imported food grains, and locally produced roughage and rough grazing, a detailed study of the type and quantity of concentrate to be imported would be required.
Meanwhile, the PDRY capacity for compound animal feed will be 6 tons per hour, half of this is to be produced by the Mansura Oil Mill.
To obtain a rough guide, the statistics for cattle and chicken supplied by the Ministry of Agriculture, together with some estimates at the oil meal and cake requirements, serve as a first guide to size the Solvent Extraction plant.

Animals (Units)	1979	1981	Oil Meal, Tons
1. Cattle including	87,300	92,600	11,600
cows	35,000	37,000	
2. Goats	848,000	883,000	13,250
3. Sheep	1,273,000	1,324,000	13,900
4. Camels	102,900	98,000	3,000
5. Chicken (State Farms only)	107,500	175,000	1,750
Total oil meal			43,500

To ensure this quantity of meal and remain as much as possible in balance with edible oil supplies, soya beans are the only available feedstock for a solvent extraction plant. The beans are now relatively cheap and look likely to remain so in the foreseeable future. The meal is of high value. Imports would be required to supplement the locally produced meal.

A Solvent Extraction plant of 200 to 250 Tons per 24 hours would be required, which would just be large enough for economic operation.

The following theoretical inputs are assumed:-

	Tons/Annum
Soya beans	45,500
Sesame seed	7,630
Cotton seed : Long staple	3,900
Medium staple	1,900
Total	58,930

c) Products and Estimates

Soya beans :	
Meal 37310 x 238/3.3	2,690,842
Oil 8190 x 610/3.3	1,513,909
Oil & Meal	4,204,751
Soya beans 45500 x 271/3.3	3,736,515
Surplus	468,236.-
Sesame over double pressing	42,267
Cotton seed over single pressing	9,980
	520,483.-
Operating costs for soya bean processing:	
Labour	80,000
Power	95,440
Fuel	22,060
Hexane	68,939
	266,550
Operating profit	254,000.-

Cost of Solvent Extraction plant including soya bean storage, pretreatment, buildings and erection

YD 1,750,000.-

This would give a 7 year pay-out period, which could be acceptable, and competitive bidding may well reduce the capital cost estimate.

d) Plant Location

A Solvent Extraction Plant could well be located at or adjacent to the Al Mansura mill, but an ideal location would be on a jetty; this would reduce material handling costs.

Soya beans would arrive by ship say from the USA or from China, in bulk.

They would be unloaded pneumatically and conveyed directly to the silos of the plant. It may be that such a location could be found at little Aden. In that case the relatively small amounts of cake from the Al Mansura mill could be transported by lorry to the Solvent Extraction plant.

6. Vegetable Ghee Production, Opportunities in the P.D.R.Y.

Present imports of ghee amount to 14 000 Tons per annum.
The manufacture of ghee has already been considered on the basis of 80% fish oil, with palm oil providing the remainder.
The difficulties in providing enough fish oil, together with the high capital cost and electricity consumption associated with the hydrogenation of this oil, makes the proposal impractical for the time being.
However, palm oil of the right physical characteristics is available in the refined state at reasonable cost.
A quotation recently obtained from a Malaysian company gives an F.O.B. price of US$ 530 per Ton of refined, bleached deodorised palm oil.
The oil is likely to remain in good supply, and production is increasing steadily.
Palm oil stearine could also be bought, if the texture of the ghee to be produced should make its use acceptable.
This means that a hydrogenation plant would not be required.
Eventually should an excess of locally produced soya or other liquid oils become available, or if fish oil production increases, a small hydrogenation plant could be considered, but would not form part of any ghee production project in the foreseeable future.

"Opportunity Cost"

Vegetable ghee based on palm oil

Ghee cost c.i.f.	YD
14 000 x 1090/3.3 =	4,624,242.-
Palm oil cost	
14 000 x 565	2,396,697.-
Difference	2,227,545.-

Chemicals, packing,	
utilities $110.0 per Ton	
14 000 x 110/3.3	466,677.-
Labour	70,000.-
	533,667.-
	2,227,545.-
Operating profit	1,693,878.-
Equipment cost, installed	
chilling	1,400,000.-
packing	800,000.-
(refining and deodorising not necessarily required)	

Although the above figures would favour such a scheme, detailed estimates will be required should a study be called for.

Action to be taken

A technical study is required to establish the feasibility of palm oil based ghee. This should include analysis of Jeddah-type ghee and test marketing of a suitable product.

A market study including availability of raw materials, including oils and chemicals, should follow.

A study of the use of local oils including fish oil and possibly soya bean oil, should follow later but would have no material influence on any decision to proceed with a palm oil based ghee project, although it would add to its attractiveness (see section 7 and 8 below).

7. Fish Oil Refining

Although fish oil quantities available in the P.D.R.Y. are small at present, refining could be attractive for several reasons:

i) Immediate refining would avoid spoilage of the product which takes place at present (see main report on Fish Meal Plant).

ii) International markets pay a high premium for refined fish oil. A recent U.K. quotation shows £ Sterling 219.- for crude and £ 361.- for refined fish oil.

iii) Refined deodorised fish oil could have a local market. The oil could be refined for instance in equipment available in the AL-KOD plant. A large sample could be refined in Al Mansura, taking care that there is no contamination of other oils.

Eventually, a partial hydrogenation of this material for purposes of stabilisation could be considered, although complete hydrogenation would be excessively costly and must be weighed against export prices of the preferably refined product.

8. Small Hydrogenation Plant

A Hydrogenation Plant of ,say,10 Tons per 24 hours capacity could eventually be considered. It could be used to produce supplementary hard fats from excess soft oils available locally, and for fish oil stabilisation,should this become desirable.

A 10 Ton Hydrogenation Plant is estimated to cost approximately Y.D. 750,000 erected.

Its best location would depend on developments in other cil processing units mentioned in this report.

9. Continuous Refining Plant

Continuous refining can materially reduce refining losses, especially of cotton seed oil, and of all oils with a high free fatty acid content.

At present, the maximum available amount of cotton seed oil is 850 Tons. Potential increased oil recovery of say 40 Tons would result in a benefit of 40 x 680/3.3 = Y.D. 8242.-

The smallest economic plant has a daily capacity of 30 Tons per 24 hours. Because Sesame oil is not being neutralised, there is no call for this capacity in the near future.

Eventually, should soya bean oil and/or fish oil become available in large quantities, a continuous plant could become justified.

The erected cost is estimated at Y.D. 150,000.- if erected in an existing building, without storage tanks. The cost is not high, if say 5,000 Tons of oil or more are available.

10. Visits made and Information Obtained

a) The Al Mansura Vegetable Oil Mill

The mill has been visited several times by the Manderstam Engineer, but was seen operating only once, due to lack of seed.

It has a rated capacity of

40 Tons/24 hours of delinted cotton seed,
residual oil content of Cake 7%

20 Tons/24 hours of Sesame seed,
residual oil content 10%
(but actual operation 11%)

It is probable that under continuous operating conditions, the cotton cake will average 8% and Sesame Cake at least 11%, perhaps more.

A sketch of the processing scheme is attached.

The equipment appears generally well designed and operates quite well, and without excessive generation of dust in the seed pretreatment section.

The layout is spacious, and provision has been made for expansion.

A layout sketch of the main building is attached.

The seed mill and expelling plant is layed out on the vertical principle, which is a satisfactory if expensive method of construction.

The building is over 22 m high.

Additional equipment can be installed without much difficulty.

There are a number of deficiencies. The most important ones are:

i) The permanent magnet does not give full protection to subsequent equipment against entry of metallic impurities.

ii) There is no provision for removing impurities from Sesame seed, which could be about 2%.

This is a most serious deficiency.

iii) The Kettles provided above the expellers for "cooking" the seeds are small, containing three stages only. No thermometers are provided, and this vital process is difficult to control.

iv) The expeller drives also drive the Kettle mixers, and this implies a multiplicity of belts and pulleys, now completely out of date in expeller design.

The absence of proper safety cages around the belts is attributable to the mill management and not to design, but is highly dangerous for the operators, and perhaps difficult to avoid, given the outmoded design.

The expellers themselves are operating quite well within the limits of the small power supplied and the processing guarantees which are not onerous.

v) The treatment of the oil is unsatisfactory The oil passes through a settling tank where so-called "slime" settles out before the oil passes to the final tank and leaves the plant. All oil rich "slime" mixture is removed periodically from the settling tank, filled into drums and sold as such. This constitutes a significant oil loss (possibly 2% or more in case of Sesame oil). An additional filter press, and steaming or airblowing of the filtercake, would alleviate the problem.

vi) Bagging of cake is manual, and this may give rise to difficulties if production is increased. There is no day bin for cake or husk.

The refinery seems adequately equipped for the quantities of oil recovered. It operates on the batch system.

The deodoriser has not as yet been tried, but no difficulties to its satisfactory working were noticed. The refinery is practically unused at present.

The seed stores are large and more than adequate to the task. Bags are stored on pallets to about 2 m height at present.

There is no fan-assisted ventilation and increase in free acidity in the seed appears to be significant and fairly rapid.

The method of storage merits a more detailed investigation.

Operation and Management

Operation is on 2-shifts a day at present, if indeed seed is available.

The plant is not exceptionally clean, considering the amount of spare time available. Dust is not adequately removed.

The lack of seed, and the uncertainty of future operations must affect the attitude of management.

Awareness of the need for continuous control of output, analytical data of seed and products and losses, and stock and spares control need active attention, especially if the recommendations of this report as to increased Sesame seed processing are followed, management should be strengthened in these areas, if need be by expatriate experts not only in technology but also in management.

Utilities

Steam production is adequate but the boiler is at present supplied with distilled water at considerable expense.

The water treatment plant automatic defeats the skill of the operating staff. Attempts are in progress to solve this problem in cooperation with the Italian supplier.

The effluent plant is of East German supply. It is of elaborate design and should be very efficient, with Ph controls and air oxydation tanks, and various settling tanks. Again, the system is too complicated for the plant operators.

At present however this plant is a disaster area, since the town of Aden has blocked at least some of the sewer outlets for repairs.

Furthermore, the effluent plant is at a low elevation, and sewage can and does backflow into it. This must be avoided as soon as possible, by installing an elevated seal tank, into which the final effluent is pumped before leaving the plant.

Electricity supply is adequate but fails occasionally. Steps are in motion to provide an emergency gen rator set locally.

Lifting beams for the roller mills and the expellers are urgently required, and discussions are in progress with the East German suppliers.

General

Several able managers and engineers have left the oil mill staff for other important jobs.

It is to be hoped that once the future of the mill is assured it will be able to retain skilled management and staff by attractive careers including good wages.

The factory was delivered in 1973, by the East German Company SKET, and was commissioned in 1979/1980.

An Animal Fodder mixing plant of 3 Tons per hour capacity is attached. The plant is about to be commissioned and appears well equipped to utilise brewers waste, wheat bran, cotton seed meal and husks and other waste products as well as food grains and fodder plants.

b) The October Oil Factory at Al Kod

The plant was delivered by a North Korean Company in 1971. It should process 30 Tons/ day of cotton seed by single pressing, and 10 Tons per day of Sesame seed by double pressing.

The mill is not operating due to lack of seed, although it is close to the ginnery and is in the centre of the cotton seed producing area. It is complete with stores, laboratory and workshop, but its oil-fired boiler has been removed and transferred to the Tomato factory.

The original boilers, based on cotton seed husk as a fuel, are still in place, but husk has never been available in sufficient quantity. The boilers do not look very efficient. Feed of husk is entirely manual.

The equipment itself is in good condition.

For Sesame, there is a cleaning sieve, reputedly adequate for the 10 Ton a day capacity.

The presses look similar to the East German SKET presses. The cookers on the presses are much larger than at Al Mansura, they are five stages high and should give better results, although here too thermometers are lacking.

For cotton there are three identical presses with five high cookers. A large preheater of about five and a half feet diameter, eight feet high in two stages, preheats the seeds before they enter the individual cookers.

The cotton seed cleaning and dehulling equipment is still usable, although it must be dusty in operation, since cyclones and fans are lacking. Their effectiveness could not be established but 20% of seed are reported in the hulls.

The roller mills are three high, 1000 x 104 x 1685, and are similar for Sesame and cotton seed.

There is some doubt whether more than 20 Tons per day of cotton seed were ever achieved.

Operational tests are required to establish the true capacity of the machines, but reuse is possible within that limitation for the presses, cookers, mills and conveyors at least.

The refinery looks in good condition, and all the vessels and presses, and probably the pumps, could be used again.

The layout of the mill is entirely at grade. Conveyors and elevators are used between all major items of equipment. This results in to a long low and fairly narrow building. Cotton seed and Sesame seed treatment plants are at opposite ends, making the building simple and accessible.

c) <u>A Traditional Sesame Seed Factory at Sheikh Othman</u>

The factory was in a small house open to the main road. It consisted of two identical mills.

Each mill is built up on the lines of a mortar and pestel. The mortar is a deep narrow trough about three feet high. The pestel moves in a conical motion around the side walls of the mortar. An electric motor is mounted above and moves a yoke to which the top end of the pestel is attached. The yoke is weighted at the far end by a sack containing about 320lbs of stones or sand.

Animals are no longer used to drive the mill.

The seed is filled into the mortar by hand and ground for about eight hours. Eight gallons per day of oil are obtained approximately. The ground paste is filtered through a filter-cloth by gravity into a tin.

Two workers and a manager are employed and local merchants earn a living on the sale of the oil.

It is reported that hundreds of such mills exist, employing directly and indirectly a large number of people. Their removal would not be related solely to technical considerations, but these units are unlikely to remain economically justifiable.

d) The Maalla Oil Factory

The factory dates from 1951, and some of the equipment was second hand even then.

Two presses were installed in 1973 and 1974.

Two linters were installed in 1974. They are usable, but need some repairs.

The capacity of each is 12 Tons per day. They could conceivably be used to improve the long staple cotton seed for further processing, by transferring them to Al Mansura. However, further tests are required to establish their effectiveness for this purpose.

The are made by an Indian company - KUBROS, India.

The company should be approached regarding the ventilation system to deal with the dust problem, should the machine be used again.

The factory is now in a very poor and dilapidated condition. The boiler has been damaged by an explosion.

There are six small expellers.

Four are Italian (Congegni GV) with two stage cookers. Two are Indian (United Oil Mill Machinery). Hullers and seed cleaners do not appear usable.

The total capacity was cotton seed 27 Tons per day. The residual oil in Sesame cake is estimated at 11 to 12% and about 75% of the oil in the seed was recovered. On the whole the reuse of this equipment is not recommended.

In the refinery there are a number of vessels which could be utilised. There are about eight 1 Ton washing vessels and three neutralisers, about 12 Ton capacity. There are also two small filter presses, about 18" x 18", 36 plates, and one large press about 2' x 2', complete with "Umas" pump. These tanks and presses could be reconditioned for various purposes and reutilised. The motors appear to be in order. There is however no prospect of reviving the factory.

e) Visit to the Agricultural Research Station of the Ministry of Agriculture : at Al Kod

Agricultural research is outside the scope of this report, but the subject of discussions with the Research Director was the seed supply position and the availability and cost of the seeds.

i) Ginning

Cotton is picked over a period from mid-January to March or April. Ginning is over two months ending mid-July.

From the point of view of seed quality, an early supply of cotton seed to the vegetable oil mill would be desirable. It is not clear why ginning cannot start sooner.

ii) Long Staple Cotton

An additional 10 000 acres are being prepared at Al Kod. The growing season is 7 - 8 months. This and the laborious handpicking explains the reluctance of farmers to grow the seed. Yield of seed cotton is 300 - 400 Kg per acre. May to July are the closed season, but irrigated crops in that period are under study. Mechanisation of long staple cotton is not viable.

Best grade seed cotton costs 125 FILS per pound down to the lowest grade at 95 FILS.

iii) Medium Staple Cotton

This crop is grown at Lakej, in the second governate. Six thousand acres are cropped to supply the spinning factory, and for exports.

However, the yield of this crop is 50% higher than long staple cotton, although the cost is lower at 105 Fils per pound for first grade cotton.

This gives a better yield to the farmer. Mechanisation is easier.

No policy to give preference to this crop has been established. From the point of view of the vegetable oil mill this would be clearly of interest, especially since the linters from this seed can be sold locally at high prices. As much as 2 Y.D. for 28lbs has been obtained in the past.

iv) Sesame Seed

Three crops per annum are possible with tubular irrigation.

Difficulties are bird damage and scattering of seed.

The prices at 500 Y.D. per Ton are attractive to farmers, but harvesting is difficult. The yield is 250 Kg per acre, and 400 Kg with irrigation.

Sesame needs less water than cotton.

V) <u>Fodder Crops</u>

Fodder crops could give three harvests, and are the simplest to work, and therefore compete effectively with oil seed crops.

11. Limitations of The Study and Recommendations for Further Studies

Some of the recommendations made depend on policy decisions, others involve further technical investigation or contacts with suppliers, or tests.

Policy decisions will determine the amount of seeds grown, imports or otherwise of Sesame seed, supply of protein concentrates to cattle owners, and any further capital expenditure on processing plant.

Technical studies are required for vegetable ghee production, fish oil to refining, transfer and purchase of equipment to the Al Mansura Mill, if it is to be requipped, and the building of solvent extraction and continuous refining plants.

With so many decisions outstanding, this study is limited to pointing out possibilities and suggestions for further action.

A list of further studies which may be required is attached.

TABLE OF

SUBJECT	GOVERNMENT POLICY DECISION	COMMENTS
Sesame Seed	Continue Imports	Expensive but important item, no real substitute exists
Sesame Seed	If so, divert seed to Al Mansura, close old mills	Much more economic, good processing essential
Cotton Seed, long staple	Decide on acreage	
Cotton Seed, medium staple	Decide on acreage	
Cotton Seed, medium staple	Decide to process at Al Mansura	
Supply of Cattle Concentrate	Increase protein concentrate. Feed to cattle	
Supply of Cattle Concentrate	If so, local production in Solvent Extraction plant	Reasonably economic

PROPOSED ACTION

RECOMMENDED ACTION	TECHNICAL AND INVESTMENT COMMENTS	INVESTMENT RECOMMENDATION	STUDIES NEEDED
	Important to viability of Al Mansura	If no imports, increase of local seed supplies essential, or shut-down	Market Agricultural
Yes	Investment required	Improve processing new expellers	Detailed Technical
	Small improvements needed	Al Mansura to receive, some improvements	Agricultural
Desirable addition to feedstock			Agricultural Market
Yes	Investment required	Install linters produce lint	Detailed Technical Agricultural
Yes, if large plant can be justified	Investment required	Solvent extraction plant 200-250 tons per day	Detailed Technical Market

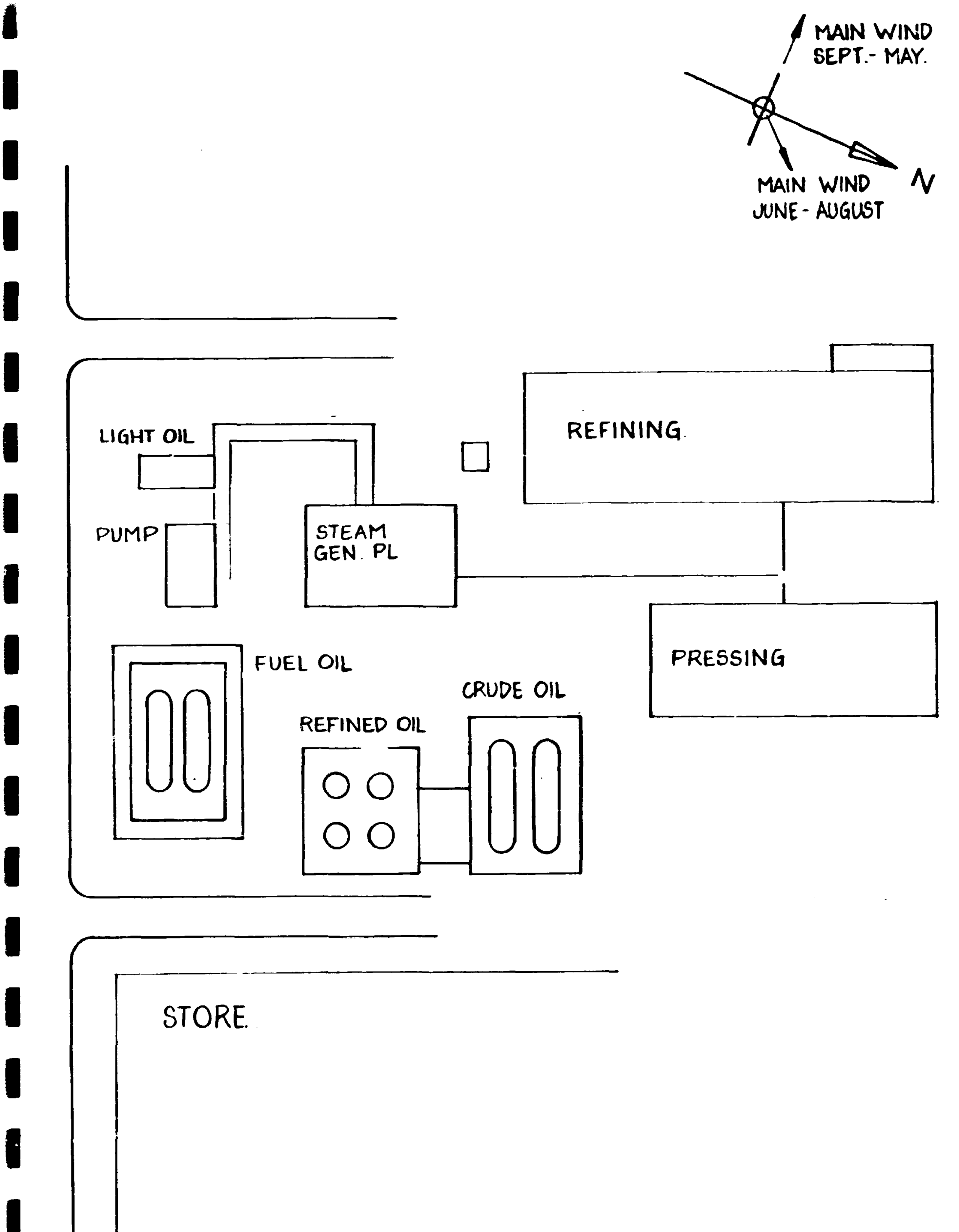
cont/ ....

TABLE OF PROPOSED ACTION

SUBJECT	GOVERNMENT POLICY DECISION	COMMENTS	RECOMMENDED ACTION
Vegetable Ghee Production	Decide on studies	Very good opportunity	Yes
Vegetable Ghee Production	If studies positive, decide on production	Good potential return	Yes
Fish Oil Refining	Decide on Studies	Potential upgrading of product	Yes
Fish Oil Refining	Decide on production		Future
Hydrogenation Plant	Future		Future
Continuous Refining	Future		Depends on oil supply

(cont)

TECHNICAL AND INVESTMENT COMMENTS	INVESTMENT RECOMMENDATION	STUDIES NEEDED
		Market and Technical
Investment required	Mixing, cooling, packing	Technical
		Market Technical
Small investment	Use existing equipment	Technical
Investment required		Technical
Investment required		Technical



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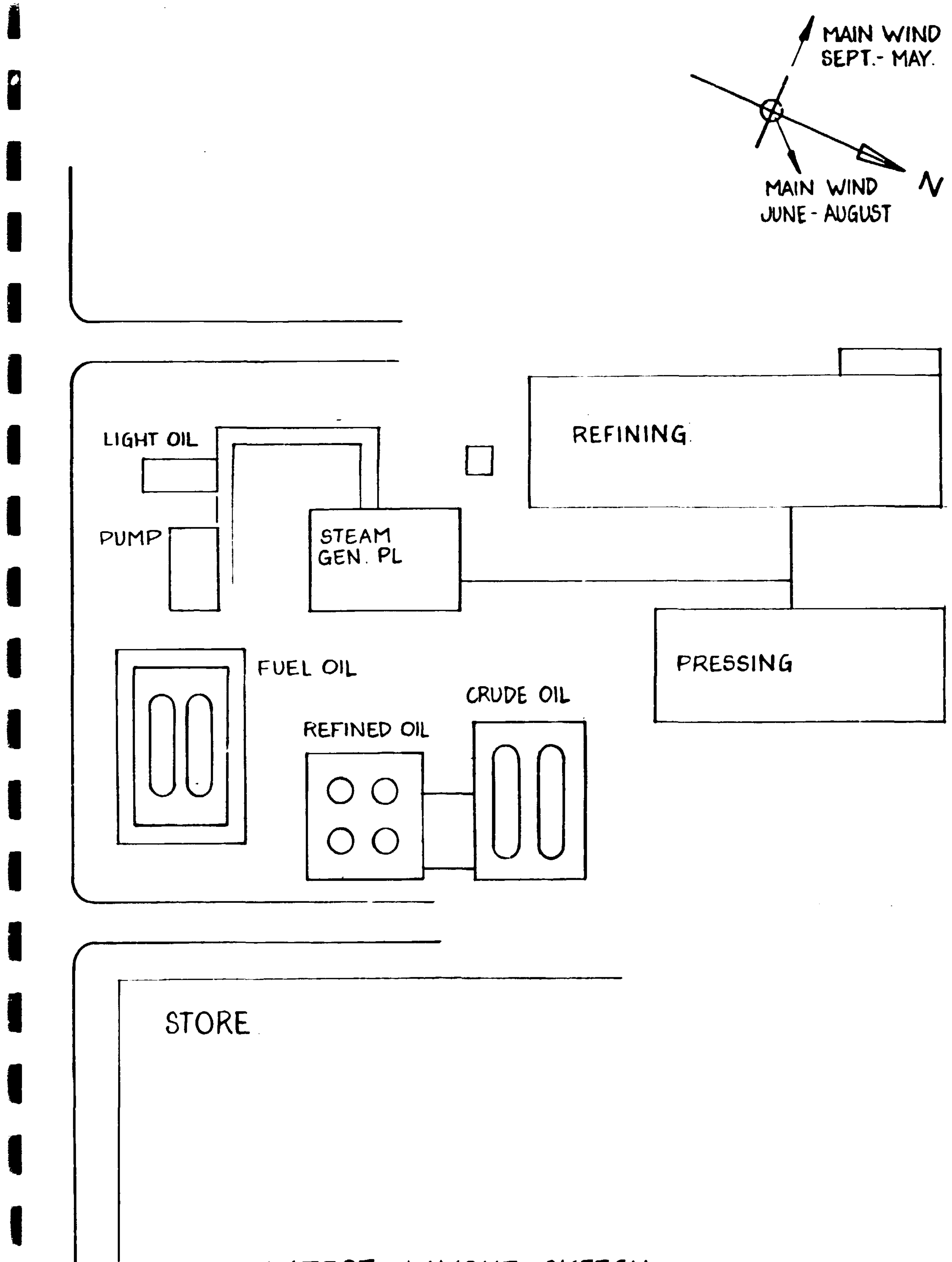

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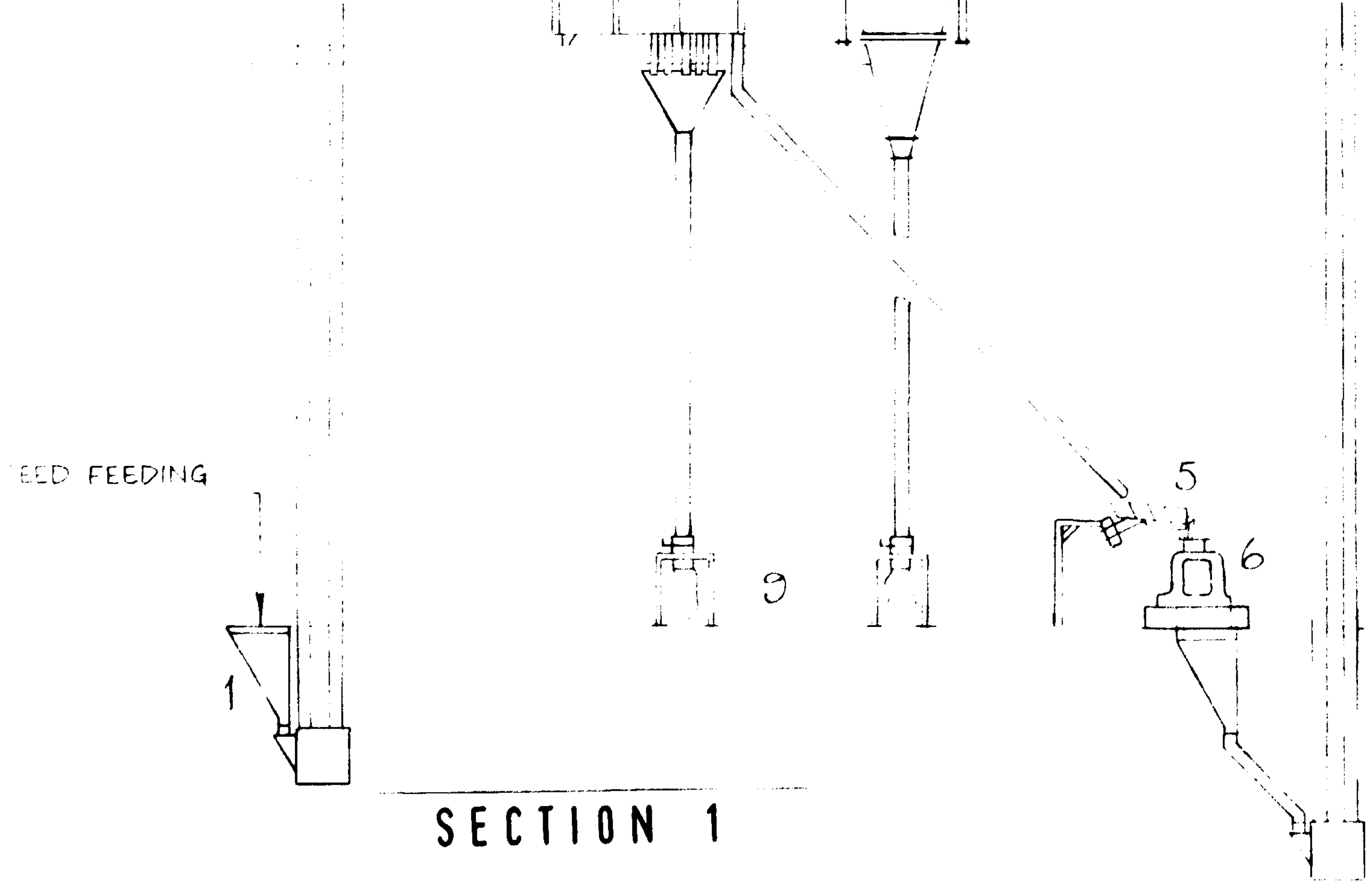
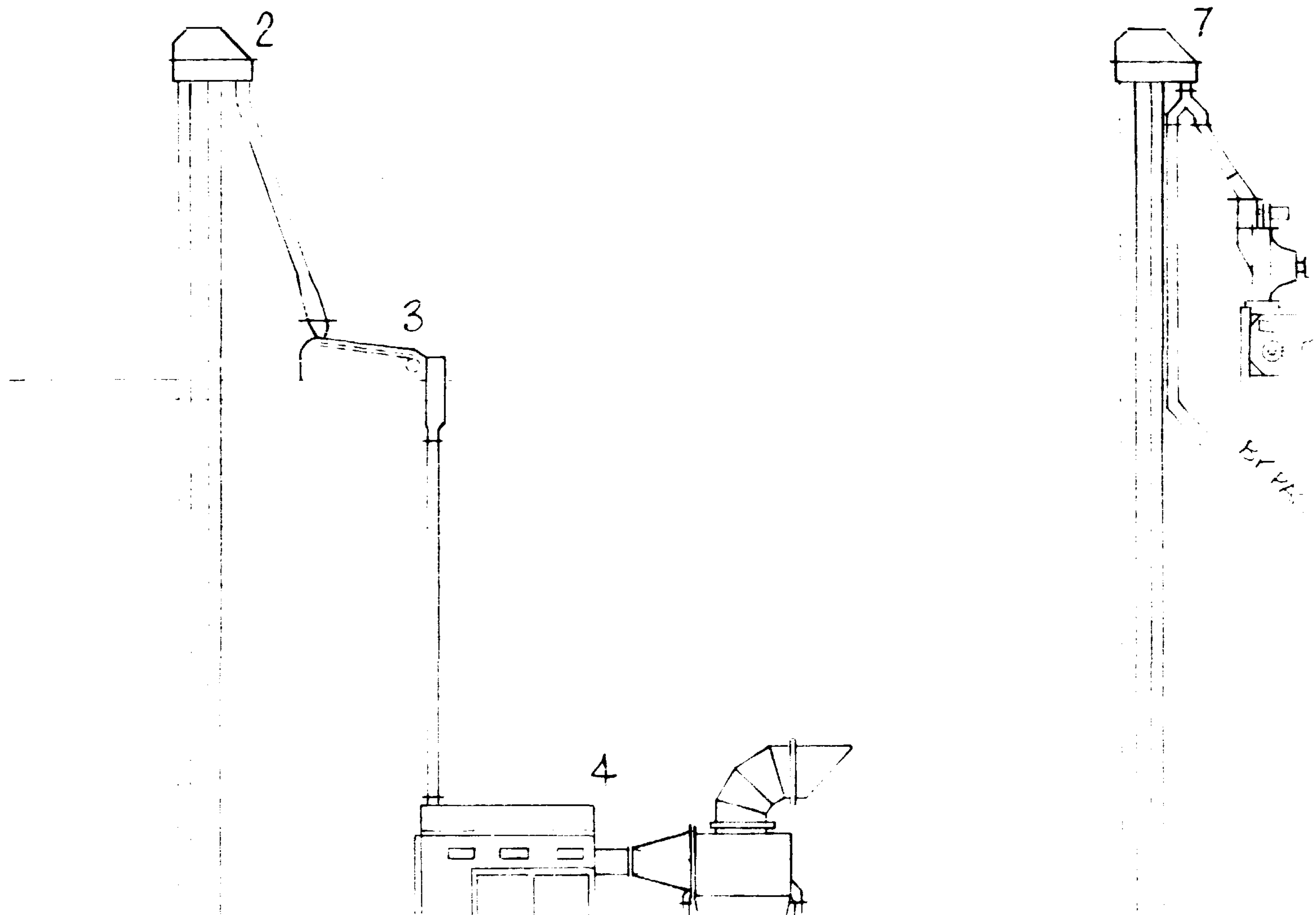


SECTION 1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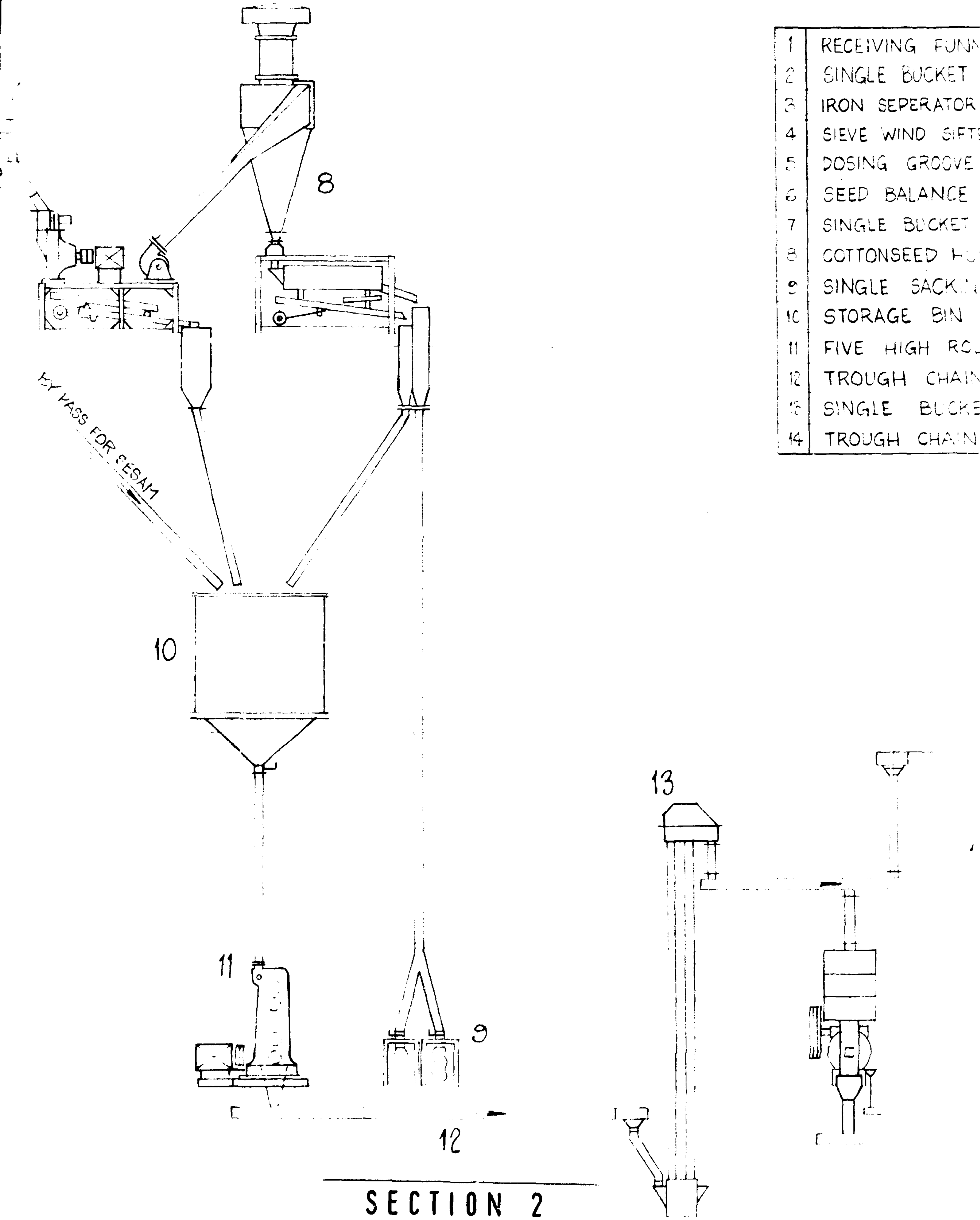


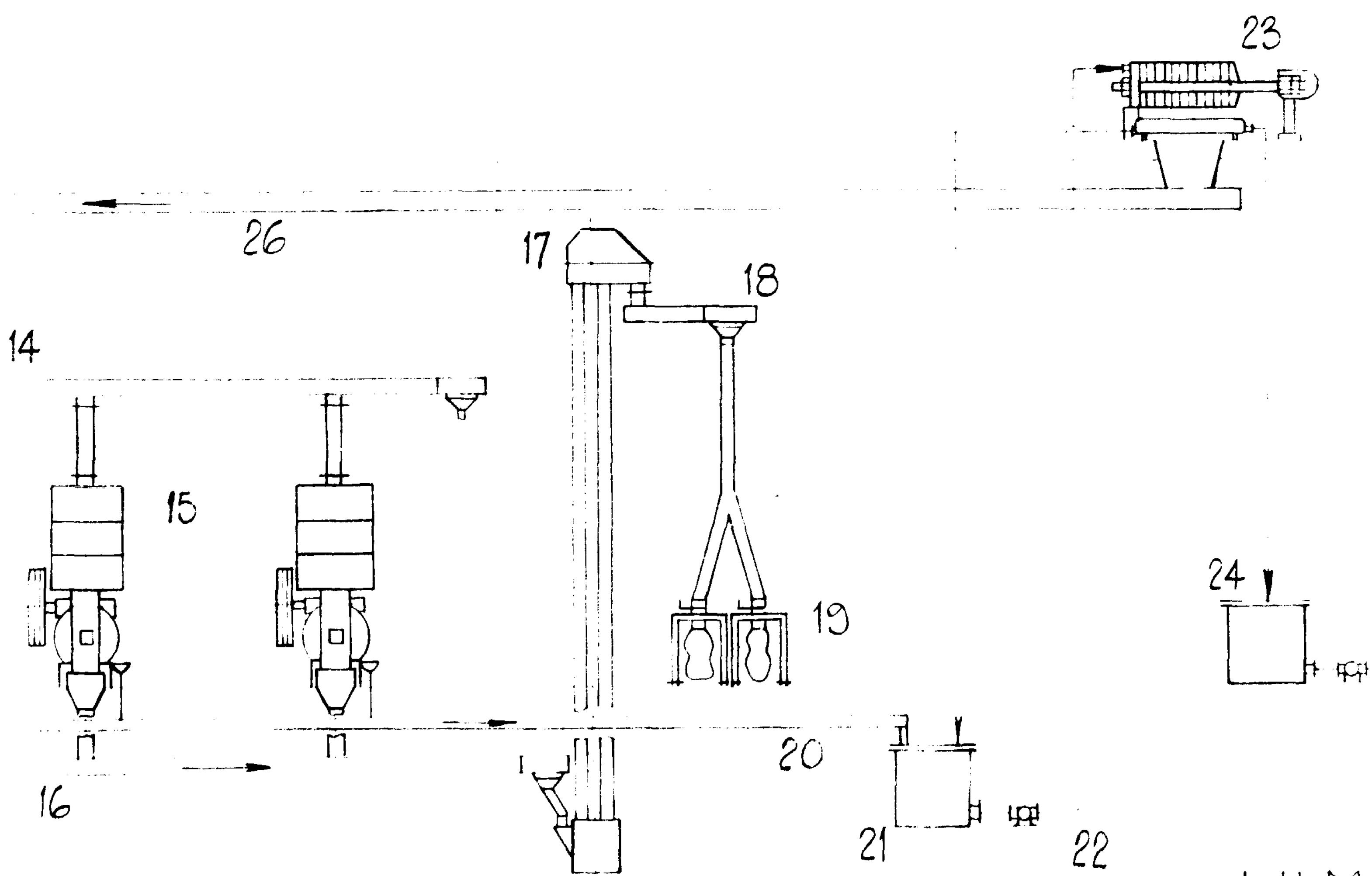
SECTION 2

1	RECEIVING FUNN
2	SINGLE BUCKET
3	IRON SEPERATOR
4	SIEVE WIND SIFTE
5	DOSING GROOVE
6	SEED BALANCE
7	SINGLE BUCKET
8	COTTONSEED H
9	SINGLE SACKIN
10	STORAGE BIN
11	FIVE HIGH RO
12	TROUGH CHAIN
13	SINGLE BUCKE
14	TROUGH CHAIN

PROCESS FLOV

AL MANSURA OI

FUNNEL	15	OIL EXPELLER
KET ELEVATOR.	16	TROUGH CHAIN CONVEYOR
RATOR	17	SINGLE BUCKET ELEVATOR
SIFTER.	18	TROUGH CHAIN CONVEYOR
OOVE.	19	SINGLE SACKING BENCH
NCE	20	OIL- GUTTERING
CKET ELEVATOR	21	OIL CONTAINER
D HUSKING COMPL.	22	OIL FEED PUMP
CKING BENCH.	23	FRAME FILTER PRESS
BIN	24	OIL STORAGE TANK
ROLL MILL	25	OIL FEED PUMP
CHAIN CONVEYOR	26	TROUGH CHAIN CONVEYOR
UCKET ELEVATOR	27	WARM WATER TANK
HAIN CONVEYOR.	28	WARM WATER PUMP



SECTION 3

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PROCESS FLOW
AL MANSURA OIL MILL

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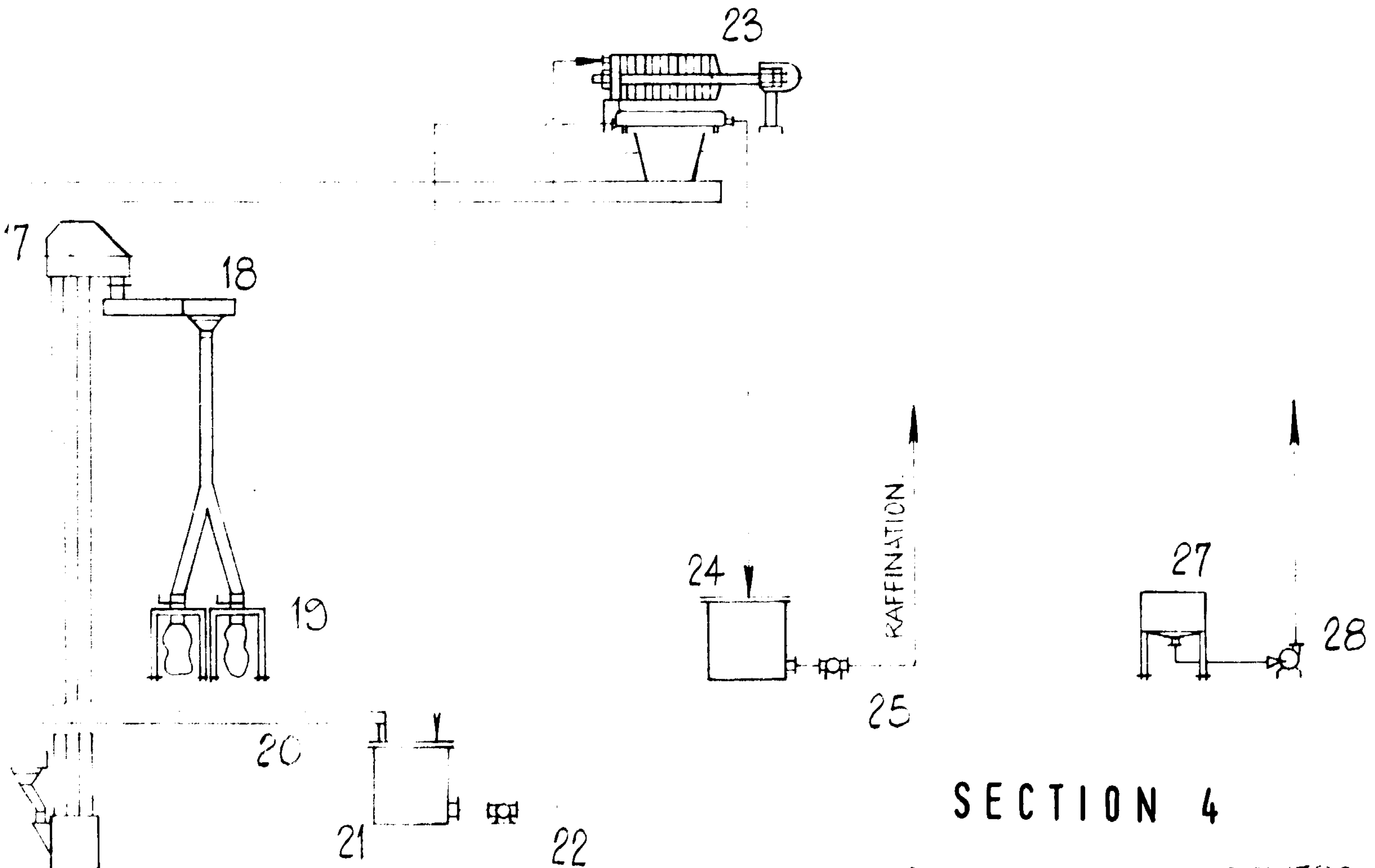

SECTION 4

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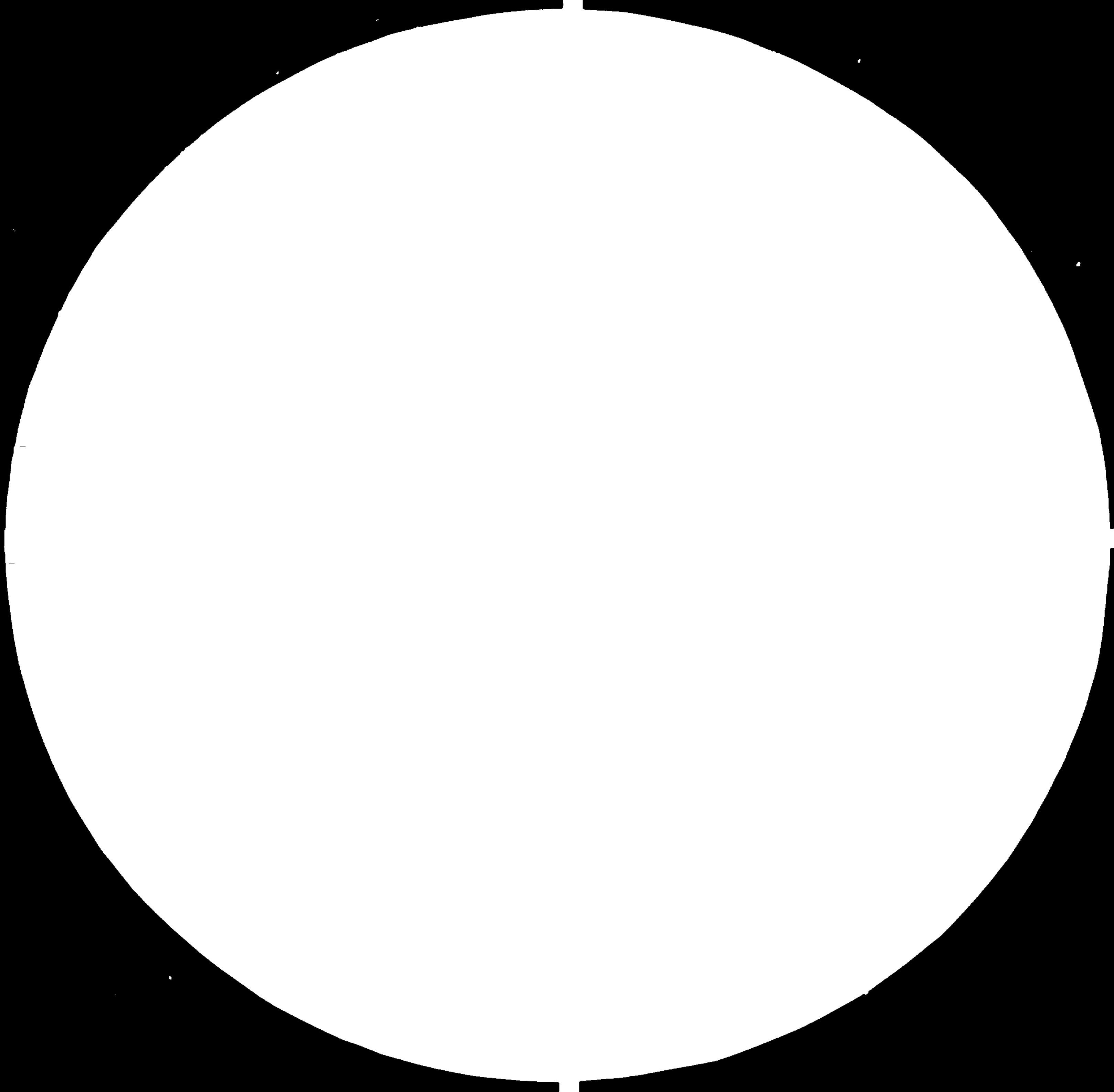

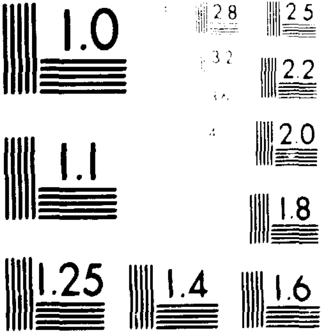
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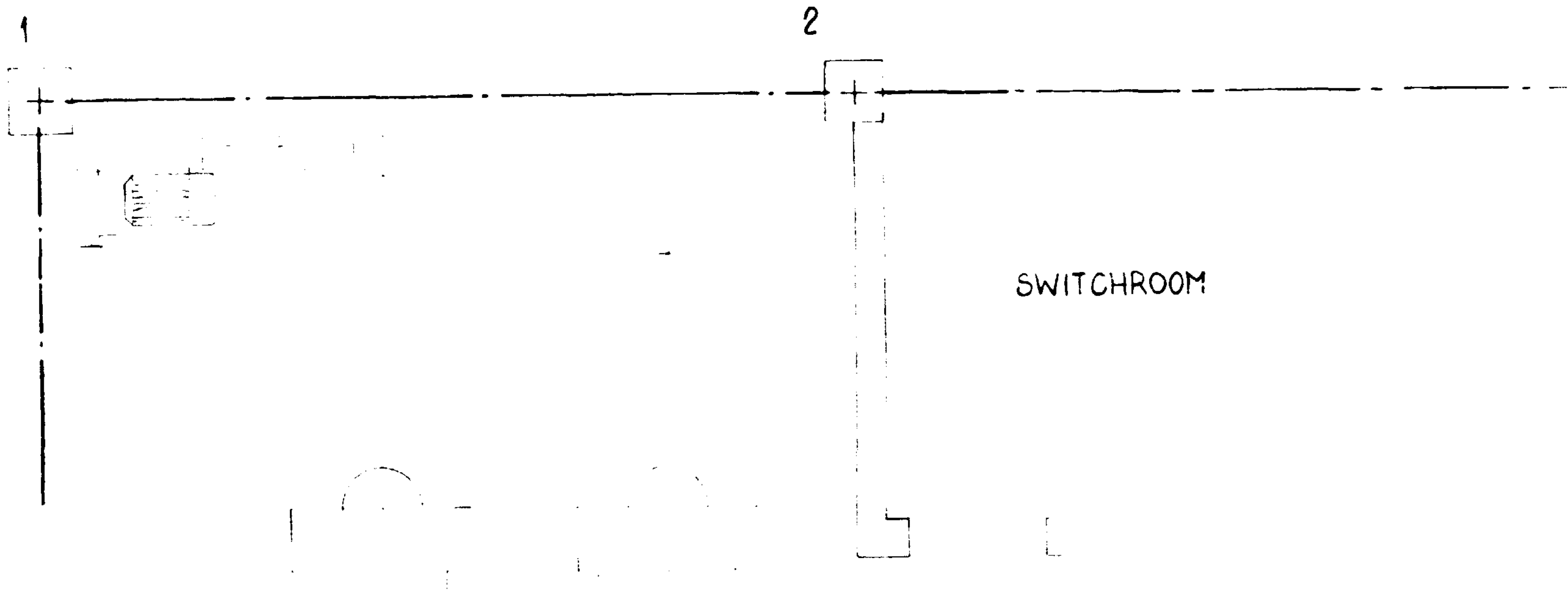

PROPOSED

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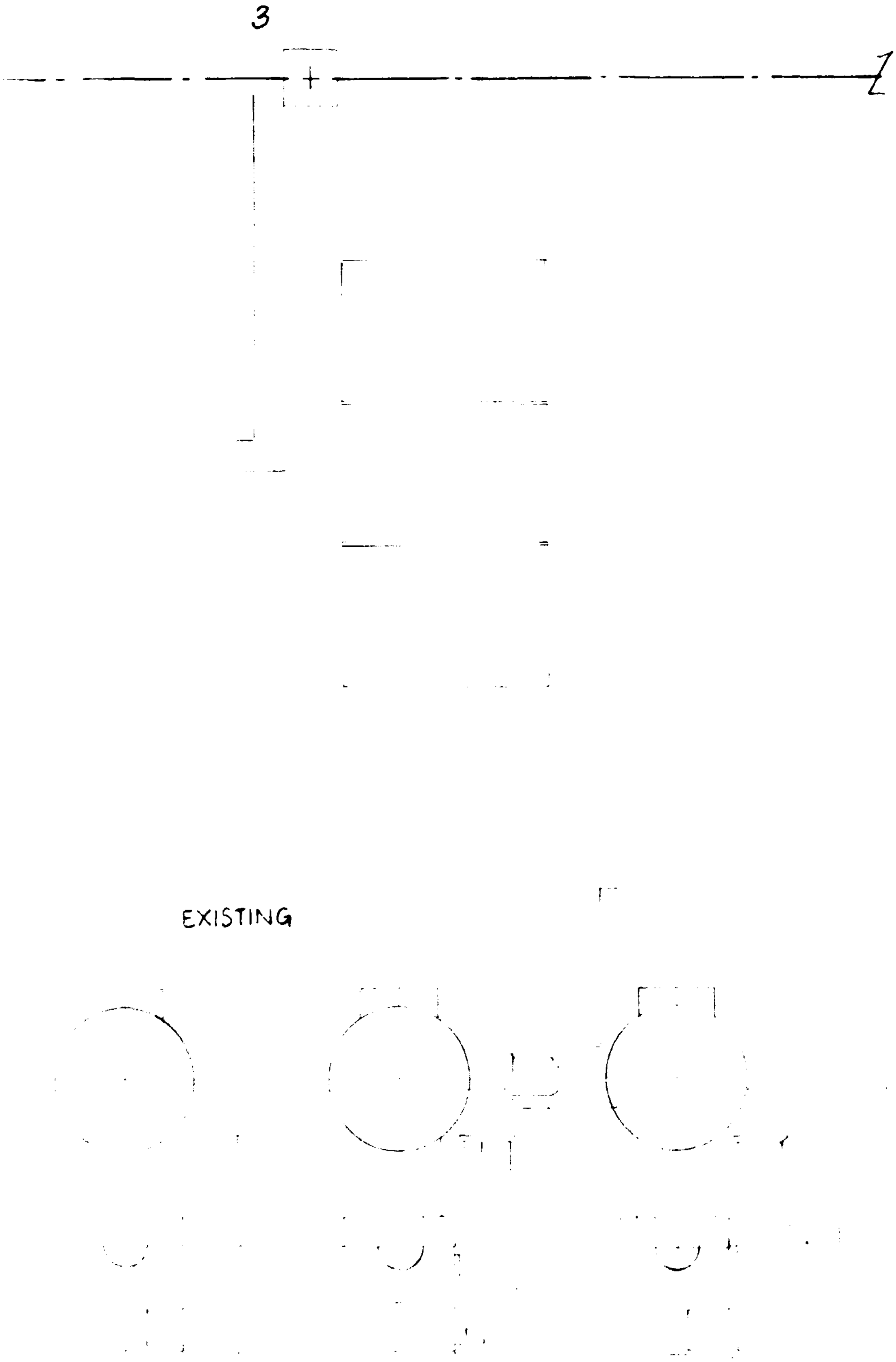
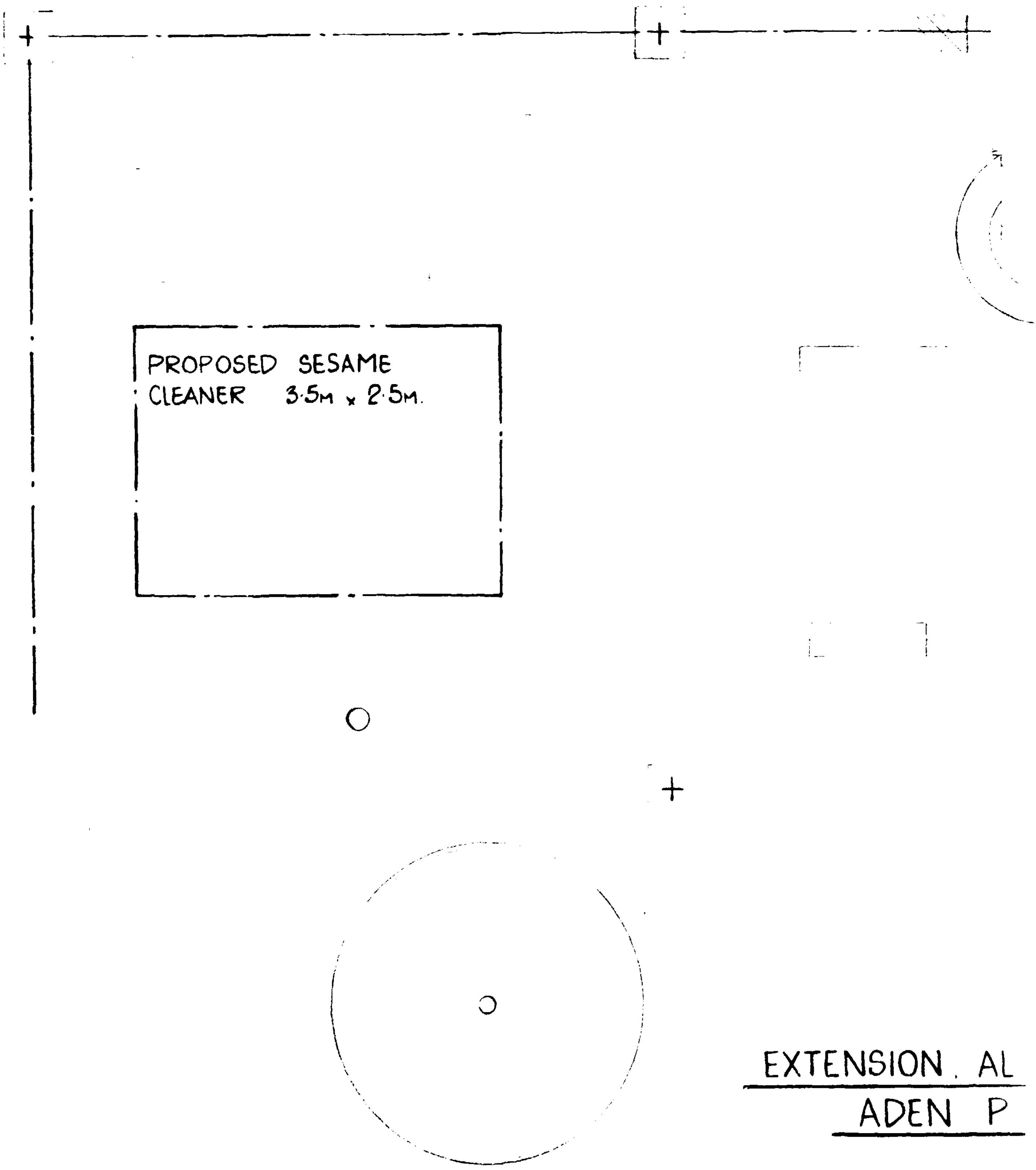
SECTION 1



SECTION 2



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SECTION 3

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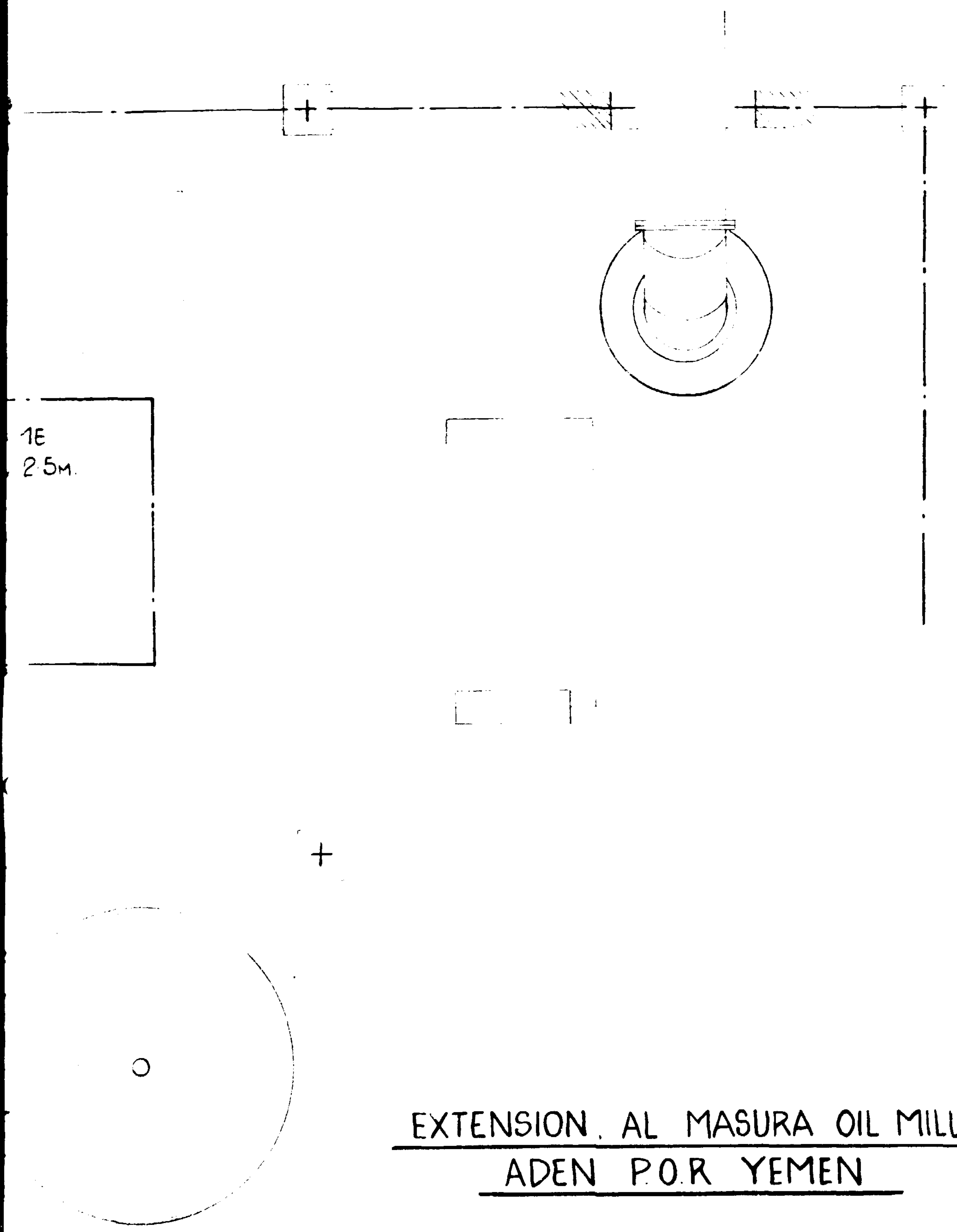

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SECTION 4

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APPENDIX IX

BITUMEN

I Proposed Project

1.1 Bitumen would normally be considered a Refinery Product, which would require a large scale production of, say, 100,000 tpa minimum. On this scale, it would be almost entirely an export orientated unit, of what is basically a low margin product. Bitumen units are being studied in other neighbouring countries, but at the present time large scale production for export does not look attractive.

1.2 Bitumen is primarily required in PDRY for road surfacing and in water supply and irrigation for waterproofing of channels and pipes. Local demand amounts to approximately 10.000 tpa at present. Imports are largely from Singapore. Local production from refinery residues would have the following advantages:-

(i) It would be possible to transport the bitumen hot in road tankers for work in areas at a considerable distance from Aden.

(ii) Drums would not be required.

(iii) Delays and costs associated with reheating would be avoided which should help the road building schedule.

(iv) Shipping costs of the corresponding crude oil would be lower than for a product which is transported in drums.

Against this must be set the capital and operating costs of local manufacture.

1.3 To have sufficient flexibility in production based on the residue at present available from the refinery, two key units are required, firstly a vacuum unit and secondly a blowing unit. The smallest package vacuum unit available has an output of approximately 20,000 tons/annum which is greater than the local demand although it is perhaps not unreasonable if the market in YAR is considered as well. A small blowing unit would consist essentially of a batch still comprising a horizontal cylindrical tank fitted with perforated air injection pipes, a heating coil which can be switched to cooling if necessary and large fume ducts. Provision should also be made for steam or water injection into the vapour space if spontaneous combustion should occur. Such a unit would need to produce 60 pen grades of Road Bitumen.

1.4 To avoid the need for a vacuum unit, a residue of 12 API or below would be needed, and in view of the varying feedstock in the refinery, this could be a problem. However, this situation could change, if other process units were added to the refinery, which would alter the atmospheric residues currently being produced.

One of the new plants under consideration by the Refinery is a Vis-Breaker which may well incorporate a vacuum distillation unit in which case the residue should be suitable for Bitumen production.

1.5 It must be pointed out that the scale and economics of the re-vamped Refinery units will be such that local Bitumen production could not be allowed to interfere either with the selection or the planned operation of such units, but should be treated rather as a marginal extra.

II Capital Costs

2.1 Vacuum Tower, 1,000 BPSD yields 400 BPSD of 85 - 100 pen Asphalt production for 300 days about 20,000 tpa. Fob cost is US $2.5 million.

2.2 A Blowing unit would produce about 60 pen Asphalt from 85 - 100 pen.
Fob cost US $0.75 million.

2.3 The cost of erection, including foundation, would add about 50 per cent to these costs. The cost of steam, water, compressed air and electricity has not been included.

2.4 The current price of bitumen cif Aden is 110 YD/ton whereas the feedstock to a bitumen unit is likely to be valued at 55 - 58 YD/ton. Further studies are indicated after the nature of the refinery expansion is known.

III Conclusion

If the Vis Breaker project is sanctioned and includes a vacuum unit the capital cost of a bitumen plant would be relatively small and the project would have a good chance of proving viable. However without a vacuum unit the project would need closer study.

APPENDIX X

GLASS CONTAINERS AND TABLEWARE

I Proposed Project

1.1 To establish a plant to produce 20 - 30 tons/day of glass bottles and tableware.

1.2 It is proposed that the furnace should feed two production lines. One would use a 4 section IS machine and the other would use a multi-station press machine. Both would operate fully automatically and continuously.

1.3 It has been assumed that electricity will normally be used for heating purposes, but that gas will be used to assist in the melting process, for the rim firing machine, and as a stand-by fuel. The furnace will be of the 'Mixed Melter' type using a mixture of electricity and gas. Metallic recuperation is included. The forehearths will be electrically heated but will use gas as a stand-by.

1.4 It is assumed that initially the IS machine will operate on single gob with a maximum requirement of 18 tons per day. The press machine will have a maximum requirement of 12 tons per day. The furnace will, therefore, have a maximum requirement of 30 tons per day and a melting area of 8 m^2 should be sufficient to achieve this with flint, green or amber glass.

II Project Description

2.1 Batch Plant

The batch plant recommended for this type of operation is semi-automatic utilising the following principal pieces of equipment:

- Storage bays or silos for sand
- Covered storage area for soda-ash (bagged)
- Covered storage area for minor ingredients
- Combination weigh-machine and mixer
- Wheel barrows, shovels and power loading shovel
- Storage bins for delivering mixed batch to batch charger hopper on furnace.

2.2 Mixed Melt Furnace

2.2.1 The furnace should have maximum flexibility with respect to output and colour change, and have the facility for altering the percentage of electricity and gas to achieve the most economical combination. The furnace will be hexagonal in shape and will be designed for a maximum output of 30 tonnes per day. The furnace will be designed to operate continuously using a combination of gas firing in the superstructure and electric heating in the glass, using immersed molybdenum electrodes.

The gas firing system in the furnace superstructure will be fitted with a vertical steel recuperator which will preheat the air to the burners.

Melting in this type of furnace, as in an electric furnace, occurs vertically and glass will be drawn from the bottom of the furnace through a conventional throat and riser which will be heated by immersed molybdenum electrodes. The glass will then pass into the forehearth system.

2.2.2 Refractories

The furnace will be built from the refractories detailed as follows:

(i) Glass Contact Refractories

These will consist of Electrocast blocks. The sidewalls and riser will be constructed from ZAC 1711 RT type material and the furnace bottom will be fitted with 1681 Dalle type tiles. Where appropriate, mating surfaces will be diamond ground.
Total weight approx 27 tonnes

(ii) Furnace Back-up

The furnace bottom will consist of a 300 mm layer of sillimanite blocks standing on fireclay bricks supported by the bottom steel members. The Dalle type tiles will be laid on

the sillimanite using ZAC cement.
Sillimanite will also be used to back up the sidewall blocks.
Total weight approx 23 tonnes.

(iii) Insulation

The sidewalls and crown will be insulated with fireclay and insulating brick.
Total weight approx 4.5 tonnes.

(iv) Superstructure

The superstructure will be constructed using a high alumina brick for both the breast-walls and crown. The crown will be of a flat Detrick type construction, the refractories being supported by the horizontal steelwork over the crown.

In locations where the operating conditions will be more demanding, ie recuperator port entry, burner block areas etc, Mullite and Sillimanite will be used.
Total weight approx 15 tonnes.

2.2.3 Steelwork

Complete steel structure for supporting and bracing all furnace refractories, including base platform buckstays, bracing members etc should be prefabricated.

Total weight approx 19 tonnes.

2.2.4 Recuperator

A metallic recuperator will be supplied to pre-heat the air used for the burners in the superstructure. The recuperator will be of the parallel flow radiation type and will be located at one side of the furnace on its own free-standing steel platform.

A short metallic stack above the recuperator will be required to ensure that the exhaust gases clear the major factory roof areas.

The necessary stainless steel ducting and fan for distributing the not air to the gas burners on the furnace will be included.

2.2.5 Furnace Transformer

1,200 kVA furnace transformer unit consisting of three independently controlled single phase transformers, immersed in oil in a sheet steel tank.

Secondary voltages will be independently variable by motorised off-load tap change switches along with continuous on-load regulation operated from the control panel.

2.2.6 Control Panel

A comprehensive metering and control panel will incorporate the instrumentation and controls necessary for operating the furnace, the main items being as follows:

- Voltmeters, ammeters, kW meter and kWh meter
- Earth fault metering and protection equipment
- Temperature indicators/recorders
- Electrode holder temperature monitoring and alarm system (Pentector)
- Visual and audible alarm system for furnace control equipment
- Glass level control electrical unit
- Circuit breaker remote control station
- Fuel metering and recording
- Combustion zone pressure indicator

2.2.7 Electrode Equipment

A set of furnace electrodes comprising molybdenum rods, water cooled holders, connector plates and flexible copper braids for connection to the secondary conductors. These will be based on 51 mm diameter electrodes for the main power circuit and 32 mm diameter for starter, throat and earth electrodes.

2.2.8 Batch Charging System

Heavy duty screw type batch charger designed to feed batch onto the surface of the furnace to ensure that the surface remains covered with batch. The nose of the screw will be protected by a water cooled tube. The charger will be fed from the furnace hopper and will be automatically controlled from the level control unit.

2.2.9 Instruments on Furnace

A glass bath pyrometer complete with temperature sensing unit. Thermocouples, platinum/platinum rhodium, each fitted with a recrystallised alumina sheath, to be located in the superstructure of the furnace.

Glass level controller (mechanical unit) comprising driving mechanism for probe arm, water cooled probe arm fitted with a platinum sensing pin, counter electrode and all cable necessary for connecting controller to the batch charger.

2.2.10 Water System

Softening and pumping system to supply an adequate quantity or water for cooling the various units on the furnace. Consisting of an automatic water softening unit, a pumping system with main and stand-by pumps.

2.2.11 Primary Switchgear

Primary switch for three phase supply, equipped with remote control coils for operation from the furnace control panel. A high voltage supply has been assumed.

2.2.12 Secondary Conductors

Secondary conductors between the transformer and the furnace in aluminium busbar including support insulators.

2.2.13 Riser Heating

A transformer with variable secondary outputs mounted in a panel for applying heating power through electrodes in the riser area, including instrumentation and remote controls.

2.2.14 Burners

A set of gas burners, complete with control valves and pressure gauges for manual operation.

The burners will be designed to be used in conjunction with the recuperated air which will be passed to the burners from the recuperator through stainless steel ductings.

2.2.15 Spare Parts and Consumables

A set of 51 mm diameter molybdenum electodes threaded each end.

A set of electrode holders for 51 mm diameter electrodes.

One spare set of flights and bearings for batch charger.

A set of lamps, fuses, relays etc for control panel.

2.2.16 Auxiliary Equipment

This consists of a furnace drain and the cooling boxes fitted on the throat cover blocks.

2.3 Forehearth System

2.3.1 It is proposed to use two forehearths, each approximately 4.5 m long and 406 mm wide with 144 type bowls. The heating will be all electric by means of molybdenum electrodes immersed in the glass. Radiant elements will be installed in the bowl superstructures and resistance elements will also be used around the bowls. Manual gas burners will be used for start-up and power failures.

Fully automatic temperature control using thyristors and temperature controllers will ensure accurate gob temperature and homogenity.

The following equipment will be supplied:

2.3.2 Radiant Elements

Radiant heating elements installed in the bowl supersturctures supplied complete with connectors and ancilliary parts.

2.3.3 Electrodes

Special molybdenum forehearth electrode assemblies for installation in the channel.

2.3.4 Bowl Blanket Elements

Specially shaped resistance elements to be installed around the outside of the refractory bowls.

2.3.5 Transformer Racks

Power transformers for all heating sections mounted in enclosed steel racks together with all associated switches, isolators and fuses. The racks will be supplied fully wired and ready for connection to the relevant heating section and control panel.

2.3.6 Control Panel

The control panel, which may joined to the furnace panel, will contain all the necessary instrumentation, switches, thyristors, temperature controls and temperature recorders for the operation of the forehearth system. A primary distribution board will be included.

2.3.7 Instruments

Continuous optical pyrometers will be used for glass temperature measurement and control, together with platinum/platinum rhodium thermocouples, in various locations in the forehearth and spout area. These will be supplied complete with connecting cables.

2.3.8 Refractories

Sillimanite channels and bowls. Superstructure refractories and element blocks. Insulating materials.

2.3.9 Steelwork

Fabricated steel casings to contain the refractories. Supporting steelwork.

2.3.10 Cables

Electrical cables to connect the control panel and transformer racks with the heating elements.

2.3.11 Burners

Three sets of manual propane gas burners.

2.4 Forming Machines

2.4.1 Feeder Mechanisms

Two 144 type single gob feeder mechanism including:

- Angular shearing
- Lubrication
- Variable speed drives with drive motors
- Shear cams
- Plunger cams
- Remote control mechanisms
- Revolving tube mechanisms
- Steel casings
- Spare parts.

2.4.2 IS Machine

One 4 section single gob 4¼" blow and blow and press and blow IS machine including:

- four single gob press and blow and blow and blow plunger mechanisms complete with blow and blow quick change cartridges and plunger positioners for mouths up to 90 mm to 120 mm

- One set of single gob mechanisms' arms including baffle arms, blow head arms, funnel arms, neck ring holders and tongue heads.

- Three sets of selected single gob variables, weight range 250 to 600 grams, each including scoops, troughs and deflectors.

- Three sets of standard mould holders.

- One set of single gob colling nozzles.

- One 4 section pusher conveyor including differential drive assembly for the synchronisation of the conveyor with the machine.

2.4.3 Press Machine

One multi-station automatic hydraulic press for the production of tumblers and other tableware.

- Pressing machine hydraulically operated with a a main table diameter of 1.5 m and capable of using between 4 and 20 stations according to production requirements.

- Hydraulic power pack requiring approx 30 kVA supply.

- Programmer and synchronisation unit.

- Automatic take-out mechanism.

- Mould opening equipment for ware with handles etc.

- Mould cooling system.

2.4.4 Rim Firing Machine

One automatic rotary rim firing machine to work in conjunction with the press machine. Produces a smooth beaded edge on tumblers and other tableware items.

2.4.5 Auxiliaries for Forming Machines

(i) Compressors

Two 90 kVA compressors to supply compressed air for the IS machine including main and stand-by compressor units, 2 air receivers, one set of gauges, driers and after-cooler, and two sets of switchgear.

(ii) Fans

Two 70 kVA fans to supply cooling air for the IS and press machines including main and stand-by fan units driven by V belts from electric motors.

2.5 Annealing System

Two Ware conveyors from machines which includes:

(i) Ware conveyor drives, corner transfer units on to cross conveyors

(ii) Two cross conveyors to be located before the annealing lehrs, to receive the glass articles and align them before their entrance to the lehrs, comprising:

- speed variators and tropical motors 220/380 50 Hz
- drive rolls lined with ferode
- conveyor belts made of C 50 steel,

width 200 mm, length 400 mm
- Lincoln lubrication systems
- steel linking plates between conveyor and lehr
- electric control boards

2.5.2 Two stackers mechanically actuated, complete with all required parts and electric control board.

Two Drive groups consisting of speed variator and motor.

Controlled by the 'UNISYSTEM' between feeder and forming machine.

2.5.3 Two electrically heated annealing lehrs.

The belts to be chrome/molybdenum steel. Fully recirculating with fan for each section. Inconel heating elements mounted below the belt. Automatic temperature control in the heating and indirect cooling sections with temperature recording. Maximum working temperature 570° C. Tunnel pressure control provided by air jet curtain between the indirect and direct cooling sections. Manual temperature control in the direct cooling section with fans above and below belt.

Two control panels including temperature controller, recorder, kWh meter, belt speed controller and indicator and all necessary switches, fuses, relays etc.

2.6 Workshop Equipment

2.6.1 One group of machine tools and miscellaneous equipment to provide sufficient means to repair moulds and other glass works machinery comprising:

Two lathes (one equipped with a copy attachment)
Two vertical Turret milling machines
One shaping machine
Two drilling machines (one large, one bench type)
Two double ended grinders (one large, one bench type)
One electric welder
One gas welder
Four bench vices
Two air grinders (or electric)
One mould polishing machine.

2.7 Laboratory and Quality Control

2.71 For routine testing/analysis of raw materials, finished products and furnace combustion conditions, including all necessary chemicals, platinum dishes, fume cupboard etc for chemical analysis:

- Glass density testing
- Stress level determination

- Seed counting
- Impact and pressure testing
- Diamond cutting machine
- Metallurgical microscopes
- Spectro photometer
- Muffle furnace
- Oxygen/CO/CO_2 analysis.

III Capital Costs

3.1 The capital costs are estimated as follows:

		US $
A Direct Costs		
(i)	Plant and Equipment	4,700,000
(ii)	Freight	376,000
(iii)	Installation of equipment	300,000
(iv)	Electrical installation	75,000
(v)	Building 5,000 m^2	1,750,000
(vi)	Site Development	250,000
	TOTAL DIRECT COSTS	7,451,000
B Indirect Costs		
(i)	Engineering and Supervision	250,000
(ii)	Construction	300,000
	TOTAL INDIRECT COSTS	550,000
	TOTAL CAPITAL COSTS US	$8,001,000

IV Operating Costs

Since the glass sand deposit is not yet being worked, we have no information on what its cost is likely to be in Aden, but for the purposes of this exercise we have assumed that it is likely to be around US $30/ton. The total operating cost is likely to be in the region of US $2.5 million or about US $0 .40 per kg of formed glass. (Table A). Bearing in mind that 1 kg of glass will make four soft drink bottles, the approximate cost per bottle will be US $0.1. This assumes that the plant works for 300 days/annum and has an output of 6,000 tons of glass . As has been noted in Section 4.15 the total demand for glass bottles is likely to be around 10 million which will only occupy the plant for about 50 per cent of the time.

V Conclusions

Under present conditions it seems unlikely that a glass bottle plant would be viable on its own because of the low level of demand. However, the glass furnace could also be used either for the production of raw material for a fibre glass plant (see Appendix XI) or for the manufacture of sodium silicate (See Section 6.8)

This would mean, however, that the bottle forming machinery would have to stand idle for half the year.

At the moment there is not sufficient data available to make a firm recommendation, but we believe that there is a prima facie case for a detailed feasibility study of a complex which would combine these three projects namely glass bottles, glass fibre and sodium silicate. Bearing in mind that PDRY is one of the few places in the Arab world with well defined resources of high quality glass sand we feel that this study should pay particular attention to the prospect of exporting to neighbouring countries.

TABLE A

Estimated Annual Operating Costs of 20 tpd Glass Bottle Plant
(300 days per annum)

			(Glass)	US $
	Raw Materials	Unit Cost	Cost/ton	Annual Cost
A	**Variable Costs**			
	72% Glass Sand (avail in PDRY)	30.0 /ton	22.0	132,000
	15% Soda Ash	150.0 /ton	22.5	135,000
	13% Lime/ Magnesium/Alumin.	96.0 /ton	12.5	75,000
	Utilities			
	Electricity	50.013 /kwh	15.6	936,000
	Water	2.5 /m^3	6.0	36,000
B	**Fixed Costs**			
	Operating Labour	US $2,000/man year, 20 men	6.7	40,000
	Operating Supplies	5% of operating labour	0.3	2,000
	Supervision and Indirect Payroll	20% of operating labour + 1 Supervisor at $20,000	4.7	28,000
	Repairs, Labour and Supplies	4% of Fixed Investment	53.3	320,000
	Plant Overhead	5% of Fixed Investment	66.6	400,000
	Depreciation	10% of Fixed Investment	133.3	800,000
	Interest on Capital	9% on 50% of Fixed Invest.	59.9	360,000
	TOTAL ESTIMATED OPERATING COSTS		403.4	2,421,600

APPENDIX XI

GLASS FIBRE PLANT

I Proposed Project

1.1 It is proposed to establish a 250/tpa glass fibre plant. The product will be chopped strand mat suitable for use into a range of glass fibre reinforced plastic (GRP) products.

1.2 Feedstock for the melting and fibre drawing units can be in the form of glass marbles, pellets, or crushed graded cullet scrap. Consistency of chemical compostion is important for the successful operation of the plant. The range of chemical composition of glass which may be processed includes the soda-lime silica 'A' glass and the chemically resistant 'C' glass, but not 'E' glass. For this reason the product is not suitable for electrical applications.

1.3 If the project to make glass bottles and tableware is approved, then obviously the glass fibre plant would be sited close to it so that both could share common melting facilities. However for the present we have included a separate furnace.

II Project Description

2.1 Each fibre drawing unit consists of:-

(i) Furnace head, complete with special nickel alloy drawbar, crucible, heating elements, temperature and level sensing probes, all encased in refractory insulation retained in an aluminium frame with asbestos sheet cladding.

(ii) Automatic glass vibrating dual feed assembly with hoppers to carry 8 hours feed supply.

(iii) Control console with thyristor control and one base load output for furnace heating, glass level controls, protection and warning equipment with visual indication of furnace and drawbar temperatures and of load current in each of the controlled circuits.

(iv) Water cooling pipes for connection to an external supply.

(v) 'Size' applicator with motor and pumped circulation.

(vi) Winding-up head with dynamically balanced expanding collet to carry standard 288 mm diameter cardboard sleeves with independent pre-set control to give constant surface speed and fitted with butterfly type spreader.

2.2 Glass Fibre Cake drying and handling system comprising for each unit:-

(i) One gas fired oven with thermostatically controlled recirculating hot air system rated to dry 54 cakes in 8 hours

(ii) Two wheeled trolleys each fitted with carriers for 54 cakes of 288 mm diameter each.

2.3 Re-winding plant for the production of multi-strand cheeses of rovings from cakes and comprising:-

(i) One heavy duty precision winding machine equipped with 10 inch long traverse (254 mm) 3 inch pneumatic spindle (76.2 mm) and 1½ hp motor and controls

(ii) One creel rack

(iii) One fibre guide and tensioning system.

2.4 One set of quality control test equipment.

2.5 One set of mixing and storage equipment for 'sizes'.

III Capital Costs

3.1 The capital costs of the proposed plant are set out in Table A and provision is made for a stock of essential spares.

IV Operating Costs

4.1 The operating costs set out in Table B are based on the current UK cost of Glass Pellets, although ultimately we would hope to use locally produced glass. Size and sleeves have been costed at the delivered price Aden, but there would be little opportunity for local manufacture.

4.2 The price of US $1.74/kg compares favourably with production costs in Europe.

V Conclusions

Bearing in mind the growing demand for products made from GRP, in particular pipes, water tanks, and boats, we believe that this project would be well worth investigating in greater detail. As has been mentioned in Appendix X it would seem sensible to combine this with the development of glass bottles and sodium silicate, but if the three projects are treated individually then the production of glass fibre would appear to be attractive and justifiable on its own merit.

TABLE A

CAPITAL COSTS OF GLASS FIBRE PLANT 250 tpa (3 shifts, 8 hrs 330 days)

				US $
A	Direct Costs			
	(i)	Plant and Equipment	645,000	
		Spares	34,000	
		Freight	48,700	727,700
	(ii)	Installation of Equipment		100,000
	(iii)	Electrical Installation		50,000
	(iv)	Building 360 m^2		345,000
	(v)	Site Development		50,000
	(vi)	Service Facilities		25,000
		TOTAL DIRECT COSTS		1,297,700
B	Indirect Costs			
	(i)	Engineering and Supervision		75,000
	(ii)	Construction		75,000
		TOTAL INDIRECT COSTS		150,000
		TOTAL CAPITAL COSTS US $		1,447,700

TABLE B

Estimated Operating Costs for Glass Fibre Plant 250 tpa
(3 shifts of 8 hrs, for 330 days)

				US $
A	Variable Costs			
	Raw Materials	Unit Cost	Cost/kg	Annual Cost
	Glass Pellets	200/ton (85%)	0.24	58,750
	Size		0.07	17,050
	Sleeves and Packaging		0.04	8,812
	Utilities			
	Electricity		0.07	17,625
	Gas		0.04	10,575
B	Fixed Costs			
	Operating Labour	US $2,000/man year, 13 man year shift	0.10	26,000
	Operating Supplies	5% of operating labour	0.01	1,300
	Supervision and Indirect Payroll	20% of operating labour and one Supervisor at US $20,000	0.10	25,200
	Repairs, Labour and Supplies	2% Fixed Investment	0.10	25,114
	Plant Overhead	5% Fixed Investment	0.25	62,785
	Depreciation	10% Fixed Investment	0.58	144,770
	Interest on Capital	9% on 50% of Fixed Invest.	0.23	56,500
	TOTAL ESTIMATED OPERATING COSTS		1.82	454,481

[redacted]