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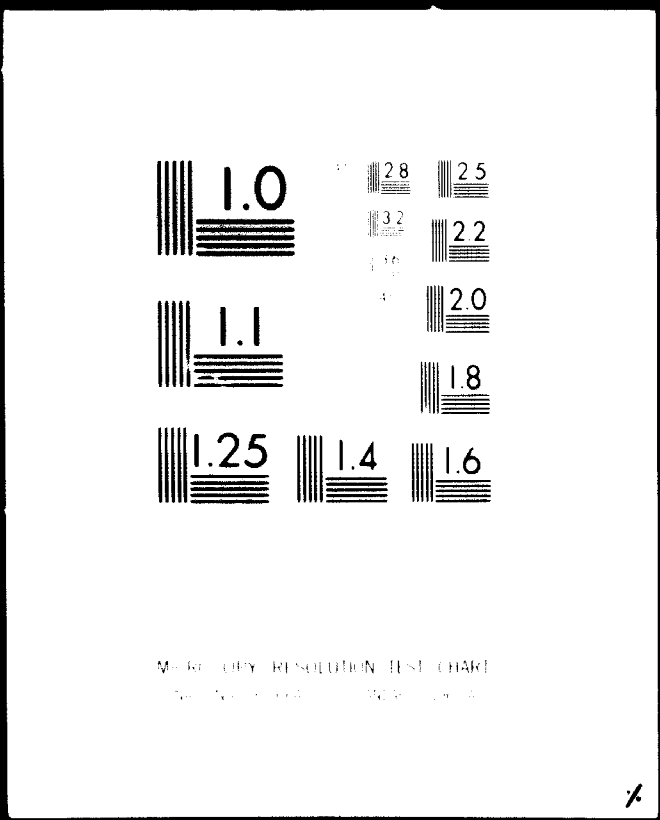
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# (R) MALT PRODUCTION IN RWANDA.
# FEASIBILITY STUDY

Prepared for

United Nations Industrial
Development Organisation



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September, 1971

## CONTENTS

## INTRODUCTION

The purpose of this study was to investigate the market, technical and economic aspects involved in erecting a malt factory in Rwanda which would promote the utilisation of locally produced barley and save imports.

In this report all prices are stated in Rwandese francs at the rate of exchange prevailing prior to 16th August 1971, namely $1 = FRw100 and £1 sterling = FRw240. All weights are given in metric tons.

## SUMMARY AND RECOMMENDATIONS

### Economic Development in Rwanda

The main obstacles facing development in Rwanda are the presence of a large subsistence sector in the economy and a balance of payments constraint. The establishment of a maltings using locally produced barley would alleviate both these difficulties (a) by expanding the cash incomes of farmers and (b) by replacing imported malt by home produced malt (Section 1.1).

### The Market for Malt

The domestic market in Rwanda for malt is determined by the brewing industry which currently imports its total malt requirement. This has grown at an average rate of 4.1 per cent in the last 4 years and, following this trend, is expected to amount to 2,000 metric tons by 1975 (Section 1.21). Demand for malt by other industries is negligible (Section 1.22). As far as export markets are concerned our calculations show that on the basis of marginal pricing, Rwandan malt would be price-competitive with European malts in Burundi, the Congo and Uganda. However, exports to these countries cannot be guaranteed because of their own import-substituting policies. We conclude that export sales should be treated as windfall gains and not be included in the economic and financial appraisal (Section 1.3). The above forecast of the demand for malt could be affected by changes in brewing policy or methods. In particular the direct conversion of barley to wort by enzyme methods could almost entirely eliminate the demand for malt in Rwanda.

### Size of Plant

On the basis of the market study, we recommend that the plant should be designed for an initial output of 2,000 metric tons annually. (Section 1.4). This plant could in fact produce up to 3,000 metric tons annually without major additional investment and with no extra labour.

## Raw Material

Barley is no longer grown on a commercial scale in Rwanda (Section 2.1) and evidence on past crops is inadequate to establish a reliable conclusion as to the malting quality of Rwandan barley. Apparent defects in quality may have been due to mishandling of the barley after harvest or inadequately controlled malting (Section 2.2). We recommend that an agronomist should be appointed by the Rwanda government to supervise the growing of experimental acreages of barley and the testing of the resultant barley over a three year period. This should be done before any decision to go ahead with the maltings is taken (Section 2.32).

## Malting Process - Type of Plant

It is technically feasible to design a maltings with an annual capacity of 2,000 metric tons. We recommend a conventional system of malting using the Saladin box type plant (Section 3.2). However on account of the small size of the plant and in the interests of building, handling and maintenance economy and flexibility, we recommend that the boxes should be designed to serve both as germination and kilning units.

## Tendering

It is usual in the malting industry for tenders to include only a general outline of the maltsters requirements, leaving manufacturers to express their own recommendations on the details of plant layout etc. and to quote for the entire cost including erection and commissioning. Our specification, however, goes into more detail than is customary (Section 3.22).

## Location of Plant

We considered two alternative sites for the maltings, Gisenyi, adjacent to the brewery and Ruhengeri, mid-way between the brewery and the barley-growing area. On balance, Ruhengeri is favoured because we attach more importance to the presence of engineering services in Ruhengeri (from the Pyrethrum plant) and to the easing of the problem of collection of the barley harvest, than we attach to the economies in handling possible at Gisenyi. (Section 4.11).

## Infrastructure Requirements

We estimate that the plant will require, for its initial annual output of 2,000 metric tons, 200 metric tons of fuel oil, 16,600 cubic metres of water and 156,000kwh of electricity. The installed capacity of the plant is 344KW (Section 4.12)

## Personnel and Training Requirements

The size of the labour force is estimated to be 10 persons. There will be a general manager who, initially, will probably have to be an expatriate. After 5 years he should hand over to a Rwandese assistant manager. The assistant manager will require about three months training in Europe before the maltings starts operations. There will need to be two laboratory assistants who should be locally recruited and trained at other laboratories in Rwanda. The remaining six workers will consist of five semi-skilled production workers and one office worker. They can be trained on the job (Section 4.2)

## Purchase of Barley

We recommend that the purchase price of barley should be FRw 8 per kilo. This is the same as the price of the alternative crop, wheat, but because barley has a higher yield per hectare than wheat, farmers could increase their incomes from a given area by up to one-third. This is thought to be sufficient incentive to ensure an adequate supply of barley. Barley purchase may be financed by a bridging loan taken out at the end of August each year and repaid in eight instalments starting in the following January. At the present rate of interest (9 per cent) the effective cost of this loan would be 6.375 per cent (Section 4.31).

## Other Production Costs

For an annual output of 2,000 metric tons, the main production costs, other than the purchase of barley are for fuel, electricity and water amounting to FRw 2,487,000 (Section 4.32) for insurance FRw 347,000 (Section 4.33) for labour FRw 2,554,000 (Section 4.34) and for office, laboratory and other expenses FRw 300,000 (Section 4.35). In total, for 2,000 metric tons of malt, all production costs including barley purchase and finance and a 10 per cent contingency allowance are estimated at FRw 37,593,000 and the marginal production cost of each additional kilo is FRw 16.98

Capital Investment

It is assumed that land would be provided by the government free of charge. The cost of the plant as specified in Section 3, including construction is estimated at FRw 55,812,000. In addition the provision of housing for the manager and his assistant at an estimated cost of FRw 2,440,000 and the purchase of vehicles at an estimated FRw 900,000 will be needed (Section 4.41). Working capital will be required to finance the barley-growing experiments and tests and to cover the pre-operational expenses of the maltings. This is estimated at FRw 9,813,000 (Section 4.42). The total capital requirement, including a 10 per cent contingency allowance is FRw 75,862,000.

Selling of Malt

The selling price of malt in Rwanda should be FRw 23.60 per kilo ex factory, allowing a delivered price at the brewery 10 per cent lower than the present import price. This is necessary to secure the essential co-operation in the project of the brewery, who will be the only customer. Because of the small size of the malt market in Rwanda, there can be no question of permitting imports once the maltings is established.

Basic Financial Rate of Return

On an initial production of 2,000 tons increasing at 4.1 per cent annually, the operating surplus of the maltings should increase from FRw 9,627,000 in the first year to FRw 16,544,000 in the tenth year (Section 4.51). This surplus yields a basic rate of return (before financing charges and taxation) of 7.9 per cent (Section 4.52).

## Sources of Finance

We recommend that the UN or a bilateral aid agency should provide up to FRw 6,000,000 for the barley-growing experiments and tests as part of a technical assistance programme. The remaining capital requirement might be covered by an export credit of FRw 30 million on the plant and equipment, a 3 per cent loan from the Banque Rwandese de Développement for FRw24,000,000 and an equity issue of FRw16,000,000 subscribed to by the Intebra Brewery and/or an international malting company. This would be the equivalent of 3 years savings on the reduced malt price. Final determination of the financial arrangements cannot occur until nearer the tendering date. The consultants' services would be available to advise further in this respect (Section 4.53).

## Return for Equity Investors

On the basis of the above financial structure, the equity investors could expect to enjoy a discounted cash flow rate of return of 11.84 per cent on their investment. The break-even period is 8.34 years (Section 4.54).

## Return to the Rwanda Economy

The economic rate of return on the project from the standpoint of the Rwanda economy may be as high as 31 per cent (Section 4.61). This high return reflects the benefits stemming from the increased cash income of farmers, a minimum FRw 5.4 million annually (Section 4.63) and the import-saving effect, minimum FRw 35 million annually (Section 4.62). There should be a net gain to the Government revenue of FRw 8.192,000 over the life of the project after taking account of the subsidy element in the loan of the Banque Rwandese de Développement (Section 4.64). It would be worthwhile in view of the high economic return for the Government to offer additional incentives if these are required to ensure the participation of the brewery in the malting project.

Timetable

The earliest practicable date for the start of malting is November 1976, the barley being harvested in August 1976 having been planted in March. This allows 3 years for barley-growing experiments and tests and one year for plant construction (Section 5.1)

Organisation

The maltings should be controlled by a board of seven directors of which the holders of the equity capital would appoint four. The other three directors would represent the different governmental bodies interested, namely the Banque Rwandese de Developpement, the Ministère d'Agriculture et de l'Élevage and the Service d'Études de Programmation Industrielles (Section 5.3)

## CONCLUSION

Because the sole consumer of malt in Rwanda is the brewery at Gisenyi and no other local outlet for malt is likely to develop in the foreseeable future and because export prospects are uncertain, it follows that, from a technical point of view, the feasibility of the project to establish a malting industry in Rwanda hinges on whether or not Rwandan barley lends itself to the production of malt of acceptable quality for brewing. Although the brewery has supplied information, which they feel is evidence for the unsuitability of Rwandan barley for malting, in the opinion of the consultants this could equally be interpreted to mean, that the barley, though potentially good for malting, was mishandled either before or during the malting process. In order to resolve this point beyond question it will be necessary to carry out a programme of barley growing experiments and malting tests. If these prove successful there should be no technical obstacles to the project.

From a purely financial standpoint the project must be regarded as marginal since the rate of return, evaluated on a discounted cash flow basis, is less than 12 per cent even with the help of a government low-interest loan. This is not likely to appeal to private investors. However, the brewery at Gisenyi might be interested because of a 10 per cent reduction in the price of malt that could follow from the project.

There can be no question, however, that the project is an extremely attractive proposition from the standpoint of the Rwanda economy. By enlarging the cash income of farmers and by saving foreign exchange, it strikes directly at the two main obstacles to economic development. Therefore, if the essential support of the brewery cannot be obtained by the inducement of a 10 per cent price reduction and a 12 per cent return on capital, it would be well worth the government's while to offer substantial additional incentives to the brewery.

## 1. MARKET STUDY

### 1.1 The Economic Background

The proposal to establish a maltings in Rwanda which would use locally-produced barley as its raw material and which would sell its output of malt to a locally-established brewery must be viewed against the general economic features of Rwanda.

There are no official estimates of Gross Domestic Product in Rwanda available on a historic basis but the following table gives data for 1967 and 1968 obtained from Government sources.

**Table 1.I - GDP by Sector 1967 and 1968**
**(FRw millions at constant prices)**

| | 1967 | % | 1968 | % |
|---|---|---|---|---|
| **Primary sector** | 10,087.9 | 68.4 | 9,776.1 | 64.9 |
| Subsistence agriculture | 7,944.5 | 54.0 | 7,557.2 | 50.2 |
| Cash Crops | 654.0 | 4.4 | 696.8 | 4.6 |
| Livestock and Fishing | 1,100.1 | 7.4 | 1,158.7 | 7.7 |
| Mining | 389.0 | 2.6 | 363.4 | 2.4 |
| **Secondary sector** | 1,127.5 | 7.6 | 1,330.1 | 8.9 |
| Construction | 600.0 | 4.1 | 730.0 | 4.9 |
| Industry (including power) | 527.5 | 3.5 | 600.1 | 4.0 |
| **Tertiary sector** | 3,535.0 | 24.0 | 3,928.0 | 26.2 |
| Government | 1,600.0 | 10.9 | 1,800.0 | 12.0 |
| Commerce | 1,240.0 | 8.4 | 1,365.0 | 9.1 |
| Transport | 165.0 | 1.1 | 183.0 | 1.2 |
| Other | 530.0 | 3.6 | 580.0 | 3.9 |
| **TOTAL** | 14,750.4 | 100.0 | 15,034.2 | 100.0 |

Thus during 1968 the GDP rose by 1.9 per cent in real terms. Population, however, is increasing at an annual rate of 3.1 per cent so that the per capita GDP fell by 1.2 per cent. Slightly different estimates of the growth of GDP have been obtained from an international source. These are given in Table 1.II.

**Table 1.II - Estimates of the Growth of GDP 1966-1970**

(constant prices)

| Year | GDP in FRw million | % Growth in GDP(1) | % Per Capita Growth (2) |
|---|---|---|---|
| 1966 | 13,394 | n.a. | n.a. |
| 1967 | 15,220 | 13.6 | 10.5 |
| 1968 | 15,514 | 1.9 | -1.2 |
| 1969 | 15,747 | 1.5 | -1.6 |
| 1970 | 17,636 | 12.0 | 8.9 |

Notes (1) Over previous year

(2) Assuming average 3.1 per cent population growth

Generally speaking these major fluctuations in growth follow changing climatic and market conditions in relation to the agricultural sector. Following substantial growth in 1967, there were two years during which per capita real incomes declined before the exceptional coffee and tea harvests of 1970 brought a further large growth in incomes.

Despite the incomplete nature of the available statistical data, some important features of the Rwanda economy are evident. Firstly, per capita income works out at only about FRw 5,000 per annum ($50) and over half of this originates in the subsistence sector. Secondly there is clearly very little prospect of long-term stable economic growth unless increasing numbers of people can be transferred from the subsistence to the cash economy every year. This is, in fact, the principal aim of government policy. The idea of encouraging farmers to grow barley for malting in a local plant is in line with this aim. If it proves feasible, it would expand the cash income of farmers on a secure basis, while the maltings itself would increase the currently negligible contribution of the industrial sector to the GDP.

In addition to the existence of a large subsistence economy, another obstacle to development in Rwanda is the balance of payments constraint. The following table gives details over the period 1968-1970.

**Table 1.III** - **Balance of Payments 1968-1970 (FRw millions)**

| | 1968 | 1969 | 1970 |
|---|---|---|---|
| Exports | 1,613.4 | 1,504.3 | 2,458.2 |
| Private Imports | -1,427.3 | -1,565.2 | -1,937.7 |
| Government Imports | - 204.0 | - 146.1 | - 177.1 |
| Freight and Insurance | - 424.8 | - 496.9 | - 422.9 |
| Trade Balance | - 442.7 | - 703.9 | - 79.5 |
| Private Transfers | + 186.1 | + 401.0 | + 187.7 |
| Aid Transfers and Government Operations | + 226.1 | + 170.2 | + 380.6 |
| Other Services | - 104.9 | - 62.5 | - 73.2 |
| IMF Credit Standby | + 100.0 | - 100.0 | - 100.0 |
| Special Drawing Rights | - | - | + 252.0 |
| Miscellaneous | + 4.3 | + 8.3 | - 2.7 |
| Bank Notes | + 8.4 | + 3.2 | + 11.9 |
| Errors and Omissions | - 3.6 | - 4.2 | - 13.5 |
| Change in Gross Reserves | - 26.3 | - 287.9 | + 590.3 |
| Change in Debt | - 17.4 | 98.1 | - 161.9 |
| Change in Net Reserves | - 43.7 | - 189.8 | + 428.4 |

Source: Situation Économique.

This shows that Rwanda has, at any rate in recent years, had a substantial trade deficit. There was even a small deficit during the exceptionally favourable conditions of 1970. The deficit has been offset to some extent by a capital inflow from abroad by private investors, governments and aid-giving bodies. Without this inflow of capital Rwanda would be unable to sustain even its present low level of incomes. Besides filling a foreign exchange gap the capital inflow also provides most of the savings available to finance development in the Rwandan economy. Table 1.IV illustrates the extent of this. It will be noted that over half of all investment funds in Rwanda come from the foreign sector and that this relationship has been remarkably consistent over the three years concerned.

**Table 1.IV** - Source of Investment Funds in Rwanda (FRw millions)

| | 1966 | 1967 | 1968 |
|---|---|---|---|
| Official Foreign Sector | 418.0 | 546.5 | 569.2 |
| Private Foreign Sector | 260.6 | 273.0 | 297.6 |
| Domestic Public Sector | 94.9 | 65.1 | 81.4 |
| Domestic Private Sector | 336.8 | 413.5 | 464.5 |
| Labour Contribution | 115.4 | 155.8 | 212.1 |
| Total | 1,225.8 | 1,453.9 | 1,624.8 |
| % Foreign | 55.4 | 56.3 | 53.4 |

An easing of the balance of payments constraint would permit a higher rate of capital inflow, a higher level of investment and thus an improvement in growth prospects. To achieve this the government has made considerable efforts in recent years to expand the production of export crops. The following table shows the growth in exports of certain of these crops over the period 1966-1970. There was no change in producer prices for coffee and tea, the most important of the crops. It can be seen that there was a substantial rise in cash income from these crops over this period.

Table 1.V - Growth in Exports of Cash Crops 1966-1970 (metric tons)

| | 1966 | 1967 | 1968 | 1969 | 1970 |
|---|---|---|---|---|---|
| Coffee | 8,738 | 10,127 | 12,054 | 11,893 | 14,729 |
| Tea | 324 | 322 | 635 | 944 | 1,268 |
| Pyrethrum | 417 | 458 | 291 | 574 | 419 |
| Dry skins | 271 | 522 | 316 | 609 | 688 |

The proposal to produce malt from locally-grown barley would reinforce the efforts that have been made to ease the balance of payments constraint in other sectors because all malt in Rwanda is currently imported. Any exports of malt would, of course, further ease the balance of payments. It is thus evident that the present project is orientated towards easing the major existing problems in the Rwanda economy, namely the expansion of cash incomes and the saving of foreign exchange.

## 1.2 Internal Demand for Malt

### 1.21 Demand for Brewing Purposes

Malt is at present used in Rwanda solely for brewing and it is likely that this will continue to be the case during the coming five year period. The country contains one brewery, the Bralirwa brewery in Gisenyi, owned by Interbra, a company which also owns breweries in Bukavu in the Congo and Bujumbura in Burundi. In 1970 the Gisenyi brewery consumed 1,530 metric tons of malt. The average price of this malt has been obtained from Rwanda's trade statistics and is given in Table 1.VI below.

Table 1.VI - Price of Malt in Rwanda 1967-1970

| | Quantity Imported (metric tons) | Cost of Imports (FRw 000's) | Price (1) (FRw per kilo) |
|---|---|---|---|
| 1967 | 1,396.1 | 37,439 | 26.8 |
| 1968 | 1,142.4 | 30,706 | 26.9 |
| 1969 | 1,303.2 | 32,209 | 24.7 |
| 1970 | n.a. | n.a. | 27.0 |

Note(1) Valued c.i.f. Rwanda border, except 1970 price is delivered Gisenyi.

Source: 1967-1969 Bulletin de Statistique
1970 Gisenyi Brewery.

Apart from 1969 when the price fell to FRw 24.70 per kilo, the average annual price has been around FRw 27.00 per kilo.. The brewery has no regular supplier the malt being purchased from various European maltings normally in fairly small quantities.

Malt beer is only consumed by a small minority of the population of Rwanda. The total consumption in 1970 for instance was only 143,000 hectolitres compared with an estimated consumption of 2,460,000 hectolitres of the traditional sorghum beer which is normally made within each household from home-produced sorghum. A major constraint on sales of malt beer in a country with such low cash incomes as Rwanda is the price. At present the normal ex-factory price of malt beer is FRw 25 per bottle (72 centilitres) and the selling price is FRw 30 per bottle. Consequently regular sales are thought to be largely confined to the 65,000 in paid employment although sharp seasonal fluctuations indicate substantial sales to the rural sector at the times of the principal harvests when cash income is at its height. A certain amount of Rwandan beer is thought to be consumed in neighbouring countries but there have been no official exports since the mid 1960s.

Of the present price of barley malt beer no less than FRw12.95 represents tax. Obviously any large changes would have a substantial effect on demand. However, tax from beer accounts for an appreciable proportion of government revenues (no less than 15 per cent in 1968) and it is therefore most unlikely that there will be any substantial reduction in the rate of taxation. There might conceivably be some increase but the tax has remained the same for some time and for the purposes of this analysis it is assumed that there will be no change during the period under review.

On this basis, the brewery is expecting an average annual increase in the demand for malt beer of some 7 per cent in the next five year period. This growth would be well within the potential of the brewery's existing plant because, although it is working at nominal capacity, output could easily be increased by up to 50 per cent by the purchase of relatively inexpensive capital equipment. However the brewery's forecast seems optimistic since between 1966 and 1970 demand for beer rose by only 17.6 per cent - or an average of 4.1 per cent annually. Table 1.VII shows changes in the consumption of beer and consequently of malt over this period and compares this with other economic indicators. It will be noted that GDP rose by 31 per cent, substantially faster than beer consumption.

Table 1.VII - Changes in Demand for Beer and Changes in Selected Economic Indicators

| | Production of Beer (bottle of 0.72 litres) | Consumption of malt (tons) | Exports Coffee (tons) | Exports Tea (tons) | Estimate of GDP (FRw millions) |
|---|---|---|---|---|---|
| 1966 | 16,661,000 | 1,315 | 8,738 | 324 | 13,394 |
| 1967 | 16,446,000 | 1,278 | 10,127 | 222 | 15,220 |
| 1968 | 17,148,000 | 1,380 | 12,055 | 635 | 15,514 |
| 1969 | 17,134,000 | 1,358 | 11,894 | 944 | 15,747 |
| 1970 | 19,860,000 | 1,547 | 14,729 | 1,268 | 17,636 |

In the next five years the Rwanda government is anticipating a rate of growth comparable to that achieved in the last five years, and, ceteris paribus, this must tend to limit domestic sales of beer to the rate of growth established in the past. Owing to high import duties imposed on imported beer in the Congo, Burundi, Tanzania and Uganda, there are unlikely to be any significant export markets for Rwandan beer.

Provided that barley malt beer continues to be made in precisely the same way as at present, a projection based on the continuation of the 1966-1970 trends gives a 1976 market of 2,000 metric tons of malt growing at 4.1 per cent annually thereafter. It must be mentioned at this point that the quantity of malt used to produce a given amount of beer can be varied by the brewery to give stronger or weaker beers. Any changes in brewing policy would invalidate the above projection. There are, however, no plans known to the consultants for changes of this nature and our forecast is based on this.

It should also be mentioned that there is an alternative to the use of malt in brewing, namely the direct conversion of barley to wort by extraneous enzymes. This could prove more attractive to Rwanda in the long-term since it eliminates the highly capital-intensive malting process while preserving the demand for barley and all that that means for the growth of cash incomes and the saving of foreign exchange. Detailed study of the feasibility of this process and its likely cost in Rwandan conditions is outside the scope of the present study. In addition this process is known to have effects on the taste of the beer, the acceptability of which to the Rwandan consumer is at present unknown. We feel, however, that it is worth drawing attention to this because, should the brewery decide to adopt such a process, it would almost entirely eliminate the demand for malt.

### 1.22 Demand for Other Purposes

In Europe malt flour is used to improve the baking qualities of wheat flour and there is a substantial demand for malt extract in the confectionery, soft drinks and pharmaceutical industries. However, there is little possibility of developing any significant sales for such purposes in Rwanda.

There is a local miller who in 1970 produced 2,600 tons of wheat flour mostly using imported grain. Even were he to substitute malt flour for the artificial additives at present used the normal proportions are 0.1 per cent of malt flour to 99.9 per cent of wheat flour so that the total demand would amount to only 2.6 tons. There are plans for expanding production of flour but on the assumptions that demand for flour in Rwanda will rise at the same rate as in the past few years and that by 1976 all wheat will be milled locally the total demand for malt flour would not exceed 10 tons per year.

The production of malt extract would necessitate the building of a special malt extract plant which could only be justified by the existence of a substantial local market. There is at present no market for malt extract and the limited possibilities can be illustrated by the demand in the nearby East African market. In this whole area which contains 30.9 million people compared with Rwandas 3.4 million and with a higher per capita GDP the total demand for malt extract amounted to only 2 tons in 1970. The only potential for malt extract would be for cough mixtures in the projected pharmaceutical plant but the demand for extract for this purpose would be minuscule.

1.3 Export Potential for Malt

The export potential for Rwandan malt is limited by Rwanda's geographic position and the high cost of transport to neighbouring markets. The closest breweries are at Bujumbura in Burundi, Bukavu in the Congo and Jinja and Kampala in Uganda. There is also a distillery in Kampala which uses malt for the production of whisky. All these plants are at present dependent upon imports to satisfy their needs. Estimates of the total demand for malt are given in the table overleaf. The Uganda figure is derived from the 1970 trade statistics, Bujumbura from the figures of production of beer in 1970. There are no recent figures for Bukavu and the demand has had to be calculated from the estimated consumption of malt in 1967.

**Table 1.VIII** - Estimated Demand for Malt in Neighbouring Countries, 1970

| | Metric Tons |
|---|---|
| Bujumbura (Burundi) | 2,500 |
| Bukavu (Congo) | 2,500 |
| Jinja and Kampala (Uganda) | 1,900 |
| TOTAL | 6,900 |

It is not possible to make any realistic comments on the potential changes in the demand for malt in these countries over the next five year period. There is a project for the establishment of a maltings in Bujumbura and the Bukavu maltings may also be rebuilt during the early 1970s. However, the establishment of a malting industry in these countries is likely to encounter the same difficulties as those faced in Rwanda and detailed in section 2 following. The demand for imported malt has actually fallen in Uganda over the past few years. The fall in demand was partially due to an increase in general taxation in 1968 and 1969. We consider that demand will start to rise again in the early 1970s. The extent to which Rwanda will be able to exploit the market potential will depend on the quality and price competitiveness of its malt compared with malt from other sources. Prices at which malt is bought at each brewery are not readily obtainable and world prices also vary very sharply from year to year. Table 1.IX, however, shows the average prices of malt in certain periods during the past two years as given in the trade statistics of each country. Some indication of the total cost of malt from the present sources can then be obtained by adding estimated costs from border of country to the brewery. The table also gives the cost of transporting malt from Ruhengeri to each of the destinations as given by a Rwandan road haulage company. Our calculations, detailed in section 4.5, show that the marginal cost of producing malt in Rwanda is about FRw 17 per kilo. Supposing that a minimum price for exported malt is 10 per cent above marginal cost, the ex-factory price for export malt would be FRw 18.70 per kilo. At this price Rwandan malt is competitive with the present sources of supply.

Table 1.IX - Price Competitiveness of Rwandan Malt

| (FRw per kilo) | Uganda | Burundi | Congo(Bukavu) |
|---|---|---|---|
| European Malts c.i.f. port of entry | 1969 14.6*<br>1970 27.5* | 1969 21.1 | 1969 16.8 |
| Transport from port of entry to brewery | 5.0* | 2.2 | 7.0 |
| European Malts delivered price | 1969 19.6<br>1970 32.5 | 1969 23.3 | 1969 23.8 |
| Rwandan Malts Export selling price | 18.7 | 18.7 | 18.7 |
| Transport from Ruhengeri to Brewery | 1.8 | 3.6 | 2.2 |
| Rwandan Malts delivered price | 20.5 | 22.3 | 20.9 |

Note: * Ugandan prices are given c.i.f. Mombasa and internal transport costs including journeys from Mombasa to brewery.

Although there appears to be some prospects for exports on the basis of marginal cost pricing, the extent of the likely market can only be regarded as uncertain, particularly in view of known malting projects in Burundi and the previous existence of maltings in the Congo which may be reconstructed. Our conclusion is, therefore, that while exports cannot be ruled out, the project must justify itself on the basis of the internal market alone. Any export sales should be considered a windfall gain.

## 1.4 Recommended Capacity of Proposed Maltings

Since export sales cannot be counted on, the effective market for Rwandan malt is given by the likely demand from the Rwandan brewing industry. This is expected to reach an annual 2,000 metric tons by the middle 1970s, and since a viable plant can be designed for this level of output, we recommend that this should be the initial capacity of the proposed maltings. The production of 2,000 metric tons of malt at 3 per cent moisture will require a supply of 2,678 metric tons of barley at 20 per cent moisture.

A plant of the capacity envisaged would, in fact, probably be able to produce up to 3,000 tons per annum with no major additional capital expenditure. Thus the proposed maltings would be able to take advantage, subject to the production of sufficient barley, of any windfall export opportunities.

There will only be one Rwandan customer for the malt, namely the brewery at Gisenyi. Thus any malt produced will have to be acceptable to this consumer. There can be no question of accepting any imports of malt once the maltings is set up, so that the brewery will have to be induced to make a long-term commitment to the local maltings. One way of ensuring that this occurs would be for the brewery to have a financial stake in the maltings. This is discussed in greater detail in section 4.53.

## 2. ASSESSMENT OF RAW MATERIAL

### 2.1 Production of Barley - Past, Present and Future

The main barley growing area of Rwanda is located in the northern part of the country near Byumba. The grain is grown on a multiplicity of small plots estimated by the Ministère de l'Agriculture et de l'Elevage to number about 5,000. Generally speaking, these are situated in elevated positions on precipitously sloping ground. Only one crop a year is produced. The seed is sown in March-April and harvesting takes place in August-September.

In the years prior to and including 1967, the crop was purchased partly by the local community for use as an adjunct in the preparation of sorghum beer (ikigage and amarwa) and partly by Intebra, owners of the brewery at Gisenyi, who shipped the grain across Lake Kivu for malting in a Saladin plant and subsequent use in the second brewery at Bukavu in the Congo. This pattern of disposal of the grain continued until 1967 when the maltings at Bukavu was destroyed.
The demand for barley thus ceased abruptly and from a record crop of 2,197 metric tons in 1967, the production of barley fell to a mere 163 metric tons in 1968 sold exclusively for local use. In 1969, there was a slight recovery to 288 metric tons, 54 per cent of which was purchased by the brewery, the remainder, as before, going to the local market. Table 2.I gives the production of barley over the period 1956-1969.

No figures are available for 1970 or 1971. Indeed, as far as the present season is concerned, it is impossible to say how much land has been put down to barley, and officials of the Ministère de l'Agriculture et de l'Elevage were unable to give us any precise idea where the crop was being grown. Neither was there any information available on the stocks of seed at present held. There are no official future plans for the production of barley, except for those which may emerge from the implementation of this report.

Table 2.I - Production of Barley in Rwanda 1956-1969

| Year | Area under cultivation (hectares) | Production (metric tons) |
|---|---|---|
| 1956 | - | 619 |
| 1957 | - | 1,648 |
| 1958 | - | 1,490 |
| 1959 | - | 1,425 |
| 1960 | - | 1,000 |
| 1961 | - | 307 |
| 1962 | - | 275 |
| 1963 | - | 293 |
| 1964 | - | 939 |
| 1965 | - | 1,163 |
| 1966 | 752 | 750 |
| 1967 | 1,890 | 2,197 |
| 1968 | 192 | 163 |
| 1969 | 333 | 288 |

Source: Bulletins Statistiques No. 15/1967, 16/1968 and 27/1970.

It should be noted that much of the land originally laid down to barley is currently being used for wheat, the price of which is approximately the same as that of barley (8 francs per kilogram), but the yield of which is only about 0.7 to 0.8 metric tons per hectare compared to 0.9-1.0 metric tons per hectare for barley. Thus there appears to be a reasonable incentive for farmers to return to the growing of barley, though, in the opinion of officials of the Ministère de l'Agriculture it would probably be impracticable to extend production much beyond 2,500 metric tons without opening up new areas for barley growing, in the region north of Ruhengeri, for example. (For an alternative suggestion see section 2.33).

## 2.2 Suitability of Rwandan Barley for Malting

Reference has already been made to the fact that, before the fieldwork was carried out in connection with this project, UNIDO had declared the barley of Rwanda to be of average quality for malting. This was repeated by officials of the United Nations in Rwanda, and also by officials of the Government, who argued that the grain must be suitable for conversion to malt because it had been purchased for this purpose by the maltings at Bukavu for many years prior to its closure and the resultant malts had been sold to the brewery at Bukavu. Against this, officials of the brewery claimed that the barley was of very poor malting quality and that it had in fact been necessary to mix malt made at Bukavu from Rwandan barley with at least 50 per cent of high grade malt obtained from Europe for satisfactory results in brewing. In addition they claimed that barley received at Gisenyi was often defective in so far as it was unduly damp, contaminated with mould (Fusarium) and contained a high proportion of non-viable corns. These criticisms of the grain were upheld by the International Beverages Corporation (IBECOR) of Brussels, the parent company of Interbra, who maintained that, in general, malt derived from Rwandan barley had the following undesirable features: an extract of less than 79 per cent; too high a level of protein; a saccharification time greater than 15 minutes (see section 3.13.4) and it gave rise to an opalescent wort (see section 3.14.9). IBECOR also claimed that in brewing with Rwandan malt difficulties were experienced in the filtration of the resultant beer, which was unstable with regard to the formation of haze (see section 2.31.2) and had a pronounced flavour of straw. To support their claims, IBECOR provided analytical data for three malts actually made from Rwandan barley at Bukavu in 1960. This is given in Table 2.II.

Table 2.II - Analyses of Commercial Malts Made From Rwandan Barley in Bukavu (1960)

| | | Malt Sample Number | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Moisture | % | 5.9 | 6.9 | 10.5 |
| Extract (fine grind) | % | 77.1 | 77.2 | 81.3 |
| Total Protein | % | 12.1 | 11.9 | 10.7 |
| Kolbach Index | % | 29.0 | 31.0 | 41.0 |
| Colour | EBC | 2.7 | 2.3 | 3.3 |
| Saccharification time | min. | 10.0 | 10.0 | 15.0 |

Source: International Beverages Corporation. Analyses carried out by Heineken's Bierbrouwerij Maatschappij NV

It can be seen that samples 1 and 2 gave relatively low extracts and low Kolbach indices. They were therefore clearly much under-modified and for this reason one would expect them to have given problems in brewing. This does not however, necessarily mean that the barley from which the malts were derived was of poor malting quality; rather, it may indicate that the malting of the grain was itself inadequate. With regard to the protein contents of these malts certainly these are higher than the brewery ideally requires but the results are of little importance when considered in relation to the obvious degree of undermodification of the samples. Sample 3 gave a good extract and could only be faulted on its high moisture content, which merely indicates that the sample was inadequately dried at the maltings, or perhaps was exposed o excessively humid conditions for a prolonged period before analysis.

A second set of analyses was provided by the brewery at Gisenyi. These are shown in Table 2.III and refer to samples of barley collected from three different growing areas, probably during the 1967 harvest as the analyses were carried out in February 1968.

Table 2.III - Analyses of Rwandan Barley from 1967 Season

| Growing Area | Mumba | Ufamando | Gungo |
|---|---|---|---|
| Moisture | 15.9 | 15.0 | 15.9 |
| Total Protein | 14.8 | 14.1 | 14.8 |
| 1000 Corn Weight | 35.6 | 38.3 | 35.6 |
| Assortment 2.8mm | 56.6 | 62.7 | 55.9 |
| 2.5mm | 25.8 | 22.4 | 26.0 |
| 2.2mm | 11.9 | 10.3 | 12.0 |
| under 2.2mm | 5.5 | 4.5 | 6.0 |
| Germinative Capacity | 89.0 | 90.0 | 91.0 |
| Germinative Energy | 82.0 | 83.0 | 84.0 |

It can be seen from this table that each of the samples had a germinative capacity well below the normally accepted minimum level of 95 per cent (see Section 2.31.1). But here again it is not reasonable to condemn the barley for malting on this evidence, which, as it is most unusual to find barley dead in the ear of the plant probably indicates that the grain was mishandled after harvest. It is a fact that the protein contents of these barleys were high compared with levels the brewery would expect in barley as normally selected for malting in Europe, but brewers are capable of handling malt made from high protein grain. This has become clear in Europe during the present year when brewers have often been obliged to accept malt made from barley with protein contents in the region of 13 per cent and have continued to brew normal beer without any particular difficulties.

A further set of results, given in Table 2.IV was obtained from the agricultural station at Byumba. It refers to barley of unknown variety collected from three different growing regions during 1954.

Table 2.IV - Analyses of Barleys and Derived Malts, from Three Different Regions of Rwanda (1955)

| | | Region | | |
|---|---|---|---|---|
| Sample Number | | Buhita 1 | Mariyajiro 2 | Kivuye 3 |
| **Barley Analysis** | | | | |
| Germinative Capacity | % | 98.0 | 99.0 | 98.0 |
| Germinative Energy | % | 98.0 | 99.0 | 96.0 |
| Moisture | % | 11.8 | 11.6 | 12.0 |
| Total Protein (d.m.) | % | 10.9 | 12.1 | 12.7 |
| 1000 corn weight | % | 27.6 | 32.3 | 36.6 |
| **Malt Analysis** | | | | |
| Extract (fine) | % | 79.1 | 78.7 | 78.6 |

Source: De Clerck 16.4.55, Belgium.

These samples were all fully viable and yielded, after malting, extracts approaching the 80 per cent level normally demanded in brewery specifications (see section 3.14.2). The protein contents of the malts were again high but not excessively so.

To conclude, it appears that under some circumstances Rwandan barley can give rise to malt of acceptable quality and that if, in the past, such quality has not been achieved it has been due either to mishandling of the barley after harvest or inadequately controlled malting. It must, however, be admitted that relatively little information on the subject of malt quality was available to us and that our conclusion is therefore subject to some uncertainty. What is urgently required is a proper assessment of the real potential of Rwandan barley for malting. This should be undertaken by an independent organisation on behalf of the Rwandan Government. This proposal is described in greater detail in section 2.4.

## 2.3 Methods of Improving Quality and Yield of Barley

### 2.31 Desired Quality of Barley

The quality of malt for brewing is determined basically by the quality of the barley from which it is made. The more important properties of the raw grain which must be considered in this connection are as follows:

2.31.1 Germinative Capacity As the changes associated with the conversion of barley to malt cannot occur without growth, it is vital that the germinative capacity of the grain should have a minimum value of 95 per cent. Thus before barley is accepted for malting it is usual to measure the percentage of viable corns by a simple staining procedure (see section 3.41.7B).

2.31.2 Protein Content In brewing, too low a level of protein in the malt can lead to problems associated with inadequate growth of yeast, and thus to poor fermentation, and also to poor head retention in the final beer (i.e. to a weak, unstable foam). On the other hand, if the protein content of the malt is too high the resultant beer will tend to throw an objectionable haze during storage, particularly in the cold. In addition the higher the protein content of a malt the lower will be its content of carbohydrate material on which the yield of alcohol depends in the fermentation process. Thus since the percentage protein of malt is dependent on the original protein content of the barley from which it is made, the latter must be measured carefully before barley is purchased by a maltings. The optimum level depends to some extent on the type of beer which is to be brewed, but for the beer of the kind made in Rwanda it would be in the region of 10-12 per cent. Thus before a sample of barley is purchased for malting it is desirable to obtain an approximate assessment of its content of protein. This is usually done by means of a standard Kjeldahl procedure or by a colorimetric technique (see sections 3.41.11 and 3.41.11B).

2.31.3 Assortment Small barley corns give rise to malt which is relatively low in extract and must be discarded. Before acceptance for malting, therefore, the grain is passed through a series of sieves, with the following mesh sizes, 2.8, 2.5 and 2.2mm. At least 80 per cent of the corns should fall into the first two categories. If more than 5-6 per cent of the corns pass through the smallest sieve the barley is usually rejected. A simple procedure to measure the percentage corns which fall into these various categories, the assortment, is described in section 3.41.3).

2.31.4 Moisture Content In order to evaluate the protein content etc. of barley on a dry basis

it is necessary to measure the moisture content of the grain. This can be done with a standard moisture meter (see section 3.41.10B). Generally speaking grain with a moisture level of above about 23 per cent is not normally accepted.for malting.

2.31.5 Thousand-corn Weight The weight of 1000 corns of barley should be between 35 and 45 grams on a dry basis. In general the extract obtainable from malt increases with increasing values of the thousand-corn weight of the barley from which it is derived. Thus the value of a barley for malting is the greater the higher this particular property of the grain.

2.31.6 Soundness The barley should not be broken or split as the valuable starchy endosperm may be lost during malting. Further, the presence of corns which are damaged is undesirable as they tend to become mouldy during malting and hence spoil the malt. Split corns often occur when the rainfall is high near the time of harvest.

2.31.7 Odour A mouldy or musty smell is a sign that the barley has been stored under damp conditions. Such grain is liable to give poor results in malting.

2.31.8 Colour The grain should be bright in appearance and show no signs of staining which indicates microflora damage and can easily lead to poor malting.

2.31.9 Steeliness Barley which is steely can be recognised by the greyish, glossy appearance of the endosperm (see Fig.4) of individual corns. Such barley, which is frequently associated with a high level of protein in the grain, is often difficult to malt in comparison with non-steely barley and should be avoided if possible. A technique for assessing steeliness is described in section 3.41.6).

2.31.10 Pre-Germination The corns of barley are liable to begin to grow in the ear if the grain, having matured in the field, is subjected to wet conditions before it can be harvested. The presence of such pre-germinated corns in an otherwise sound parcel of barley is undesirable because their capacity to germinate falls off rapidly during storage and because they soon die under the conditions of steeping required to promote the germination of normal corns. If more than 5 per cent of these corns are present in the barley, the sample is not suitable for malting.

2.31.11 Foreign Seeds Barley should not contain more than 1 per cent of foreign seeds or 0.5 per cent of awns as these have no malting value.

2.31.12 Uniformity In malting, for best results the conditions of processing must be adjusted to suit the properties of the barley. It is therefore important when a substantial quantity of barley is to be malted at one time, as is normal in malting plants, that there should be as little variation as possible in the physical and germination characteristics of the sample.

2.32 Recommended Programme to Achieve Required Quality

With the foregoing background on what are the desirable properties of malting barley consideration may now be given to the steps which need to be taken to improve the malting quality of Rwandan barley. It must be stressed, however, that very little information was available to us regarding conditions of harvesting etc. and we were only able to obtain one sample of immature barley for examination.

Firstly, there is no control at present over the conditions of drying the grain from which the moisture is removed by spreading it out in the sun. Neither is the moisture content of the grain measured before or after the drying process. Further there is no recommended procedure for storage of dried grain. This is clearly unsatisfactory and lends support to claims, made by officials of the brewery, with regard to the receipt at Gisenyi of damp and mould contaminated samples.

One of the first steps which ought therefore to be taken by the Ministère de l'Agriculture et de l'Elevage before any programme of malting can be successfully launched is to emphasise to the farming community the importance of drying the grain down to a low level of moisture (12 per cent) before placing it in storage. Alternatively, and probably a better solution, would be for all barley to be delivered to a central depot immediately after harvesting where rapid tests could be made for the germinative capacity of the grain, its moisture content and its nitrogen content. The weight of the grain would also be measured at the same time to establish the buying price for the sample. At the depot the grain would be sacked off and quickly transported to the maltings for drying. In this way it should be possible to ensure that sound barley was not allowed to spoil between harvesting and drying. It would also be possible for samples of grain to be drawn from the various growing areas for a detailed examination of their physical, germinative and chemical properties as outlined in section 2.31 above and thereby to determine their suitability for malting. This information would gradually lead to an identification of the most favourable locations for growing and show up those areas where help was most urgently required to improve growing techniques.

Secondly, to achieve an optimum level of protein poses a complex problem chiefly related to the conditions of soil and climate but strongly influenced by other factors such as time of sowing, previous crop, variety etc. We recommend that the Ministère de l'Agriculture et de l'Elevage extends the services of the Byumba agricultural station to include an additional agronomist. He should have specialised knowledge in the area of barley and should study the problem in depth. He should analyse statistically the results obtained over a number of years from the experimental acreages of barley which we recommend should be grown. (see section 2.11)

As far as the use of different varieties of barley in relation to the levels of grain protein laid down is concerned, it would be well worthwhile initially in order to locate suitable samples for study, to seek advice on this from the

Barley Committee of the European Brewery Convention.*

2.33 The Yield of Barley

The yields of barley in Rwanda are, under present methods of cultivation, usually in the region of 0.9-1.0 metric tons per hectare which is somewhat lower than the yields of 2.5 metric tons per hectare obtainable in Kenya** and substantially below the yields of 4 metric tons per hectare commonly produced in Europe.

Some yield improvement trials have been carried out in Rwanda. For example, some trials undertaken near Byumba in the early sixties revealed that the yield of grain could be increased from 1.150 to 2.257 kg/ha by raising the sowing rate from 70 to 100 kg/ha. This is illustrated in Table 2.V.

Table 2.V - Variation in Yield of Barley With Rate of Sowing

| Barley Variety | Rate of Sowing (kg/ha) | Yield (kg/ha) |
|---|---|---|
| Kenia | 70 | 1.150 |
| Research | 80 | 1.172 |
| Glacier | 90 | 1.156 |
| Germain | 100 | 2.257 |

Source: Ministère de l'Agriculture et de l'Élevage.

Further small-scale trials had been carried out in 1967, 1968 and 1969, of which only those carried out in 1967 were really successful, a yield as high as 2.589 kg/ha being recorded for the variety Research. The full results are given in Table 2.VI.

Table 2.VI - Yields of Barleys from Trial Plots, 1967/68

| Barley Variety | Yield kg/ha |
|---|---|
| Research | 2.589 |
| Sabsum | 2.500 |
| Gena | 2.411 |
| 4.229-1-12 | 2.054 |

Notes: Seed Density - 100 kg/ha
Sowing - 31 Oct.67
Harvest - 27 Mar.68
Plot Size - 28m²
Station - Rwerere

Source: Rapport Annuel 1968. Institute des Sciences Agronomiques du Rwanda.



*Correspondence should be addressed in the first instance to the Chairman, Ir. W. Wilten, c/o NIBEM-TNO, Polderstraat 10, Rotterdam 25, Holland.

**Information from National Institute of Agricultural Botany, Cambridge, England.

It is of interest to note that the 1968 series gave disastrous results owing to a dry season, whilst those of 1969 gave mostly poor results due to bad soil conditions. Details of the 1969 trials are given in Table 2.VII.

Table 2.VII - Yields of Barleys from Trial Plots, 1969

| Barley Variety | Yield kg/ha |
|---|---|
| 1. 4.229-1-12 | 2.012 |
| 2. Gerste kork perle | 1.387 |
| 3. Sommergerste fresia | 1.225 |
| 4. Sabsum | 1.012 |
| 5. Research | 0.960 |
| 6. Gerste-starkness | 0.887 |
| 7. Gena | 0.512 |
| 8. Brevia | 0.225 |
| 9. Wisa | 0.100 |
| 10. Union | 0.037 |

Notes: Seed Density - 100 kg/ha
Sowing - 15 Apr.70
Harvest - 19 Sept.70
Plot size - 8m$^2$

Source: Rapports Annuel 1970 Institute des Sciences Agronomiques du Rwanda (unpublished)

The Director of ISAR (Institute des Sciences Agronomiques du Rwanda) though clearly of the opinion that such studies were of fundamental importance as a means to the improvement of yields, expressed his concern that they were not at present being carried out under sufficiently controlled conditions and stated that in his view there must be some doubt about the accuracy of the results presented in Tables 2.VI and 2.VII.

A possible way to increase the production of barley from a given area in any one year would be to grow two crops, which is the present practice with wheat. This was apparently tried with barley in earlier years but the idea was abandoned due to heavy incidence of pre-germination in the October-March crop. Pre-germination is, however, a varietal dependent characteristic of the grain. It would therefore be worthwhile to obtain a selection of barleys known to be well adapted to resist pre-germination and to set up a series of trials to find a variety suited to the conditions of the October-March growing season.. Here again, in locating such barleys it might be helpful to seek the advice of the Barley Committee of the European Brewery Convention.

Finally one further aspect of barley production which touches on both quality and yield should be mentioned. It is understood that 6-7,000 hectares of what is at present marsh land are currently being recovered in the barley growing area. This land is ear-marked for livestock farming and subsistence crops but only 5-6,000 hectares will actually be required for this purpose. It is, therefore, well worthwhile to consider setting aside part of the remaining land for the growing of barley. This would allow a degree of control over the yield and quality of the grain which cannot easily be achieved under present circumstances and is a scheme which would certainly recommend itself to the brewery if they are to accept reliance on home-produced supplies of their major raw material.

## 2.4 Recommended Tests to be Carried out on Barley

From the above discussion it is apparent that there is a marked lack of information on the malting quality of Rwandan barley and that such information as is available has been produced by the brewery to show that locally grown grain is in fact unsuitable for malting. It is therefore quite clear that before a malting project can be undertaken with any confidence of success, or indeed before any firm calculations of the real value, in brewing terms, of malt made from Rwandan barley can be made, it will be necessary to carry out a detailed series of tests. Our proposals in this respect are as follows:

i) collect 10 average samples of barley from 10 well distributed growing areas at the time of harvest. This should be done under the supervision of a responsible representative of the Ministère de l'Agriculture et de l'Elevage, who would at each location periodically note the condition of the grain in relation to the incidence of disease, length of straw, broken straws, tillering, staining and pre-germination. This representative would also make observations with regard to climate variations during the growing period, soil conditions and yields of grain, taking particular note of variations which occur in connection with the direction and slope of the plots.

ii) after harvest, measure the moisture content of the threshed grain, which should subsequently be dried in a current of warm air (not exceeding 40°C) until its moisture content has been lowered to 12-14 per cent and then stored in air-tight containers.

iii) on the dried grain, carry out the following analyses (see section 3.41).

a) immediately

<u>Germination Tests</u>

Germinative capacity
Germinative energy
Water-sensitivity

<u>Physical Tests</u>

1000-corn weight
Assortment
Broken corns
Foreign seeds
Steeliness

<u>Chemical Tests</u>

Moisture
Total nitrogen (Protein % = Nitrogen % x 6.25)

b) <u>Every 2 Weeks</u> (until germination counts have reached indicated levels)

<u>Germination Tests</u>

Germinative energy (95%)
Water sensitivity (80%)

The above tests could easily be carried out in Rwanda, probably most conveniently at the ISAR. When the barleys have emerged from dormancy i.e. the germinative energy test gives a value of 95 per cent or higher, malting trials should be carried out to observe optimum conditions of water uptake consistent with full and rapid germination and optimum conditions for fast and complete modification. Resultant malts would be analysed by standard methods of the European Brewery Convention for:

| | |
|---|---|
| Extract (fine grind) | % |
| Extract (coarse grind) | % |
| Fine grind/Coarse grind Difference | % |
| Total Protein | % |
| Soluble Protein | % |
| Kolbach Index | |
| Diastatic Power | °W-K |
| Colour | °EBC |
| Moisture | % |

The above malting trials require special technical facilities so that in the first instance it would probably be best if such tests were carried out by a laboratory already suitably equipped for and experienced in the type of work which they would involve.

The complete trials should be carried out in duplicate over a period of three years and could include a study of new varieties.

Approximately 1 kg of grain should be set aside for the barley analyses and 5 kg for malting. Thus, for one trial, the total requirement of barley would be 6 kg excluding about 1 kg of seed which would be needed for the next season's crop. Assuming a requirement of 10 kg to cover all contingencies and a yield of 1 metric ton of grain per hectare, the area of each plot should therefore be 100 sq. metres.

When the first series of trials has been completed and some idea has emerged of the best growing areas then about three of the best plots should be increased in size in the next two seasons to allow sufficient grain to be collected to permit small-scale brewing trials to be carried out on the resultant malts. It would be necessary in this case to increase the plot size to approximately 150 sq. metres.

From the knowledge gained by the above trials it should be possible to assess reasonably accurately the potential of Rwandan barley for malting and to judge the quality of the malt made from such barley in respect of its value in brewing. At this stage one would be in a strong position to decide whether or not to proceed with the malting project as envisaged prior to the present investigation.

# 3. TECHNICAL STUDY

## 3.1 Description of the Malting Process

### 3.11 General Principles

The course of events leading to the production of malt from barley by conventional means are, briefly, as follows: the grain is first steeped in water at a temperature of between $13^{o}$ and $20^{o}$C. in order to raise its moisture content to 44-46 per cent. It is then drained and allowed to germinate at $15^{o}$-$20^{o}$C. for 4-6 days in an open box at a depth of about 1m. Respiratory activity of the grain during this period results in the generation of a considerable quantity of heat. The germination box is therefore provided with a false perforated bottom through which suitably attemperated and humidified air can be passed to control the temperature and moisture content of the grain at the desired values. This passage of air also serves to remove the carbon dioxide of respiration, which if allowed to accumulate would seriously impair the normal processes of growth. The development of the grain during germination is accompanied by the formation of roots. These, unless disturbed, quickly mat together converting the bed of grain to a solid impenetrable mass. It is consequently necessary to turn the grain periodically, and for this purpose germination equipment is fitted with mechanical stirring devices, or may itself be revolved if such equipment is in the form, as it sometimes is, of an enclosed drum.

When the process of germination is complete the grain is dried down to a moisture content of 3-5 per cent. It is the final stage of the drying procedure which confers on malt its characteristic flavour and promotes the formation of colour in the product. In appearance, malt, deprived of the aforementioned roots, closely resembles barley. In texture, however, it exhibits a marked difference from the raw grain. Thus, whereas the corns of barley are hard and cannot be easily extracted with water, malt is a friable material, which is easily crushed and on digestion with water, yields, under suitable conditions, an extract containing approximately 80 per cent of its dry weight. The conversion of barley to malt, when looked at in these terms, is generally referred to as 'modification'.

The process of malting will now be discussed in more detail and considered in relation to operational practice from the stage at which the grain is delivered to the maltings to the point at which the final malt is outloaded for delivery to the brewery.

3.12 Sequence of Operations in Malting

3.12.1 Barley Intake In Rwanda the barley would probably be delivered to the maltings in sacks. It would be subjected to the following series of operations:

3.12.2 Weighing This would be done by removing the sacks from the delivery lorry and weighing the grain in batches. A more sophisticated method would be to weigh the lorry before and after unloading the grain but this is considered to be too expensive a system for the relatively small quantity of grain that is likely to pass through the maltings in any one season..

3.12.3 Sampling An average sample should be taken from each consignment of sacks. This is done by withdrawing samples from 10 per cent of the sacks by means of a sampling spear preferably of the kind which is subdivided into compartments arranged so that the spear can be inserted while closed, opened, and closed again before withdraw With more than 100 sacks the number to be sampled is given by taking the square root of the number of sacks. The well mixed samples are run through a sample divider and reduced to about 500g. This sample must immediately be transferred to a dry airtight container. It is subsequently used for:

i) a quick moisture check by means of a standard dielectric moisture meter (see section 3.41.10B),
ii) a quick measurement of the germinative capacity of the grain by means of the vitascope (see section 3.41.7B),
iii) an evaluation of nitrogen by the colourimetric procedure (see section 3.41.11B),
iv) a brief examination of the colour, odour and uniformity of the delivery.

A part of the sample would be set aside for the following more exact tests in the laboratory:

v) moisture (see section 3.41.10A),
vi) total nitrogen (see section 3.41.11A),
vii) 1000 corn weight (see section 3.41.2),
viii) assortment (see section 3.41.3),
ix) broken corns (see section 3.41.4),
x) foreign material (see section 3.41.5),
xi) steeliness (see section 3.41.6),
xii) germinative capacity (see section 3.41.7A).

3.12.4 Cleaning and Grading If possible these operations are best carried out before storage. They include removal of dust, iron and steel particles (by magnetic separator),.

stones, broken corns, and foreign seeds. When grain is passing through the cleaning machinery, small samples should be taken to check the proper functioning of the plant. The barley is graded, corns passing through the 2.2mm sieve being rejected. The latter may be used as animal fodder.

3.12.5 Drying For safe storage the grain must be dried until its moisture content has been reduced to 12-14 per cent. This is most conveniently done in the same plant as the malt is kilned. The conditions of drying are important since too high a temperature can damage the embryo (i.e. the growing part of the grain, See Fig.4), thus reducing its capacity to germinate. The maximum temperature of the 'on' air in drying is about 40°C. Apart from removing moisture from the grain, drying at this temperature has the added advantage of diminishing dormancy (see section 3.12.8).

3.12.6 Storage The barley must then be stored in silos or in one large bulk on a flat surface. In either case the grain must be properly ventilated. As a protection against insect infestation it is of utmost importance to observe good hygiene. It is essential in barley storage areas to employ a regular programme of cleaning to remove accumulations of dust, debris and spillage which will prevent the completion of the life cycle (generally a period of several weeks) of most insects found in barley (and malt) stores. It is also helpful to stack bagged grain on pallets, to keep sacks away from walls and also from sources of heat. Empty sacks returned from outside premises should be disinfected by heat or by fumigation before being reused or stored near infestible commodities. Many chemical methods of insect control are available. Of these probably contact insecticides are most suited for use in the maltings. One such insecticide which would conveniently lend itself to use in Rwanda is pyrethrum. Thus damage to bagged commodities may be largely prevented by the regular spraying of the bags with 1.3 per cent pyrethrum in technical white oil at 3 week intervals or by fogging the storage space two or three times per week. The emulsion or dust added to the grain during the filling of a silo or bin remains effective for as long as twelve months. With regard to the equipment required for application of the insecticide, for general use in the maltings a one or two gallon knapsack sprayer is probably the most suitable device

3.12.7 Transport Within Maltings It is usual to move the grain from point to point in the maltings by means of mechanical conveyors and elevators. It may alternatively be transported in sacks.

3.12.8 Testing for Dormancy Freshly harvested grain often exhibits dormancy, a condition in which the corns are slow to germinate, or perhaps will not grow during the normal period of processing, after conventional methods of steeping. Two types of dormancy are recognizable: profound dormancy and water sensitivity. In profound dormancy the grain will not grow at all when moistened unless for example the husk is removed to expose the embryo. This type of dormancy does not usually constitute a serious problem in the maltings, disappearing in 6-8 weeks, or in less time if the grain has been dried in air at 40°C. Barley which has been grown under relatively humid conditions, particularly towards harvest time, will usually exhibit the other form of dormancy known as water sensitivity. Such grain can be recognised by the fact that it will not grow when its moisture content is raised by continuous immersion in water but can be made to germinate satisfactorily if the steeping process is occasionally interrupted and the grain exposed to air. This method of steeping is known as the 'air-rest' procedure. The grain generally emerges from the water-sensitive state after 3-4 months of storage.

Clearly, it is necessary to know in advance of malting a) if profound dormancy has disappeared and b) to what extent the grain is water-sensitive, in order to plan the steeping schedule in relation to the optimum times of immersion in water and exposure to air to secure maximum germination. The information may be obtained by means of two simple germination tests, for a) the 4-ml test, which indicates the so-called germinative energy of the grain and for b) the 8-ml test, which measures water-sensitivity (see sections 3.41.8 and 3.41.9).

3.12.9 Steeping The next step is to withdraw the barley from storage, to sample for moisture determination (see section 3.41.10 and to weigh off into a hopper-bottomed circular shaped vessel containing the steep water, which should have a temperature in the range 15°-20°C. Shortly after the commencement of steeping the steeping vessel is underlet with water and any foreign matter such as awns and the seeds of weeds which escaped screening removed by flotation. The steeping vessel is equipped with aeration holes and periodically the grain is rcused in order, first, to assist further removal of foreign matter and, second, to promote uniformity of water absorption by the grain. If continuous steeping is employed it is usual to change the water two or three times. If the air-rest procedure is used the grain may be exposed to air for either one or two periods. A guide to the optimum conditions of steeping is obtained by micro-malting tests (see section 3.44)which also serve to furnish useful information regarding the optimum conditions of the following germination phase. Whilst the grain is exposed to air in the steeping vessel, respiratory activity of the corns leads to the formation of carbon dioxide, which if allowed to accumulate would asphyxiate the grain and impair germination. Steeping vessels are thus equipped with means of sucking air ($1.4 m^3/min.$ per metric ton of original barley) down through the bed of grain to remove the carbon dioxide, the frequency with which this is done depending on the activity of the grain, i.e. the more rapidly the corns are growing the greater will be the production of carbon dioxide and correspondingly the more frequent the need to apply the suction device.

3.12.10 Germination When the moisture content of the corns has been raised to a satisfactory level by steeping the grain is transferred to the germination compartment, which is most conveniently placed directly under the steeping vessel. This germination compartment is usually in the form of a simple oblong box, constructed either of concrete or steel and fitted with a false perforated floor on which the steeped grain is deposited to a depth of 0.75-1.0m. It is usual to maintain this bed of grain at a temperature of $15^o$ to $20^oC$. Thus, because of continuing and intensified respiratory activity and the accompanying development of a considerable quantity of heat (approximately 200 k cal per kilo of barley) the grain must be continuously ventilated with cool air (approximately $11m^3/min.$ per metric ton of original barley) which must also be suitably humidified to minimise loss of moisture. Even so, some evaporation of water is inevitable and periodic sprinkling of the grain is often required. It is also necessary, periodically, to turn the grain, otherwise the roots which form would quickly mat together. For this purpose the box is usually equipped with a special turning device, which consists of a system of vertical helical screws fitted to a machine which spans the narrow section of the box. The machine is capable of travelling the length of the box on rails fitted to the side walls. It may be conveniently fitted with a sprinkling device to maintain the desired level of moisture of the grain as described above.

During germination a constant watch must be kept on the temperature of the grain and samples should be periodically checked for i) moisture and ii) extract (see, respectively sections 3.42.1 and 2). The static pressure and humidity of the air entering the grain bed should also be checked regularly.

3.12.11 Kilning When the grain, or green malt as it is usually called at this stage, is satisfactorily modified as judged by the level of extract achieved, it is transferred to the perforated floor of a kiln (though see section 3.2) where its moisture content is reduced to 3-4 per cent by means of warm air over a period of about 24 hours. Kilning serves i) to arrest growth of the grain, ii) to reduce the moisture content of the corns to a level which renders them in a suitable condition for storage and subsequent milling in the brewery and iii) to confer on the malt its typical flavour and colour demanded by the brewer.

It is an important part of kilning to maintain a precise control of the temperature, which in the early stages must be kept low (about 50°C) in order not to damage those properties of the malt which facilitate a good yield of extract in the brewery. When the moisture content of the malt has fallen to below about 10 per cent the temperature may be safely raised to 75°-80°C to bring about the formation of colour and flavour. At the end of kilning the heating equipment is switched off and cool air passed through the grain for 20-30 minutes.

3.12.12 Handling and Storage of Kilned Malt The kilned malt is discharged into a hopper under the kiln floor. It is then conveyed to a screen where the roots (or culms) are removed. This operation is carried out with the minimum of delay after kilning as: i) it helps additionally to cool the grain and ii) culms are very hygroscopic and are more easily removed whilst they are still dry. The clean malt is weighed. As it too is hygroscopic it is stored in air-tight bins. Before transfer to storage, however, it is important to ensure that the temperature of the malt is lower than about 32°C, a precaution which minimises further development of colour and other changes in the composition of the malt which might reduce its capacity to yield extract in the brewery.

The final product is eventually weighed off into polythene lined sacks for delivery to the customer.

3.12.13 Measurement and Control of the Malting Loss In converting barley to malt there is an overall loss in the dry weight of the grain. This is accounted for by: i) the leaching out of various substances into the steep water, ii) the evolution of carbon dioxide and water which accompanies respiration and iii) the growth of roots, which are removed after malting and have no value in brewing.

Clearly it is desirable to keep such losses to a minimum. Collectively they are known as the 'malting loss', which is defined as the percentage loss of dry matter referred to the dry weight of original barley used for malting i.e.

$$\frac{\text{dry barley weight - dry malt weight}}{\text{dry barley weight}} \times 100$$

Malting loss should be checked regularly and in conventional malting should not exceed 6-8 per cent. Higher values than this generally indicate that insufficient control has been exercised over the management of the germination process with regard to the temperature and moisture content of the grain. It should be noted that steeping losses are usually small, about 1.0 per cent and can be ignored.

### 3.13 Modern Developments in Malting

To increase the efficiency of the malting process it is possible to treat the grain with various additives, of which the two most commonly used are i) gibberellic acid and ii) potassium bromate. The former compound, a natural plant hormone, may be applied to the grain either by adding it to the steep water, when it is used at the rate of 0.1 to 0.5 ppm referred to the dry weight of barley steeped or by spraying it on to the steeped material as it passes into the germination box or in the germination box itself. In the latter method of application the optimum rate of usage is 0.025 to 1.0 ppm referred to the dry weight of barley steeped. The effect of gibberellic acid is to shorten the period required to achieve full modification and thus to increase the throughput of the maltings. Factors which limit its use are its relatively high cost (FRw 150 per g) and marked increases both in the soluble protein and the colour of malt when used at levels in excess of those quoted above.

Potassium bromate may be used either alone or in conjunction with gibberellic acid. Added to the steep water (400 ppm) or applied as an aqueous spray (250 ppm) it reduces the production of soluble protein and, by partially inhibiting root growth, it helps to decrease malting loss. It is inexpensive, but its use is governed by patents, though these are unlikely to be operative in Rwanda.

### 3.14 Specification of Malt to be Produced

The specification for malt depends on the type of beer which it is required to brew. For lager beer, such as that manufactured in Rwanda, the more important characteristics are as follows:

3.14.1 Moisture This should not be above 5.0 per cent and preferably below 4.5 per cent as slack malt may lead to brewing problems particularly in milling when mills have been set to achieve an optimum degree of crushing for efficient mash tun operation.

3.14.2 Extract (fine grind) The amount of extract obtainable from a given quantity of malt defines the quantity of beer which can be produced at a specified gravity from it. Thus it is of considerable economic importance to the brewer that malt should yield the maximum possible extract and in general a minimum extract of 80 per cent is demanded.

3.14.3 Fine Grind, Coarse Grind Difference Whereas the fine grind extract of malt usually reaches a maximum value after about three days of processing the development of the coarse grind extract is somewhat slower and approaches the fine grind extract only when the malt is well modified. The brewer thus uses the difference between the fine and coarse grind extracts as a measure of the degree to which the malt has been modified and usually specifies that this should not be greater than 2.5 per cent.

3.14.4 Saccharification Time The measurement of saccharification time provides a guide to the amylolytic activity of the malt on which the dissolution of the starch depends in mashing. A saccharification period in excess of 15-20 minutes is indicative of an inadequately modified or perhaps well modified but kiln-damaged malt.

3.14.5 Speed of Filtration The speed of filtration of the wort after mashing is also related to some extent to the degree to which the original malt was modified. For an adequately modified sample the time for complete filtration should not exceed one hour.

3.14.6 Total Soluble **Protein** **As explained in section** 2.31.2, the protein content of a malt has special significance in relation to several aspects of brewing. For optimum results in the brewery the protein solubilized in the mashing process should be between 4.0 and 4.7 per cent.

3.14.7 Kolbach Index Many brewers consider that the ratio of the total soluble protein to the total protein content of malt (usually quoted as a percentage) is a further useful guide to the degree of modification of the grain and judge malt to be acceptable for brewing if the value of this ratio (the Kolbach index) is in the range 35-41 per cent.

3.14.8 Colour Lager beer is characteristically light in colour. To succeed in producing a pale beer of this type it is a necessary requirement of the malt that it should provide a wort which does not have a colour value in excess of 3.0 EBC units.

3.14.9 Clarity Though there is no positive correlation between the brightness of a wort and its brewing value, it is generally true that a bright wort is indicative of a well modified malt. Thus brewers place some value on a malt which gives rise to a clear extract.

3.14.10 pH The pH of a malt wort should be between 5.6 and 6.0 for maximum yield of extract. If it falls outside these values it may be expected either that the grain is undermodified (pH above 6.0) or that it was subjected to anaerobic conditions in germination or to contact with sulphur dioxide emanating from the fuel in kilning. (pH less than 5.6).

3.14.11 Diastatic Power In mashing, the conversion of starch to low molecular weight sugars, which are converted by yeast to alcohol in the fermentation of wort, is to a large extent dependent on the production in malt of the enzymes, $\alpha$ and $\beta$ amylase. The combined action of these two enzymes on starch is called diastatic activity and their concentration in malt is measured in units of diastatic power, known as Windisch-Kolbach (or simply W-K) units. A well modified lager malt should have a diastatic power of 200-250 W-K units. Lower values indicate either that the grain has been inadequately modified or that having reached full modification it has been damaged through insufficient control over kilning.

3.14.12 Thousand-corn weight  The thousand corn weight of barley falls due to respiration. Thus by measuring the thousand corn weight of both a barley and the malt resulting from it, it is possible to judge the malting loss, though this is rather an inexact determination.

3.14.13 Assortment  The corns of barley increase in volume when converted into malt. For a well modified malt 85-90 per cent of the corns should remain over the 2.5 and 2.8 mm screens.

3.14.14 Steeliness  The steeliness of malt is evaluated in the same way as for barley. If less than 2.7 per cent of the corns are steely in appearance the malt is judged to be well modified. The presence of 5.0-7.5 per cent of such corns indicates a satisfactory level of modification, whilst over 10 per cent shows the sample to be undermodified.

## 3.2 Plant Specification

### 3.21 General Description

During recent years much publicity has been given to new designs of malting equipment, including both fully continuous and continuous batch systems, the purpose of which has been to allow the incorporation of modern ideas of malting and at the same time to reduce labour and capital costs. However, such have been the improvements made both in the basically conventional methods of malting and in the efficiency of operation of conventional plant (reference: A. Macey, Internationales Symposium der Garungsindustrie, p.575, 1968) that very few plants incorporating novel ideas have been built and tried in commercial practice. It is therefore recommended that a conventional system of malting should be employed in Rwanda and that preferably this should be of the Saladin box type. However, whereas in the Saladin box type of plant it is usual to provide for a single kiln to serve two or more germination units, it is recommended that it would be better in Rwanda to employ boxes which serve both for germination and kilning. The advantages of this system are:

i) the boxes may be used for drying barley thus saving the cost of separate barley drying equipment. It is, of course, usual in most maltings to utilise the malt kiln for drying raw grain but as only one kiln is provided for several boxes, the facilities are limited and additional equipment is often required to meet the high demand for drying at harvest,

ii) saving in handling costs, as the step of moving the grain to a separate kiln is avoided,

iii) saving of building costs in the absence of a separate kiln,

iv) considerable flexibility of use as each unit is self-contained, a facility which makes it possible to malt barleys of widely different properties, without the difficulty encountered in normal plant of adhering to a fixed germination cycle to fit in with a fixed programme of kilning,

v) the ability to continue to malt in one section of the plant if, for example, the kilning section of the other fails, a facility which is not available in plants which rely on one kiln to serve several boxes. This is considered to be of particular importance in Rwanda where the situation may not be easy with regard to spares and maintenance.

vi) heating the boxes serves to sterilize them and reduce the common problem of under floor mould growth.

The only noteworthy disadvantages of this type of installation are that extra cost is incurred in providing two sets of heating equipment and some loss of time occurs whilst the boxes cool down after kilning; these are, however, well off-set by the many advantageous aspects of the system described above.

As a result of the market study we are estimating a throughput of approximately 2,500 tons of barley at 12 per cent moisture per year. We therefore recommend that the plant should comprise a) a barley intake and storage section, b) a malting section. consisting of one steep vessel (capacity 25 tons) and two germination/kilning compartments (capacity 25 tons each), suitable for barley drying. The plant would be used for 300 days a year for malting and would be operated on a 6-day cycle in respect of germination (5 days) and kilning (1 day) with a 3-day interval between batches. The remainder of the year would be taken up with barley drying and plant maintenance.

3.22 Tendering Procedure

It is quite usual in the malting industry for tenders to include only a brief outline of the maltsters processing requirements, it being left to equipment manufacturers to express their own recommendations as to the type of plant layout, etc, which should be employed to satisfy these requirements and to quote for the cost of the complete installation, including erection and commissioning, with a price breakdown in relation to major items. In this report, however, a specification has been prepared for tender which defines the proposed plant in more than customary detail as a) it is desired to exclude all but the dual purpose germination/kilning type of equipment already referred to and b) it is assumed that in the event of the envisaged malting project going ahead, the tender will be handled initially by people not fully conversant with the malting industry who will, unlike established maltsters, be unable to engage in technical dialogue with malting equipment manufacturers in working out the preliminary plant details. The plant manager, of course, should be available for discussions regarding the final specification. The proposed form of the specification is given below; it should be read in conjunction with the flow diagram depicted in figure 1 and the plant layout shown in figure 2 It should be stressed that this specification, particularly in regard to the permitted assumptions relating to times of steeping and germination and malting loss, may need to be slightly modified prior to tendering, depending on the knowledge gained on the malting performance of Rwandan barley from the proposed testing programme described in section 2.4.

The major suppliers of complete malting installations who could be approached to tender for this project are as follows:

i) the Saladin Malting Construction Division of Stockland Road Machinery Company, 637-12th Avenue South, Hopkins, Minnesota, USA.

ii) Kaybee Kamas Ltd., 66 Armley Road, Leeds LS12 1XU, England.

iii) C. Seeger, Maschinenfabrik, Stuttgart-Bad, Cannstatt, Federal Republic of Germany.

iv) Heinrich Muger, Malzereibau, Darmstadt, Fed.Rep.of.Germany.

v) Anton Steinecker, Maschinenfabrik, 8050 Freising, Federal Republic of Germany.

vi) Miag, 33 Braunschweig, Federal Republic of Germany.

vii) Nordon-Fruhinsholz-Diebold, 9 Avenue du 20$^{e}$, Nancy, France.

viii) Robert Boby, Bury St. Edmunds, Suffolk, England.

## 3.23 Proposed Form of Tender

A tender is required for the construction of a complete malting installation in the Republic of Rwanda for malting 2,500 tons of kiln-dried barley annually, including all buildings, grain handling equipment and the provision of services according to the following specification.

3.23.1 Site of Plant The site of the plant is .... For the purposes of this tender it may be assumed that the site is clear and level.

3.23.2 General The arrangement of the plant will be as generally shown in drawings numbered .... (Figures 1, 2 and 3 of the present report). The tender will include provision for the supply, erection and commissioning of:

a) a barley reception area, conveyors and elevators with attendant, supports, chutes, valves etc.

b) cleaning, weighing and grading machinery for barley and malt,

c) storage silos,

d) malting plant, including facilities for steeping, germination and kilning,

e) buildings etc. to house all machinery, the malting plant, a laboratory and office and necessary cover for the barley reception area,

and will additionally include for the provision of all necessary services and instrumentation.

It should be assumed that the ground bearing pressure must not exceed about 11 metric tons/m$^{2}$. Structural and electrical work should comply in all respects with the local standards of safety as follows... (these standards to be supplied by Services d'Études et de Programmation Industrielles).

3.23.3 Barley Section

a) Intake Road vehicles will deliver the grain to the intake point, which at the moment is to be designed to receive sacks. However, the design of the intake shall be such as to allow for possible future use of tipping vehicles. An intake grid, strong enough to take pedestrian traffic only shall be supplied as an integral part of the intake hopper and a fine mesh grid shall be fitted under the main load bearing grid to act as a protection against contamination of the pit with string, large rubble etc.

b) Roof over Intake Pit Provision should be made for the supply of an asbestos sheeted roof over the grain intake area with sufficient clearance to accommodate all types of lorry.

c) Grain Flow Conveyors and elevators will be provided to transfer grain from the intake pit to an automatic batch weigher and pre-cleaning equipment. A facility should be provided for grain emerging from the pre-cleaning equipment to pass i) through a second automatic batch weigher thence either to storage or to the germination/kilning boxes for drying and ii) directly to storage by-passing the second weigher, all necessary conveying equipment being provided. Provision should also be made for suitable conveying equipment to remove kilned-dried barley from the drying section to storage passing through the cleaning equipment but avoiding the weighers. As regards the transfer of barley from storage to the steep, removal of the grain from the silos will be achieved by means of a sweep auger, which will discharge the grain into a conveyor to feed an elevator. The valve at the head of this elevator will be so arranged as to allow the grain to feed the barley dresser and a second automatic batch weigher, which shall be fitted with a counting device capable of isolating the feed conveyors and elevators after the passage of a pre-determined weight of material, thereby permitting the feed system to the dresser to be evacuated. Provision should be made to pass grain from the dresser by way of conveyors and elevators to the steeping vessel.

d) Conveyors All conveyors shall be of the chain and flight type, totally enclosed in mild steel casings and each should be fitted with suitable motor, drive and guard. They should be self-cleaning and designed so that small pockets of grain cannot accumulate.

e) Elevators All elevators shall be of the belt and bucket type, totally enclosed in mild steel casings. They should be self-cleaning and be designed to prevent small pockets of grain accumulating.

A slipping cut out device should be fitted to all lower pulleys. This device should sound an alarm if an elevator fails and automatically switch off all conveyors feeding it.

f) Outlet and Inlet Slides The tender should allow for hand operated inlet bin and conveyor slides and change-over valves.

g) Pre-Cleaning and Grading Equipment Machinery should be provided capable of removing stones, string, sacking, iron, dirt, sand etc, and produce a 'pre-cleaned' sample at a rate to match the capacity of the intake conveying equipment.

This machine should also be capable of dressing and grading, when it should have the facility to produce controlled proportions of headcorn over either a 2.5 or 2.8mm screen, which when tested should be in the region of 88 to 92 per cent with a maximum of 0.5 per cent of headcorn through a 2.2mm screen. It should have the facility to dress malt.

A suitable cyclone must be included with this equipment, which should operate at a capacity of 50-60 ton/hour when serving as a pre-cleaner and at a capacity of 25-30 ton/hour when acting as a barley grader/dresser or malt dresser. Conveying equipment must accordingly be designed to operate at the higher capacity and be provided with suitable restricting devices at the relevant inlets for use at the lower capacity.

h) Drying The raw barley will be dried on the germination/kilning boxes at a temperature not exceeding 45°C and at a maximum depth of 1.5m until its moisture content has been lowered to 11-12 per cent.

i) Storage Provision should be made for the storage of 2,500 tons of kilned dried barley ($1.4m^3$/ton) in mild steel circular bins, complete with roof, external ladder with safety hoops, roof ladder with handrail and manhole access door, internal sweep auger for discharge, aeration ducts, suitable aeration equipment for grain at a moisture content of 12 per cent, temperature indication for each 3m of depth and level indicators to show the 'full' and 'empty' state of the bins.

3.23.4 Malting Section

a) General It may be assumed that i) the plant will be used for 300 days per year for malting and that the remainder of the year will be used for barley drying and maintenance, ii) clean barley will be supplied for malting at 12 per cent moisture, iii) steeping will occupy 2 days, germination 5 days and kilning 1 day, iv) the grain will be sprinkled during germination, and v) the malting loss will be between 6 and 8 per cent on dry matter.

b) Water Storage Vessel One mild steel water storage vessel should be provided having a capacity of $400m^3$ complete with overflow device and low level alarm, temperature indication and control, manhole in top cover and access ladder inside.

c) <u>Steeping Vessel</u> One circular mild steel vessel with conical hoppered bottom with a capacity for 25 tons of barley, braced and stiffened as necessary, should be provided. This vessel is to be complete with weir gate, malting gate and steep valve and equipped with a suitable fan to suck air through the grain at the rate of $35m^3/min$. and a steep aeration blower to deliver $11m^3/min$. at $0.7\ kg/cm^2$ through three banks of externally connected 0.6mm nozzles arranged around the hoppered bottom of the tank at 0.75m intervals from the base. the horizontal separation of such nozzles to be approximately 0.75m. A distant reading thermometer should be provided to indicate the temperature in the centre of the steep vessel at about half the grain depth.

d) <u>Germination/Kilning Boxes</u> Two boxes, each suitable for both germination and kilning and having a capacity of 25 tons of original barley should be provided. Each box is to be complete with.

i) galvanised slotted (2mm) floor sections: each is to be conveniently sized to allow their removal for access to permit maintenance and cleaning in the lower air chamber.

ii) an underbed supporting steelwork frame.

iii) turner/stripper rails along the length of each box in rust resistant steel complete with fixing brackets.

iv) one turner/stripper machine for use in either box. This machine to be of the vertical helix type and to be capable of levelling the grain, after discharge from the steeps, by a single traverse of the box. It should also be fitted with a raisable plate operated either electrically or hydraulically on one face of the turner to allow it to be used as a grain stripper.

v) removable end panel to facilitate the removal of malt into a discharge conveyor and movement of the turner/stripper machine from one box to the other.

e) <u>Air-conditioning</u> Each box to be equipped with one air-handling unit, fitted with a centrifugal fan capable of driving air through the grain at the rate of $11m^3/min$ per ton against 11.5cm water gauge. Spray equipment is to be provided to facilitate raising the humidity of ambient air to 98 per cent humidity on one passage through the unit. Further, spray water is to be cooled as necessary to permit adjustment of the air-temperature to $15^oC$. It may be assumed that the maximum and minimum air temperatures are $28^oC$ and $8^oC$ respectively and the maximum and minimum relative humidities are 95 and 60 per cent respectively. 30% recirculation of air should be allowed for and temperature recording charts should be provided to indicate the air-temperature entering and leaving the grain. A wet bulb thermometer will also be required in the 'air-on' ducting.

f) Kilning Each box to be equipped with a second fan, which it may be assumed will be required to work against approximately 32cm. watergauge, and direct oil fired burner, using 35 second (Redwood No.1 at 38°C) sulphur-free oil. This equipment should be capable of reducing the moisture content of green malt from 50 to 3 per cent in 22 hours, assuming that the 'on' air temperature may not exceed 50°C until the grain moisture has fallen to below 10 per cent and the curing temperature must not exceed 80°C. Provision must be made to record 'on' and 'off' air temperatures.

g) Grain Flow Provision will be made to move barley from store through the barley dresser and second automatic batch weigher to the steep vessel, from which it will pass by way of a suitably arranged conveyor system to either box and be distributed evenly along the length of each box.

At the completion of kilning, provision will be made to return the processed grain back to store via a magnetic device, the dressing equipment and second automatic batch weigher. From store the grain will be again passed through the dresser and weigher to a sacking off station at ground level.

3.23.5 Electrical It will be necessary to supply single line diagrams, power and earthing layouts and cable schedules.

It may be assumed for the purposes of this tender that a high voltage supply exists at the battery limits.

All electrical equipment to be of the damp protected type except in hazardous or dusty areas where it should be flameproofed.

3.23.6 Instrumentation The degree of instrumentation is to be such as to provide ease of plant control without the plant being fully automatic. Generally instruments should be locally mounted or grouped on locally sited boards.

3.23.7 Procurement Production of mechanical data sheets and requisitions for the items of plant and mechanical equipment covered by the flow diagrams.

## 3.3 Schematic Design of Plant

Flow diagrams and a layout of the proposed plant are shown in Figures 1 and 2 respectively. A simple isometric drawing of the installation is shown in figure 3. The system comprises first a barley intake hopper in which it is envisaged that raw grain will be tipped by hand from sacks brought to the maltings by lorry. This grain will be carried by means of a horizontal conveyor and elevator to an automatic batch weigher, from which it will be discharged into combined pre-cleaning, dressing equipment followed by a second automatic batch weigher, thence to be moved either to the germination/kilning boxes for immediate drying, or, if these boxes are already occupied in drying, direct to storage (see flow route 1, figure 1). Grain taking the latter route will be subsequently conveyed to the drying section, via the pre-cleaner/dresser and second automatic batch weigher, as soon as this becomes free (see flow route 2, figure 1). Dried barley will be transferred to storage via conveyors situated under the drying boxes to the storage bins (see flow route 3, figure 1). Note that the combined pre-cleaner dresser has been arranged in such a position that it may be used whenever the grain is moved, facilitating the extraction of dust, the elimination of which from the system is essential in the interests of health and, in particular because the accumulation of dust constitutes a dangerous fire hazard.

For malting the barley is moved from storage, following route 4 of Figure 1 to the steep vessel and to either of the germination kilning boxes. Kiln-dried malt from these boxes is taken via route 5 to storage and from storage to the dispatch area by way of route 6.

## 3.4 Laboratory Tests and Apparatus

Laboratory tests essential to efficiency and quality control have been briefly referred to in previous sections. Full details of these tests are described in the following sections.

## 3.41 Tests on Barley - Physical Tests

3.41.1 Sampling On receipt of a sample for analysis in the laboratory it should be allowed to reach room temperature before opening the container. Samples for analysis should always be re-run through a sample divider.

3.41.2 Thousand corn Weight Duplicate samples should be taken by a sample divider, and quantities of at least 40g should be taken. It is strictly stipulated that the whole sample must be weighed first and counted afterwards. The counting can then be by any convenient method, e.g. by hand using a hand counter, or by Kickelhayn 500 corn counter with hand counting of the residue. Half corns and foreign matter are removed and the weight subtracted before calculating the thousand corn weight to one decimal place.

3.41.3 Assortment (sieving test) A special shaking apparatus is used. This consists of three sieves spaced 12-25mm above one another with a cover and receiver, the total height being 8-10cm. The dimensions of the sieves are 43cm long and 15cm broad. The sieves are made of hardened brass 1.3 $\pm$ 0.1mm thick with slots milled to a width tolerance of $\pm$0.03mm. The slots are 25mm long on top and 22mm long underneath. The width of the slots is for Sieve I 2.8mm, Sieve II 2.5mm and Sieve III 2.2mm. The number of slots is for Sieve I 28x13, for Sieve II 30x13, and for Sieve III 32x13. The unslotted edges of the sieves are 4-6mm wide. The speed of shaking is 300-320 revolutions per minute, arranged to give to and fro motions of 18-22mm. The sieve surfaces must be exactly horizontal in both directions and the width of the slits must be checked frequently.

100 grams of barley, taken by sample divider, are weighed and put on the top sieve and the apparatus set in motion for exactly five minutes. Foreign matter, including all grains not barley, and half-corns should be picked out, weighed and the result stated as a part of the reject fraction. The weights of each fraction are then measured and reported as percentages of the total weight to the nearest whole number.

3.41.4 Broken Corns Not less than 30g ($\pm$0.1g) of barley are spread out on a clean flat surface. All broken pieces of grain are removed and weighed. to 0.01g. Broken corns are reported as a percentage of the whole sample to one decimal place.

3.41.5 Foreign Material Not less than 30g ($\pm$0.1g) of barley are spread out on a clean flat surface. All foreign matter (non-barley particles) is removed and

and weighed to the nearest 0.01g. The percentage of such foreign material in the sample is calculated to one decimal place.

3.41.6 Steeliness 100 corns are cut transversely in a farinator and the cut surfaces are classified as mealy, half-steely or steely. The percentage of corns in each class is calculated to the nearest whole number.

Tests on Barley - Germination Tests

3.41.7 Germinative Capacity

3.41.7A Hydrogen Peroxide process

(i) Reagent 0.75% $H_2O_2$

A fresh solution is prepared each time by diluting 5ml of 30% $H_2O_2$ to 200ml with tap water. The strength of the concentrated peroxide must be checked and it must be stored in a refrigerator.

(ii) Method

Two lots of 500 corns are taken by means of a sample divider. Each lot of 500 corns is steeped for 2 days in 200ml of 0.75% hydrogen peroxide. After this the steeping liquor is poured off through a strainer, and an addition of 200ml of fresh 0.75% hydrogen peroxide is made. The steeping in this solution is continued for two days. Then the corns are strained off, and those which have not germinated are counted. The total steeping time is four days and the temperature of the solution is 18-21$^{o}$C.

If more than 95 per cent of the corns have germinated the percentage is calculated and reported.

If less than 95 per cent of the corns have germinated or for greater accuracy, the remaining ungerminated corns are peeled and incubated for 1 day longer.

The technique of peeling is as follows: A stout, spear-pointed dissecting needle is inserted in the grain at the side of the germ and swept out and round to allow a piece of husk over the germ to be peeled back and off. This exposes the germ which is still covered with a fine brownish skin. By rubbing with the finger this skin can be removed to expose the pure white germ itself. it is essential that this exposure should be made. The peeled grains are incubated for one day on moist sand or filter paper.

The germinative capacity is then recorded as the sum of the percentage of the grains which have germinated in the hydrogen peroxide and peeling tests:

$$\text{Germinative capacity} = \frac{500 - n}{5} \%$$

where: n=number of corns which have not germinated.

### Comparison of Results

When comparing different results it must be remembered that the laws of chance govern the result, so that (for the 1000 corns taken) the following table of allowable tolerances must be used:

| Mean values of germination (per cent) | Allowable tolerance between the results from two different laboratories (or two sub-samples) (per cent) |
|---|---|
| 97-100 | 2 |
| 95-96 | 2.5 |
| 90-94 | 3 |

If greater precision is needed, a larger number of grains is taken. For 5000 grains the tolerances are:

| | |
|---|---|
| 97-100 | 1 |
| 95-96 | 1 |
| 90-94 | 1.5 |

3.41.7B Rapid Process (staining method)

i) Reagents- A 0.3% solution of 2-(p-iodophenyl)-3-(p-nitrophenyl)-5-phenyl tetrazolium chloride. The solution must not be heated and must be kept away from light.

ii) Method- Cut a convenient number of grains (preferably selected by sample divider) in half longitudinally, using a machine which accurately bisects the grains longitudinally. Transfer one set of half grains to a test tube, cover with a solution of the tetrazolium compound, and remove the air by evacuating the tube for 3-4 minutes with an electrically driven pump, while tapping. Readmit air to force the solution into the grains.

With the triphenyl tetrazolium halide solution maintain the test tubes at 40°C for half an hour in a water bath. After staining, remove a thin slice of dead tissue from the exposed surface by a sharp razor.

After either treatment spread the grains on moist filter paper for classification.

Reporting Results- Since damaged corns are incompletely stained, care must be taken in interpreting the results. Usually the root is the first to die, and corns with unstained roots will still germinate and modify satisfactorily. This will happen even if the damage extends a little way up the hypocotyl towards the shoot, but if the damage extends still further - say more than half the germ - it must be classed as dead. When more than half of the germ (but not the whole) is stained, it should be classed as damaged. Pre-germination when recognized, should be reported separately. The stained germs are classified into:

a) Those completely coloured, i.e. healthy living germs.

b) Those which, although damaged, are sufficiently intact to germinate satisfactorily on malting. Usually this means that, as a minimum, the shoot and scutellum together with a little of the tissues between the shoot and the root are stained.

c) Unstained germs or those less stained than the minimum given under b)

If x is the percentage of healthy germs under a) above and y is the percentage of damaged germs under b) the result is reported as "germinative capacity x + y%, including y% damaged".

This method may possibly not indicate the full extent of heat damage.

A suitable commercial apparatus allowing this test to be completed in 5 minutes is known as a Vitascope.

3.41.8 Germinative Energy (4ml test) Place two black (Whatman No.29) filter papers in the bottom of a 10cm petri dish; add accurately 4ml of distilled water to wet the papers evenly. Select 100 corns using a sample divider and place them in the petri dish so that each makes good contact with the papers. Cover the dish with its lid; place in a dark cabinet controlled at 18-21°C. Examine dishes after 24, 48 and 72 hours, removing chitted corns (those which show signs of growth) on each occasion. After 72 hours count the corns which have not chitted. Report percentage growing corns to the nearest whole number taking the average value from three separate determinations.

3.41.9 Water-sensitivity (8ml-test) Proceed as described until the 4ml-test but use 8 as opposed to 4ml of water.

Tests on Barley - Chemical Test

3.41.10 Moisture

3.41.10A Normal Process A sample of about 20g for both moisture and nitrogen content determination is taken by sample divider. When over 17 per cent moisture content is found, the grinding and analysis are repeated after pre-drying the whole grain at a temperature below 50°C.

When pre-drying is used then the moisture content of the grain should be calculated as follows:

$$M=W_1+W_2-\frac{W_1W_2}{100}$$

where: M=Moisture content of moist barley;
$W_1$=Percentage of moisture lost by pre-drying;
$W_2$=Percentage of moisture found in pre-dried sample.

i) **Mill Recommended**

The EBC mill with the sieve having circular holes of 1mm in diameter is considered preferable.

ii) Oven

The following general recommendations are made:
a) The oven should if possible not be placed in a room where the humidity of the air is increased by evaporation of water.
b) Metal weighing dishes are used. They should be flat, about 5cm across and not more than 2cm in depth and provided with lids.
c) About 5g of ground barley is placed in a dish, immediately covered, and weighed as quickly as possible, preferably on an air-damped balance.
d) The drying temperature is 105-107$^{o}$C and the time in the oven is 3 hours.
e) An oven is not to be regarded as satisfactory unless 5g of pure copper sulphate ($CuSO_4.5H_2O$), passing a 16 mesh (1mm holes) sieve, loses at least 21 per cent and preferably 25 per cent of its weight in 30 minutes time from the moment of placing the dish in the preheated oven.

Electrically heated air ovens with an even distribution of the heating elements are recommended. Tt is desirable that the shelves should be 3-5mm thick metal plates pierced with holes and with a flat surface to conduct heat to the tins.

After drying, each tin is immediately covered by its lid, immediately placed in a dessicator and allowed to cool for at least 20 minutes. Silica gel with indicator is recommended as the dessicant. The tins are then weighed. The percentage loss of weight is calculated and reported as moisture to one decimal place.

3.41.10B Rapid Process For speed, when a large number of samples have to be dealt with, for example, at harvest time, the moisture content of grain delivered to the maltings may be approximately determined on the whole or ground corns by means of an apparatus which measures the dielectric constant of the sample.

3.41.11 Total Nitrogen (Protein)

3.41.11A Kjeldahl Process

i) Apparatus

Kjeldahl digestion rack, heated by gas or electricity, with arrangement for trapping sulphuric acid fumes, or venting them.

Kjeldahl distillation apparatus with lagged Rhodin cylindrical type spray traps, having internal tubes top and bottom, joined to a simple tube-type condenser of block tin or borosilicate glass, with the upper curved end sloping downwards to the spray trap.

Kjeldahl flasks, 500 or 800ml size.
Coffee mill

ii) Reagents

Sulphuric acid - 98%, nitrogen free
Sodium hydroxide solution - 40% w/v boiled to remove ammonia, and cooled.
Catalyst mixture - as powder (potassium sulphate Analytical Grade, $CuSO_4.5H_2O$ Analytical Grade, and selenium in the proportions 100:6:1).
Boric acid solution - 2% w/v in water.
Standard 0.1-N hydrochloric or sulphuric acid.
Screened bromo-cresol green indicator - 0.1% bromo-cresol green in 95% ethanol and 0.1% methyl red in 95% ethanol in the proportions 10:4. The indicator is pink in acid solution, grey at the end point and blue in alkaline solution.
Pure acetanilide - previously dried in a vacuum pistol at $80^oC$.
Pure sucrose.

iii) Method

Finely grind a sample of about 20g of barley for the determination of moisture and nitrogen content. Transfer the sample as soon as possible to a stoppered bottle and then mix by stirring with a long spatula so as to ensure even distribution of husk, flour and grits.

For the nitrogen determination, weigh duplicate samples of about 1.5g accurately and transfer carefully to completely dry Kjeldahl flasks. Add approximately 10g of powdered catalyst mixture to each and intimately mix with the ground barley before adding 20ml of concentrated sulphuric acid, shaking and digesting by gentle heat. After the digest has lost its brown colour, heat the flask strongly for 20-30 minutes. It is most important that direct heat does not reach the flask above the level of the liquid.

Allow the digest to cool and dilute carefully with 250ml of distilled water. Run approximately 70ml of sodium hydroxide solution (40%) underneath, this quantity being sufficient to provide an excess over the amount of acid left. To prevent bumping, add small pieces of zinc or coarse carborundum particles. After connecting the flask to the distillation apparatus mix the sodium hydroxide in and distil the ammonia into an excess of 2% boric acid solution (about 25ml) containing 0.5ml of screened indicator.

When the volume distilled has reached about 180ml titrate the ammonia with standard acid.

Calculation - Report the nitrogen percentage on dry matter =

$$\frac{X \times 14}{W \times D.M}$$

where: X = ml of 0.1-N acid required to neutralise the ammonia after subtracting the blank.
W = weight of sample in g.
D.M = dry matter percentage of sample.

Blank and Check - Blank estimations on the reagents must be made and, as a check, the nitrogen content of pure dry acetanilide must be determined by the following method:

Weigh into two Kjeldahl flasks, A and B 0.200g and 0.020g respectively of acetanilide and 1g of pure sucrose. Digest the contents of each flask and distil into boric acid as described above. From each result (corrected by the usual blanks) calculate the nitrogen percentage. The result, as a percentage of 10.36, gives the percentage recovery of nitrogen and should be around 99.5 for flask A and at least 98 for flask B. These conditions also test the accuracy of both the standard acid and the standard alkali.

Results - Results are to be given as percentage nitrogen in the dry sample to two places of decimals. The precision of the method is about $\pm$0.07%.

To express the result as protein multiply the nitrogen figure by 6.25.

3.41.11B <u>Colorimetric Process</u>

i) Apparatus Commercial nitrogen analyser employing the dye orange G.

ii) Method A sample of finely ground barley (2g) is briefly digested with a solution of orange G. The resulting mixture is filtered and the protein content of the sample obtained from a knowledge of its moisture content and the absorption characteristics of the filtrate.

## 3.42 Tests on Green Malt

3.42.1 Moisture

i) Apparatus

Coffee grinder
Interval timer Reading up to 30 minutes and graduated in 0.2 seconds
Infra-red balance

ii) Method

Set the rider on the infra-red balance arm to zero position. Thoroughly mix the sample by inverting a number of times. Place the unground grains on the aluminium weighing pan to bring the needle to zero and set the lamp to the $1\frac{1}{2}$" mark. Switch on the lamp and set the timer to $\frac{3}{4}$ hour. The needle must be maintained at the zero position by moving the rider along the beam, so as to avoid charring of the roots and endosperm. At the end of the set time, take the first moisture reading. Switch the lamp off and move it to its highest position above the pan, transfer the grains quickly to the coffee mill. Grind for about five seconds, then immediately transfer to a cold aluminium pan. Set the rider to the 50% moisture mark and bring the needle to the zero position with the ground sample, i.e. 1g ground sample. Re-set the lamp to the $1\frac{1}{2}$" mark, switch on and set the timer to $\frac{1}{2}$ hour. Again the needle must be maintained at the zero mark by moving the rider along one position. At the end of $\frac{1}{2}$ hour, take the second moisture reading.

Calculation

Let the first "moisture reading" be A
Let the second "moisture reading" be B

For the first moisture determination 2g are taken and for the second, 1g of the same sample, partially dried and ground.

Then % moisture $=(A + 2B - \frac{2AB}{100}) - 1.3$

3.42.2 Extract 500g green malt is kilned by the same method used to dry the bulk commercial sample, though using the micro malting kiln (see section 3.44). The resultant dried material is screened and analysed for extract as described in section 3.43.7). (A moisture determination of the sample will of course also be required).

3.43 Test on Malt - Physical Tests

3.43.1 Thousand-corn Weight Carry out as for barley, see section 3.41.2

3.43.2 Assortment (sieving test) Carry out as for barley, see section 3.41.3.

3.43.3 Steeliness Carry out as for barley, see section 3.41.6.

3.43.4 Mould Report the presence or absence of mould by visual inspection, indicating none, trace etc.

**Test on Malt - Chemical Tests**

3.43.5 Moisture Carry out as for barley, see section 3.41.10. The necessary grist may be obtained from the finely ground material used in the estimation of extract (see section 3.43.7)

3.43.6 Total Protein Determine total protein as for barley, see section 3.41.11A.The necessary grist may be obtained from the finely ground material used in the estimation of extract (see section 3.43.7)

3.43.7 Extract

i) Apparatus

Mill The standard Casella mill as recommended by the European Brewery Convention. This is provided with both fine and coarse sieves.

Mash Bath Mashing must be carried out in beakers immersed in a water-bath and each beaker must be provided with a mechanically-driven stirrer. The stirrers must all turn at the same speed as one another and this speed must lie between 80 and 100 revolutions per minute.

The water in the mash bath must reach a level above that of the mash in the beakers and must be stirred to ensure uniformity of temperature.

The Mashing Process

Coarse Grind - Duplicate quantities of 51g of malt are weighed out and ground in the EBC mill using the coarse sieve. A preliminary portion of malt is ground in the mill while tapping on the lower funnel by means of a leather hammer. This malt is discarded, and, without opening or brushing out the mill, the weighed portion is ground while tapping the lower funnel with the leather hammer. Subsequent malts are ground in the same way and without opening the mill. At the end of the series the mill is opened, brushed out and the brushings discarded. Each grist is well mixed with a spoon and immediately brought to a weight of 50.0g. The mashing process is carried out as for the fine grind.

Fine Grind - Duplicate quantities of approximately 55g of malt are taken (58g quantities if total nitrogen is to be determined), ground in the EBC mill using the fine sieve and following the method given for the coarse grind. Transfer the ground malt into a mash beaker, where the grist is well mixed with a spoon. Portions for moisture (and for nitrogen) estimation are taken and then 50.0g portions for the extract are weighed in the beakers on an accurate balance and with tested weights.

200ml of distilled water at 45-46°C are stirred into each beaker with a glass rod or with the metal stirrer so as to avoid clumping. (The rod must afterwards be rinsed clean with a small quantity of distilled water).

The beaker is immediately placed in the mash bath, which must already be at a temperature of 45°C, and the stirrers set in motion. The temperature of 45°C in the mash is maintained for exactly 30 minutes. Then the temperature of the mash is raised 1°C a minute for 25 minutes. At this time (when the temperature is 70°C) a further 100ml of water at 70°C is added. From this point the saccharification rate is measured. This temperature is maintained for one hour and then the mashes are cooled to room temperature in 10-15 minutes. The stirrers are washed off, the outsides of the beakers dried and the contents made to a weight of 450.0g.

The contents of the beaker are thoroughly stirred with a glass rod and immediately and completely emptied onto a filter. This is a 30-32cm diameter fluted filter of one of the following makes (or papers from other firms guaranteed as equivalent):

| | |
|---|---|
| Schleicher and Schüll | No.597½ |
| Macherey, Nagel & Co | No.614¼ |
| Munktell | No.9100 |

The filter paper must not project over the edge of the funnel. The first 100ml of the filtrate is returned to the funnel. Filtration is discontinued when the filter cake appears dry, or, with slow filtrations, after two hours. Immediately before filling the pycnometer (see below) the contents of the filtrate jar are well mixed.

Determination of the Specific Gravity of the Wort

Precisely made pycnometers of the Reischauer type are used for the measurement of the wort specific gravity. They are graduated, by a mark on the neck, to contain 50.000g of pure water at 20.0°C and should have the following dimensions:

| | |
|---|---|
| Contents | about 50ml |
| Total height | 140-160mm |
| Length of neck | 65-85mm |
| Internal diameter of neck | 2.5-4.0mm |
| Distance from the calibration mark to the top lip | 25-35mm |

The specific gravity is determined at 20.0°C. The pycnometer, which must be thoroughly cleaned, is washed out with two lots of about 10ml of wort (filtrate).

The pycnometer is then filled with wort and placed in a constant temperature bath at 20°C (±0.05°) and allowed to stand for half an hour, with the water above the level of the calibration mark on the pycnometer.

After 25 minutes, the wort is removed to the mark, and, after a further 5 minutes is adjusted exactly to the mark.

After drying the outside of the pycnometer, it is allowed to stand for about 5 minutes and then weighed to 0.0002g.

Calculation of Extract from the Specific Gravity

The extract content of the wort is found from the specific gravity with the help of the official sugar table (Plato table) for 20°C, as given in the Table of F. Goldiner and H. Klemann (1951; Institut fur Garungsgewerbe, Berlin N 65, Seestrasse 13).

The specific gravity is calculated to five places of decimals and is not corrected to the in-vacuo figure.

If the duplicate determinations give specific gravities which differ by more than two units in the fourth decimal place the analysis must be repeated.

The extract content of malts is reported to one place of decimals. It is calculated as:

$$E=\frac{P(M+800)}{100-P} \text{ (to extract on sample)}$$

$$\text{and as } \frac{E \times 100}{100-M} \text{ (to extract on a dry basis)}$$

**where:** E = extract "as is",
P = grams extract in 100g of wort (Plato)
M = the moisture content of the malt in per cent.

Saccharification Rate

Ten minutes after the mash has reached 70°C a drop is transferred to a gypsum plate and a drop of iodine solution (2.5g of iodine plus 5g of potassium iodide dissolved in a litre of water) is added. The test is repeated at five minute intervals until saccharification is complete: that is, a clear yellow spot is obtained.

The result is reported as "under 10 minutes", "10-15 minutes" and so on.

If saccharification is not complete after an hour, the saccharification test is repeated on a fresh experiment in which the temperature is taken to 75° instead of 70°. This test cannot be used for the extract determination.

The gypsum plates are made by thoroughly mixing 135g of plaster of Paris with 100ml of water and pouring into a suitable flat mould.

### Odour of Mash

This is noted during the mashing process as "normal" when it corresponds to the type of malt analysed. When the normal aromatic smell of a Munich malt is absent, this is noted as "non-aromatic". Foreign odours are noted.

### Speed of Filtration

When the filtration is complete within an hour, it is recorded as "normal". If it takes longer, it is recorded as "slow". No other expressions should be used.

The saccharification rate, odour of mash, speed of filtration and clarity of the wort are reported only on the fine grind mash.

3.43.8 pH The yield of extract is influenced by the pH of the mash, consequently the pH of the wort is measured by means of a glass electrode pH meter to 0.1 pH unit intervals.

### 3.43.9 Colour

i) Apparatus Lovibond Comparator or the Hellige Comparator with five EBC colour discs each with nine colour glasses, viz. 2-6, 4-8, 6-10, 10-18, 19-27 and with cells of 40, 25, 15, 10, 5, 2½ and 1mm optical length. The Lovibond discs should all be of the latest (yellow spot) issue.

The colour match (yellowness) of the glasses is with pale worts at the lower end of the scale but the glasses are redder at the upper end of the scale to give a better match with dark worts. The light used must be artificial light of Standard B (Commission Internationale de l'Eclairage) at an intensity of 90-110 Ft Lamberts (343-377 cd/m$^2$) and employing a white reflecting surface of more than 95% reflectivity). The lamps must not be used for more than 100 h.

Every person entrusted with the measurement of wort colour must be known to be free from colour blindness. To ensure this it is necessary to test each one by means of the book of charts by Ishihara (Tests for Colour Blindness published by H.K. Lewis and Co., 136 Gower Street, London W.C.1.)

ii) Method

Standard malt mash worts - These must be protected from strong light during mashing and filtration and the colour must be measured as soon as possible. The worts must be bright before measurement in the comparator with EBC discs. Measure colours up to 10 (25-mm cell) in the 40-mm cell, colours from 10 to 26 in a 25-mm cell and colours from 26 to 650 in a suitable cell thickness to give a reading of between 20 and 26 units. Calculate all results to that for a 10% wort in a 25mm cell and report to two significant figures or to the nearest 0.5° for colours below 10°. For pale malts the precision is about ±1°.

3.43.10 Total Soluble Nitrogen (Protein)

i) Method Pipette duplicate portions of 20ml of bright wort into 500-ml Kjeldahl flasks, add a few drops of concentrated sulphuric acid to each, and evaporate the liquid nearly to dryness on a sand bath. Cool, add the sulphuric acid and catalyst and carry out digestion and distillation as for the total nitrogen of barley, using an excess of 2% boric acid solution.

ii) Calculation This is best explained by an example. Consider a malt containing

80.8% of extract on dry matter
1.70% nitrogen on dry matter
8.48% extract in the laboratory wort
71.4mg of soluble nitrogen in 100ml of wort

therefore: 100g of wort with 8.48% Plato contains 8.75g of extract in 100ml of wort (from the Plato Table). Since the malt gives 80.8% extract on dry matter 100g of malt contain:

$$\frac{0.0714 \times 80.8}{8.75} = 0.659$$ soluble nitrogen as a percentage on dry malt.

The total soluble protein of the malt is calculated by multiplying the total soluble nitrogen result by 6.25.

3.43.11 Kolbach Index The Kolbach index is the Total Soluble Nitrogen of the malt expressed as a percentage of the Total Nitrogen.

The foregoing wort analyses are carried out only on the filtrate obtained from the fine grind mash.

3.43.12 Diastatic Power

i) Reagents

Acetate Buffer Solution Dilute 30g of acetic acid (Analytical Reagent (AR)) to 1 litre with distilled water. Dissolve 34g of sodium acetate ($CH_3COONa.3H_2$),AR) in water and make up to 500ml. Mix the two solutions to give 1½ litres of acetate buffer solution with a pH of 4.3±0.1.

Sodium Hydroxide Normal (N) sodium hydroxide solution (AR).

Sulphuric Acid Normal sulphuric acid solution (AR).

Iodine N/10 iodine solution.

Sodium Thiosulphate N/10 sodium thiosulphate solution (AR)

**Starch Solution** A starch solution is prepared as follows: an amount of Merck's soluble starch corresponding to 10g dry matter is weighed and stirred into a paste with a little cold water in a mortar. This paste is slowly poured into 400ml of boiling water in a beaker so that the water does not cease to boil. The mortar is washed out with a little water and the starch solution is boiled for five minutes. It is then stood in cold water to cool and is stirred, in order to avoid the formation of a surface film. After cooling the solution is transferred to a 500ml measuring flask and made up to the mark with water.

ii) Method

**Extraction of Diastase** The malt should be finely ground. Exactly 20g is weighed out in a tared resistance-glass or stainless steel beaker, 480ml of cold, distilled water is stirred in and the beaker put in the mash bath at a temperature of 40°C and stirred continuously with a glass or stainless steel stirrer. After 1 hour the beaker and contents are cooled and the contents made to a total of 540g. The contents are then poured on to a filter of the same size and type as for the standard mash filtration. The first 200ml of filtrate are discarded and the next 50ml immediately used for the analysis by measuring its action on starch solution.

**Saccharification** The tests are carried out in duplicate together with the necessary blanks. Four 200ml measuring flasks are taken and 100ml of the 2% starch solution put in each. To the first two (main test) flasks 5ml of acetate buffer are added and then all four flasks are placed for 20 minutes in a bath at 20°C. At the end of this time an exactly measured 5ml of the malt extract is pipetted into flask 1 and after exactly one minute an exactly similar amount is pipetted into flask 2. Each flask is well shaken and kept in the bath for 30 minutes from the commencement of the addition of malt extract. Exactly at the end of the time 4ml of N sodium hydroxide is added in order to inactivate the diastase. Since they contain no buffer solution, it is only necessary to add to each of flasks 3 and 4 0.65ml of N sodium hydroxide and then, after shaking, 5ml of malt extract. Each of the flasks is then made up to the mark and well shaken. The contents of each should be alkaline (blue) to 0.5% alcoholic thymolphthalein solution.

**Estimation of Maltose** The sugars formed by diastatic action are estimated iodometrically. 50ml is taken from each of the 200ml measuring flasks and put into four corresponding 150ml conical flasks. To each of these is added 25ml of N/10 iodine solution and 3ml of N sodium hydroxide, shaken and allowed to stand for 15 minutes. (To prevent loss of iodine the flasks are covered by loose glass stoppers). At the end of this time the four solutions are each acidified by an addition of 4.5ml o N sulphuric acid and the unreacted iodine titrated with N/10 thiosulphate solution until the disappearance of the blue colour. The reacted iodine should lie between 6 and 12 ml, otherwise the tests are repeated with more or less malt.

The results are calculated as grams of maltose which would be produced under the specified conditions by 100 g of malt. The number of ml of iodine reacted, after substracting the blank, is multiplied by a factor to give the result. These factors are:

| | Multiplied by |
|---|---|
| When 10g of malt is used the net ml of N/10 iodine | 68.4 |
| When 20g of malt is used the net ml of N/10 iodine | 34.2 |
| When 40g of malt is used the net ml of N/10 iodine | 17.1 |

The results so obtained are in Windisch-Kolbach units.

### 3.44 Micro-malting Tests

Micro-malting tests are useful to determine the general behaviour of a new seasons crop of barley and the behaviour of different batches of barley in advance of malting on the commercial scale. Commercial equipment, allowing the simultaneous processing of 8 x 1kg lots of barley. and including apparatus for steeping, germination and kilning, is available for such tests. It is expensive and in the ordinary way would not be recommended for control purposes in a small maltings. It is however envisaged that in time the maltings will co-operate in the assessment of the malting quality of barleys derived from agricultural studies and for this reason it would be advisable to equip the laboratory of the maltings with micro-processing equipment.

### 3.45 Type and cost of Equipment Required

The more important pieces of laboratory apparatus required to carry out the foregoing analytical tests are shown in the following list. The cost of each item, quoted ex-supplier, is given in Rwandan Francs (FRw) on the basis of the present (July 1971) rate of exchange.

| | Fkw |
|---|---|
| **Mills** | |
| 1 x EBC Casella Mill | 57,500 |
| 1 x Moulinex Coffret No.3 | 1,750 |
| **Balances** | |
| 1 x Infra-red MV660 moisture balance | 17,500 |
| 1 x Top pan Mettler P1200 reading up to 1200g to 0.001g | 62,750 |
| 1 x Single pan Mettler H10 automatic balance reading to 0.1mg | 45,500 |
| 1 x Steinmetz 4-place St 2 mash bath | 52,250 |
| 1 x Kjeldahl combined digestion and distillation unit | 37,500 |
| 1 x Prometer rapid nitrogen apparatus | 123,750 |
| 1 x Marconi, Model TF 933A moisture meter | 16,750 |
| 1 x Foss Electric Vitascope | 42,500 |
| 1 x Gallenkamp Size 1BS Oven | 35,500 |
| 1 x Lovibond AF 607/EBC Comparator and cells | 17,500 |
| 1 x EIL Model 23A direct reading pH meter | 37,500 |
| 1 x Townson and Mercer constant temperature bath complete with stirrer, refrigeration unit and adjustable shelf | 90,750 |
| 1 x Gallenkamp Cooled Incubator | 45,000 |
| 1 x Raleigh Model 2 deconiser | 23,750 |
| 1 x Reeves Sample Divider | 5,600 |
| 1 x Walking Stick grain sampler for taking samples from open sacks and bins | 1,600 |
| 1 x Farinator | 2,000 |
| 1 x Set of slotted steel sieves of 2.2,2.5 and 2.8mm | 1,700 |
| 1 x Seeger micro-malting apparatus including cooling equipment and sections for steeping, germination and kilning | 1,011,000 |
| Miscellaneous equipment (glassware etc) | 100,000 |
| 15m fully equipped benches and fume cupboard | 240,000 |
| | 2,069,650 |

## 4. ECONOMIC AND FINANCIAL STUDY

### 4.1 Location

#### 4.11 General Requirements

As both the barley growing region and the brewery are situated in the northern part of Rwanda it is clear that the maltings should be situated in this area of the country. Two locations present themselves as appropriate sites: a) Gisenyi, near to the brewery and b) Ruhengeri, which lies between the barley growing region and the brewery.

The choice of a site at Gisenyi adjacent to the brewery has numerous advantages:

i) It is adequately supplied with electricity and water.

ii) It is possible that services available in the brewery could be shared with the maltings.

iii) Direct connection could be established between the maltings and the brewery thus minimising handling costs.

iv) It has a good road connection to the barley farms.

As far as Ruhengeri is concerned it is proposed that the maltings could conveniently be sited near the new pyrethrum plant, which is scheduled to go into production in January 1972. Ruhengeri is adequately supplied with water and although there may be a shortage of electricity in the short-term, plans are already in hand for increased production. It is also situated on the main road between the barley growing area and the brewery. The most important advantage of Ruhengeri would be that engineering and workshop facilities could definitely be made available in accordance with a part of the declared purpose of the pyrethrum project, which reads as follows:

> "A secondary purpose of this project is to stimulate the future industrialisation of the country by utilising the services of the plant and investing the profits resulting from its operation to develop other industrial activities" (Extract from paragraph 3, page 5 of Plan of Operation for Pyrethrum Plant - reference UNIDO/TCD/SF5).

Both sites have similar climatic conditions and each has an adequate local labour force immediately to hand. We consider however that the presence of engineering services in Ruhengeri is more important to the success of the project than the marginal savings in handling costs to be realised by having the maltings adjacent to the brewery. Without these services, the maltings might have to employ an expatriate engineer and this would have a major adverse effect on overheads. We consider that there are also advantages to be had from a site nearer to the barley growing areas, since this will facilitate the rather tricky problem of getting barley quickly from the harvest into the maltings before it has time to spoil. Furthermore, the transport of malt presents a much more straightforward organisational problem, requiring a regular and simple point to point operation.

4.12 Fuel, Power and Water Requirements

The major infrastructure requirements are for fuel, power and water. The requirements for a malt output of 2000 metric tons are as follows:

Fuel oil, 1 metric ton per 10 metric tons of malt, a total of 200 metric tons.

Electricity, 78 kwh per ton of malt, a total of 156,000 kwh Installed capacity 344KW

Water, 7 cu. metres per ton of barley at 12% moisture, a total of 16,600 cubic metres.

The cost of the above items is detailed in section 4.32 following.

## 4.2 Personnel and Training requirements

### 4.21 Personnel Requirements

The type of staff and the qualifications they require are given in Table 4.I. It can be seen that the plant is highly capital intensive. The total number of employees is only 10 so that with a fixed capital* of FRw61,393,000 the capital per employee is no less than FRw6,139,300. There is no possibility of substitution of unskilled labour for capital at the scale of production of malt envisaged (i.e. 2,000 metric tons). The number of employees given is the maximum which can be genuinely employed in a maltings under the conditions prevailing in Rwanda and it should be possible to increase output substantially without any increase in labour requirements.



*Buildings and equipment only plus contingency.

As there is unlikely to be a Rwandese with experience of malting the manager will almost certainly have to be an expatriate, but a Rwandese assistant manager should rise to be co-manager after a period of some three years and would be expected to take over from the manager after a period of five years. Because of the limited career prospects it might prove difficult to obtain a manager with the requisite qualifications and experience demanded. One way around this difficulty might be to give the management contract to another malting company should it be possible to attract equity from such a source.

No difficulty is envisaged in recruiting the remaining staff. It might not be possible to find suitable laboratory assistants with secondary school education but in this case it would probably be possible to employ an applicant with only primary school education although a longer period of official training would be required than the two months allowed here. The manual staff will need to be of high calibre since they must be trained, for example, to read and record temperature gauges. Malting, by its nature, requires a shift system and it is envisaged that two men will be on duty during the day shift and one man on each of the two other shifts. Consequently a manual worker will on occasion be the only employee in the works and each must therefore be highly responsible. The labourers should therefore be classified as semi-skilled workers and paid accordingly.

The maltings would also require the occasional services of a technician/maintenance engineer for the overhaul and replacement of machinery, a plumber and electrician. Such skilled labour is in desperately short supply in Rwanda. However if the maltings is sited in Ruhengeri it should be possible to draw on the engineer from the pyrethrum plant. A self-employed plumber and electrician should also be available in this place.

Table 4.I - Personnel Requirements of Maltings

| Full Time Staff | Number | Qualifications |
|---|---|---|
| Managing Director | 1 | At least 5 years experience as manager or assistant manager of a maltings. Probably expatriate. |
| Assistant manager (later co-manager) | 1 | Chemistry graduate. No experience required. |
| Laboratory assistants | 2 | Some post-primary education. Preferably including science. |
| Secretary/office worker | 1 | Typing and book-keeping experience. |
| Skilled labourers | 5 | None but ability to learn simple techniques. |
| TOTAL | 10 | |
| **Part Time Staff** | | |
| Technician/maintenance engineer | 1 | Degree and three years of experience. Probably expatriate. |
| Plumber | 1 | Plumbing qualifications and experience. |
| Electrician | 1 | Electrician's training and experience. |
| TOTAL | 3 | |

4.22 Suggested Training Programme

The assistant manger, laboratory assistants and manual labourers will all require some specific period of instruction.

We recommend that the assistant manager should be seconded to a European maltings for three months. During this period he should familiarise himself with all aspects of malt production including intake and assessment of barley quality, sampling methods both for barley and malt, steep house procedure, the management of germination and kilning processes and the normal practices of quality control. He could also work for a period in the quality control laboratory. As the harvest in Europe is usually collected in the months of August and September it would clearly be desirable that his training period covers at least part of this period. We therefore suggest that he leaves Rwanda in July 1976 and returns to take up his post in October to be present during the dummy runs and start-up of the plant. Further details are given in the timetable in section 5.1.

The cost of this secondment would depend upon the terms agreed with the maltings. If, as we suggest, the brewery and/or a malting company have some financial stake in the proposed Rwandan plant, it might be possible to obtain the training free. Alternatively, the cost might be borne under a technical assistance programme. The cost, excluding the training element, for a three-month stay would amount to around FRw 289,800 of which a subsistence allowance of about FRw 2,400 per day would come to FRw 216,000 and return fare to Europe of FRw 73,800.

The laboratory assistants would need to be instructed in the series of tests outlined in section 3.4. Instruction in the germination tests could probably be obtained at the ISAR research centre in Rubona and the malting tests at the brewery in Gisenyi. The instruction should take around two months. Because the ISAR station is a government station and because the brewery will probably have a financial interest in the maltings, it is assumed that no charge need be allowed for the training. The only cost that would be involved would be a small subsistence allowance which is calculated at FRw 200 ($2)per day. The total cost of training for the two assistants for two months would then be FRw 24,000.

The training of manual workers is vital to the effective operation of the plant. It should, however, be possible for this training to take place on site during the two-month period assigned to "dummy runs". Accordingly, there will be no specific costs other than salaries which are included in the pre-operational costs of the project. The following table summarises the training costs of the above programme.

Table 4.11 - Training Programme Costs

| | |
|---|---|
| 1 Assistant manager (3 months assignment in Europe) | FRw 289,800 |
| 2 Laboratory assistants (assignment to laboratories in Rwanda) | 24,000 |
| 3 | 313,800 |

The labour costs of the plant both before and during operations are given in section 4.34.

## 4.3 Production Costs

### 4.31 Barley Purchase and Finance

The ex-farm price of barley has been put at FRw8 per kilo. Although this is no higher than the price of the alternative crop, wheat, as pointed out in section 2.1, the yields to be expected from barley are higher than from wheat so that, at this price, cash incomes from barley could be up to one third higher than from wheat. This is thought to constitute sufficient incentive to ensure adequate production. The full price would only be paid for sound barley free from mould or discoloration with 6 per cent or under of screenings and a moisture content of 23 per cent or below. Barley which fell slightly below the specified quality in relation to screenings would be accepted but with a price differential sufficient to compensate for its lower yield of malt. The cost of manning collection centres for the barley and the transport to Ruhengeri has been put at FRw2 per kilogramme, or the same as the cost incurred by the brewery in 1967 for the collection of barley and its transport to Gisenyi, some 170 kilometres from Byumba. Ruhengeri is about 60 kilometres closer to Byumba and the cost might therefore be somewhat lower in practice. However, considerable difficulty was experienced with transport and additionally we recommend more rigorous control of collection. Accordingly, a high estimate seems desirable. The total cost of barley delivered to the maltings would then be FRw10 per kilo. Allowing for a 2 per cent loss in screening and an 8 per cent malting loss, the maltings would require 2,678 metric tons of raw barley for a malt production of 2,000 metric tons.

In order to prevent a loss of quality between the time that the barley is harvested and the time when it is required for malting, we have recommended in section 2.32 that the barley should be purchased by the maltings immediately after harvesting so that it can be dried and stored under optimum conditions. It will therefore be necessary to provide bridging finance for the crop to cover the time between the actual purchase of barley and the sale of malt. It is common practice for commercial banks to provide self-liquidating bridging loans for this purpose. The following table shows how such a loan would be repayed, after a 4 month period of grace, in eight instalments. The ruling rate of interest in such loans in Rwanda is 9 per cent.

Table 4.III - Typical Bridging Loan for Crop Finance (FRw)

| Month | Amount loaned end month | Amount outstanding during month | Amount Repayed End month | Interest paid end month |
|---|---|---|---|---|
| Aug. | 1000 | - | - | - |
| Sept. | | 1,000 | - | 7.50 |
| Oct. | | 1,000 | - | 7.50 |
| Nov. | | 1,000 | - | 7.50 |
| Dec. | | 1,000 | - | 7.50 |
| Jan. | | 1,000 | 125 | 7.50 |
| Feb. | | 875 | 125 | 6.56¼ |
| Mar. | | 750 | 125 | 5.62½ |
| Apr. | | 625 | 125 | 4.68¾ |
| May | | 500 | 125 | 3.75 |
| June | | 375 | 125 | 2.81¼ |
| July | | 250 | 125 | 1.87½ |
| Aug. | | 125 | 125 | 93¾ |

It will be seen that the total interest payable on such a loan comes to 63.75 per 1,000 or 6.375 per cent.

The total annual costs of barley purchase and finance are therefore:

| | FRw |
|---|---|
| At Production Level of 2,000 metric tons of malt | |
| 2,678 metric tons of barley at FRw10 per kilo, delivered | 26,780,000 |
| Interest on crop finance at effective rate of 6.375 per cent | 1,707,225 |
| For Each Additional Metric Ton of Malt | |
| 1.339 metric tons of barley at FRw 10 per kilo, delivered | 13,390 |
| Interest on crop finance at 6.375 per cent | 854 |

4.32 Fuel, Electricity and Water

Fuel oil is required for the drying of both barley and malt and will represent a considerable expense to the maltings. The average consumption of fuel oil is at the rate of 1 ton per 10 tons of malt produced. The price of fuel oil delivered to another industrial plant in Rwanda in 1970 was FRw10,200 per ton. On this basis annual fuel costs would be:

| | FRw |
|---|---|
| At a production level of 2,000 metric tons of malt | 2,040,000 |
| For each additional metric ton of malt | 1,020 |

As far as electricity is concerned the installed capacity of the plant is expected to be 344 KW and it is estimated that electricity consumption will be 78 kwh per ton of malt. In Rwanda, electricity is charged on a two-way tariff, a fixed annual charge of FRw 500 per KW installed and a variable charge of FRw 0.7 per kwh consumed. On this basis the annual electricity costs would be:

| | FRw |
|---|---|
| At a production level of 2,000 metric tons of malt | |
| Fixed charge of FRw500 per KW installed | 172,000 |
| Variable charge of FRw 0.7 per kwh consumed | 109,000 |
| For each additional metric ton of malt | |
| Variable charge of FRw 0.7 per kwh consumed | 55 |

The requirement for water is estimated to be 7 cubic metres per metric ton of barley, at 12 per cent moisture content. The 2,678 metric tonsof barley, at 20 per cent moisture content, required for 2,000 metric tons of malt reduces to 2,365 metric tons of barley at 12 per cent. The cost of water is FRw10 per cubic metre. On this basis the annual water costs would be:

| | FRw |
|---|---|
| At a production level of 2,000 metric tons of malt | 166,000 |
| For each additional metric ton of malt | 83 |

The total costs under this heading therefore come to

| | FRw |
|---|---|
| For 2,000 metric tons of malt | 2,487,000 |
| For each additional metric ton of malt | 1,158 |

### 4.33 Insurance

The average cost of insurance for equipment in maltings in the United Kingdom would be 0.25 per cent, and the insurance of buildings would be rather less. It has not been possible to obtain comparable quotations for Rwanda but the rates will certainly be higher. Accordingly we have assumed a rate of 0.5 per cent. The value of buildings and equipment is estimated at about FRw 56 million (for details see section 4.41). The annual insurance would therefore come to FRw 280,000.

It will also be necessary to insure the barley crop at a similar rate. However, since the stock of barley varies at different times in the year, we have applied an effective rate of 0.25 per cent. The annual costs are therefore:

| | |
|---|---|
| At a production level of 2,000 metric tons of malt | FRw |
| Barley stocks of value FRw 26,780,000 at 0.25 per cent | 66,950 |
| For each additional metric ton of malt | |
| Barley stock of value FRw 13,390 at 0.25 per cent | 33 |
| The total insurance costs are therefore | |
| For 2,000 metric tons of malt | 347,000 |
| For each additional metric ton of malt | 33 |

### 4.34 Labour Costs

The following table shows the estimated cost of labour based on the requirements for personnel described in section 4.21. For Rwandese employees social security payments have been put at 5 per cent. For the expatriate manager this item includes his insurance, pension and overseas leave allowance.

After 5 years it is envisaged that the general manager should return to Europe and that his assistant should take over. Although not strictly necessary, it will probably be prudent to appoint a new assistant manager. The salary of the Rwandese general manager has been estimated at FRw500,000 per annum +5 per cent social security +5 per cent additional pension, making a total of FRw550,000. This represents a saving of FRw1,150,000 per annum, so that in the sixth and subsequent years the total labour costs will be reduced from FRw2,554,000 to FRw1,404,000 per annum.

Table 4.IV - Annual Labour Costs of Maltings (FRw000s)

| Full Time Staff | Salary | Social Security | Total |
|---|---|---|---|
| General Manager (expatriate) | 1,400 | 300 | 1,700 |
| Assistant Manager | 180 | 9 | 189 |
| 2 Laboratory Assistants, total | 148 | 7 | 155 |
| Office worker | 48 | 2 | 50 |
| 5 Semi-skilled Workers | 120 | 6 | 126 |
| TOTAL | 1,896 | 324 | 2,220 |

| Bought-in Engineering Services | |
|---|---|
| Engineer (expatriate) 26 working days per year, cost is assumed to be based on 230 day year at rate of salary x 2 | 316 |
| Plumber and electrician, 52 days each per year at FRw175 per day | 18 |
| Total | 334 |
| Grand Total | 2,554 |

Labour costs will not increase with output because the plant will have to be manned all round the clock anyway and production can be increased up to 3,000 tons a year without needing additional capital and thus without requiring workers to man additional machines.

4.35 Other Costs

An allowance of FRw 300,000 per annum has been included to cover the running expenses of theoffice and laboratory, the running costs of the company vehicles and any other items not elsewhere specified.

4.36 Summary Costs of Production Programme

The following table draws together the results of the costings carried out above. A customary 10 per cent is added for contingencies.

**Table 4.V - Production Costs of Malt**

| Item | Cost of 2,000 tons of Malt (FRw000s) | % | Marginal Cost per Ton (FRw) |
|---|---|---|---|
| Purchase of Barley | 26,780 | 71.3 | 13,390 |
| Crop Finance | 1,707 | 4.5 | 854 |
| Fuel, Electricity, Water | 2,487 | 6.6 | 1,158 |
| Insurance | 347 | 1.0 | 33 |
| Labour Costs | 2,554 (1) | 6.7 | 0 |
| Office, Laboratory and Miscellaneous expenses | 300 | 0.8 | 0 |
| Sub-total | 34,175 | 90.9 | 15,435 |
| Contingency 10% | 3,418 | 9.1 | 1,544 |
| TOTAL | 37,593 | 100.0 | 16,979 |

Note: (1) Reduced by FRw 1,150,000 after 5 years.

As described in section 1.2, the market for malt in the middle seventies is expected to be around 2,000 tons annually exclusive of any windfall exports. In establishing a production programme we have taken this as the initial level for the year Dec.1976-Nov.1977. Demand is assumed to increase at an annual rate of 4.1 per cent. No account is taken of possible exports for the reasons given in section 1.3. Table 4.VI following gives the proposed production levels and the estimated production costs in the ten years of the project.

Table 4.VI - Production Programme and Costs 1977-1986

| Year (1) | Output Metric tons | Production Cost (FRw000s) |
|---|---|---|
| 1977 | 2,000 | 37,573 |
| 1978 | 2,082 | 38,965 |
| 1979 | 2,167 | 40,408 |
| 1980 | 2,256 | 41,920 |
| 1981 | 2,349 | 43,499 |
| 1982 | 2,445 | 43,979 |
| 1983 | 2,545 | 45,677 |
| 1984 | 2,650 | 47,459 |
| 1985 | 2,758 | 49,293 |
| 1986 | 2,871 | 51,212 |

Note: (1) Year ending November 30.

## 4.4 Capital Costs

### 4.41 Fixed Capital

Normally, it would be necessary to include an estimate of the cost of land to be occupied by a maltings. In Rwanda, however, a precedent has been set in the case of a pyrethrum plant where the government provided the land free of charge. We recommend that the same procedure should be adopted in the case of the maltings and accordingly the land has been costed at zero.

Sections 3.2 and 3.3 above have described the main technical and constructional features of the proposed plant. The costs of equipment have been estimated by the consultants as a result of discussions with a UK manufacturer of such equipment and estimates have been included for the cost of transporting such equipment to Rwanda. The building costs were worked out by the consultants as a result of discussions with the company responsible for the construction of the pyrethrum plant and an allowance has been included for the necessary engineering supervision. The type of laboratory equipment and its cost, worked out from current catalogues, has been specified in section 3.45. A further allowance has been included for the cost of transport to Rwanda. Office furniture and equipment has been costed on the basis of ruling prices in Rwanda.

The costs for plant, machinery and equipment are:

| | FRw 000s |
|---|---|
| Land | – |
| Buildings | 15,360 |
| Equipment (inc.delivery) | 40,452 |
| of which malting equipment | 19,308 |
| grain handling and storage equipment | 18,324 |
| laboratory equipment | 2,320 |
| office equipment and furniture | 500 |
| **TOTAL** | 55,812 |

The cost of connecting basic services to the plant, such as sewage, power and water is likely to be small since these are available at the proposed location. A token amount of FRw10,000 is added for this purpose.

It is also intended to supply housing for the general manager and his assistant as fringe benefits. The cost of this housing has been calculated by applying a rate of FRw12,000 per sq. metre which we estimate to be the current average cost of new houses in Rwanda. Provision must also be made for the purchase of company vehicles. It is intended that the general manager and his assistant should each have a company car, and that a landrover or similar vehicle should be purchased for travelling as necessary to farming areas. No vehicles are provided for the transport of barley to the maltings or for the transport of malt to the brewery. This is because it is proposed to contract this work out to transport companies. Provision for this transport element has been made in calculating the production costs and ex-factory price of malt. The costs of housing and vehicles are:

| | | FRw 000's |
|---|---|---|
| Housing | | 2,440 |
| Of which: | general manager | 1,440 |
| | assistant manager | 1,000 |
| Vehicles, 2 cars, 1 landrover | | 900 |

The housing is assumed to have a residual value at the end of 10 years equal to its original cost. Since real estate is, in principle, likely to appreciate in value, this may be regarded as a conservative assumption.

4.42 Working Capital Requirements

Working capital is required for two purposes. Firstly it will be needed to cover the cost of the experimental barley crops and their testing which we feel is essential before a firm decision can be taken on whether to go ahead with the maltings project. Secondly, it will be needed to cover costs during the pre-operational period, including initial stocks of such items as fuel and packaging materials (sacks). The cost of financing crop purchases is not included in working capital because it will be covered by a commercial bank loan. The proposed loan and repayment schedule has been described in section 4.31 and the cost of this finance has been included in the production cost estimates.

For the crop experiments, the major cost will be the employment of a suitably qualified agronomist over a 3-year period. We feel, however, that supervision of the growing and tests will not constitute a full-time job and we assume that the agronomist will be shared with another project or projects in Rwanda. It is probable in our view that an expatriate will be required for this work and we assume that his costs will be similar to those for other expatriates, such as the general manager of the maltings. The costs of the actual growing will be small, but tests will need to be carried out in laboratories probably in Europe. The Consultants would be prepared to offer suitable facilities for such tests. The estimated cost of this growing and testing programme is:

| | FRw 000's |
|---|---|
| Agronomist's salary ($1\frac{1}{2}$ man-years spread over a total period of 3 years) | 2,550 |
| Growing expenses | 250 |
| Testing expenses, 3 years, total | 2,700 |
| Total | 5,500 |

As far as the pre-operational expenses are concerned, the main item will be labour. In section 5.1 we give details of the proposed timetable for the setting up of the maltings. Table 4.VII below is derived from this timetable and shows the number of man-months of employment in the pre-operational period, i.e., to November 30, 1976.

Table 4.VII - Labour Costs in the Pre-Operational Period

| | Date of Employment | Man-months | Annual Cost (1) (FRw 000's) | Total Cost (FRw 000's) |
|---|---|---|---|---|
| General Manager | June 1975 | 18 | 1,700 | 2,550 |
| Assistant Manager | July 1976 | 5 | 189 | 79 |
| 2 Laboratory Assistants | July 1976 | 5 | 155 | 65 |
| Office Worker | June 1975 | 18 | 50 | 75 |
| Semi-skilled workers | Sept.1976 | 3 | 126 | 32 |
| | | | | 2,801 |

The training programme for these workers has been described in section 4.22 and has been costed at FRw 313,800.

There will be substantial fuel costs during the pre-operating period as the raw barley collected from the first harvest must be dried. We have estimated that about one quarter of the annual fuel bill will cover this operation (FRw 510,000). As far as electricity is concerned, the cost should amount to little more than the standing charge for 3 months (FRw 43,000), while we have included a token FRw 10,000 for water consumption which is expected to be negligible. The fuel, power, and water costs therefore come to FRw 563,000 in total for the pre-operation period.

There will be some office expenses during the pre-operation period though the manager will be expected to work from his house. There will also be small items such as chemicals for the laboratory. These, and other miscellaneous expenses,are unlikely to be as heavy as during a normal operating year and we estimate that FRw 200,000 should be adequate to cover them.

Finally, the plant will require initial stocks of 6 weeks fuel oil supply and initial stocks of packaging materials, principally sacks. The stocks of fuel oil will cost FRw 235,000 and the sacks FRw 200,000. Since provision is made for replacement of these items in the operating expenses, this part of working capital will be recovered at the end of the project.

The following table summarises the working capital requirements.

Table 4.VIII - Working Capital Requirements (FRw 000's)

| | |
|---|---|
| Experimental barley growing and testing | 5,500 |
| Labour in pre-operational period | 2,801 |
| Training programme | 314 |
| Electricity, fuel, and water in pre-operational period | 563 |
| Office, laboratory, and other expenses | 200 |
| Initial stocks fuel oil | 235 |
| Initial stocks packaging materials | 200 |
| Total | 9,813 |

4.43 Summary Schedule of Capital Expenditure

The total capital requirements, as developed in sections 4.41 and 4.42, are summarised below. A customary 10 per cent has been added for contingencies.

Table 4.1X - Capital Budget for Establishment of Maltings (FRw 000's)

| Item | Amount |
|---|---|
| Land | 0 |
| Buildings | 15,360 |
| Equipment | 40,452 |
| Housing | 2,440 |
| Vehicles | 900 |
| Working capital | 9,813 |
| SUBTOTAL | 68,965 |
| Contingency 10 per cent | 6,897 |
| TOTAL | 75,862 |

The timing of capital expenditures has an important effect on the economic and financial viability of projects. It is therefore necessary to establish a schedule of capital expenditure giving details of the capital sums required on specific dates.

In the years 1971, 1972 and 1973 capital sums will be required for the barley growing experiments and tests in the following years. These experiments will cost FRw 5,500,000 plus 10 per cent contingency, and can be covered therefore by a capital subscription of FRw 2,000,000 on November 30, 1971 and on the same day in 1972 and 1973.

Since the general manager is to be appointed in June 1975, the capital subscription on November 30, 1974 will have to cover his house (FRw 1,440,000), his salary and other benefits for 6 months (FRw 850,000), the salary for 6 months of the office worker (FRw 25,000), at least one vehicle (FRw 300,000), and provision for office and miscellaneous expenses (FRw 100,000). Including 10 per cent contingency, this totals FRw 2,987,000.

The balance of capital will be required on November 30, 1975 since all construction, equipment, and other pre-operating costs will fall due in the following year.

The complete schedule of capital costs is therefore given in Table 4.X below.

Table 4.X - Schedule of Capital Payments (FRw 000's)

| Date | Amount |
|---|---|
| November 30, 1971 | 2,000 |
| November 30, 1972 | 2,000 |
| November 30, 1973 | 2,000 |
| November 30, 1974 | 2,987 |
| November 30, 1975 | 66,875 |
| Total | 75,862 |

## 4.5 Financial Analysis

### 4.51 Operating Surplus

The operating surplus is the amount by which revenue exceeds production costs. Hence it is the sum of money which, in principle, is available for distribution to the government by way of taxation and to the owners of capital, as a return either by means of interest payments or dividends.

The costs of the proposed production programme have been calculated in section 4.36. The revenue can be calculated by applying the selling price for malt to the proposed production volume. The present price of imported malt is FRw 27 per kilo, delivered at the Gisenyi brewery. This brewery is the only customer for the maltings and will need some real incentive before it can commit itself exclusively to the purchase of locally produced malt. It is suggested that this incentive should be a 10 per cent cut in the price of delivered malt from FRw 27 per kilo to FRw 24.3 per kilo. This would save the brewery FRw 5.4 million per annum, assuming a malt requirement of 2,000 tons by 1977. The cost of transport from the proposed maltings at Ruhengeri to Gisenyi has been estimated at FRw 0.7 per kilo, which gives an ex-factory price for the malt of FRw 23.6 per kilo.

In section 1.3 it was estimated that the maltings could sell for the export market at FRw 18.7 per kilo and still make 10 per cent on marginal production costs. However, for the reasons given in that section, we are not considering any export sales in our financial and economic assessment of the project because of the uncertainties involved. Similarly, there appears to be no market for by-products.

The following table summarises the likely growth of the operating surplus over the 10-year life of the project.

Table 4.XI - Operating Surplus of Maltings 1977-1986

| Year(1) | Output Metric tons | Revenue FRw 000's | Production Cost FRw 000's | Operating Surplus |
|---|---|---|---|---|
| 1977 | 2,000 | 47,200 | 37,573 | 9,627 |
| 1978 | 2,082 | 49,135 | 38,965 | 10,170 |
| 1979 | 2,167 | 51,141 | 40,408 | 10,733 |
| 1980 | 2,256 | 53,242 | 41,920 | 11,322 |
| 1981 | 2,349 | 55,436 | 43,499 | 11,937 |
| 1982 | 2,445 | 57,702 | 43,979 | 13,723 |
| 1983 | 2,545 | 60,062 | 45,677 | 14,385 |
| 1984 | 2,650 | 62,540 | 47,459 | 15,081 |
| 1985 | 2,758 | 65,089 | 49,293 | 15,796 |
| 1986 | 2,871 | 67,756 | 51,212 | 16,544 |

Note (1): Year ending November 30

4.52 Basic Financial Rate of Return

In a discounted cash flow (DCF) analysis of an investment project, the rate of return to the entrepreneur depends on the method of financing of the project. Generally, the lower the rates of interest at which the entrepreneur is able to borrow the better will be the DCF rate of return. However, entrepreneurs are seldom able to borrow all the money they need to invest and generally rates of interest on marginal borrowing tend to rise quite sharply. The choice is often therefore between borrowing a smaller sum of money at a lower average rate of interest, and borrowing a larger sum at a higher average rate of interest. The object of a financial appraisal is to calculate the rate of return to the entrepreneur, assuming the optimum financial structure.

The simplest way of doing this is to calculate the basic rate of return on the project. This is the hypothetical case where it is assumed that the entrepreneur has sufficient capital for investment at all times. Thus there is no need to borrow, and therefore no financing costs. When this rate has been calculated the optimum financial strcture can be derived. Basically, any borrowing at a lower rate than the basic rate of return is likely to improve the DCF rate of return, while any borrowing at a higher rate is likely to depress it. In carrying out this test, it must be remembered that the actual rate of interest on commercial loans is often different from the stated rate, so that a schedule of capital and interest payments must be worked out in full. Tax regulations may also lead to complications that require separate assessment.

As far as the present project is concerned, the basic rate of return can be derived from the schedule of capital payments given in section 4.43 and the operating surplus given in section 4.51 above. At this stage of the analysis it is not possible to take into consideration tax payable to the Rwanda Government on profits since this depends on the actual financing structure which is yet to be decided. The following table gives a full analysis of the basic financial return on the project.

Table 4.XII - Basic Financial Rate of Return of Maltings (FRw000's)

Payback period is 11.58 years.

Time-adjusted (internal) rate of return is 7.90 per cent.

Analysis of Cash Flows and Discounted Values (FRw000's)

| Year to November | Net Cash Flow | Cumulative Cash Flow | Present Value | Cumulative Present Value |
|---|---|---|---|---|
| 1971 | - 2,000 | - 2,000 | - 2,000 | - 2,000 |
| 1972 | - 2,000 | - 4,000 | - 1,854 | - 3,854 |
| 1973 | - 2,000 | - 6,000 | - 1,718 | - 5,571 |
| 1974 | - 2,987 | - 8,987 | - 2,378 | - 7,949 |
| 1975 | -66,875 | -75,862 | -49,340 | -57,290 |
| 1976 | 0 | -75,862 | 0 | -57,290 |
| 1977 | 9,627 | -66,235 | 6,101 | -51,189 |
| 1978 | 10,170 | -56,065 | 5,973 | -45,215 |
| 1979 | 10,733 | -45,332 | 5,842 | -39,373 |
| 1980 | 11,322 | -34,010 | 5,712 | -33,661 |
| 1981 | 11,937 | -22,073 | 5,581 | -28,080 |
| 1982 | 13,732 | - 8,341 | 5,951 | -22,129 |
| 1983 | 14,385 | 6,044 | 5,777 | -16,352 |
| 1984 | 15,081 | 21,125 | 5,613 | -10,738 |
| 1985 | 15,796 | 36,921 | 5,449 | - 5,289 |
| 1986 | 16,544 | 53,465 | 5,289 | 0 |

4.53 Sources of Finance

Since the basic rate of return on the project has been assessed at about 8 per cent, it is now possible to proceed to an examination of alternative sources of finance. In principle, this may come from internal (Rwandan) or external (foreign) sources.

Banks are the most important Rwandan sources of finance. There are two commercial banks, the Banque de Kigali and the Banque Commerciale du Rwanda. These extend medium- and short-term credit at rates of interest varying between 9 and 13 per cent depending on the creditworthiness of the borrower. They do not normally extend long-term loans and are in fact specifically prohibited from financing investment in housing. Moreover, their interest rates, minimum 9 per cent, are rather too high in relation to the basic rate of return on the project.

The Banque Nationale du Rwanda, the central bank, only lends money to government departments and public bodies.

The Banque Rwandaise de Développement is the most likely source of funds. It was established in 1967 with an initial capital of FRw 50 million and is specifically charged with the encouragement of all types of investment in Rwanda. Under the terms of its charter it may participate in the equity of a concern but, owing to the shortage of funds, most of its assistance has been in the form of medium- and long-term loans. The funds for these loans are not derived from its capital but are borrowed direct from the Banque Nationale. No official limit has been placed on the funds which the Banque de Développement may obtain in this way. Certain of its loans have been substantial: for instance, a recent loan to a tea processing plant amounted to no less than FRw 33 million and was repayable over 30 years. The rate of interest charged by the Banque de Développement is normally 3 per cent but may vary between 3 and 9 per cent. The 3 per cent is clearly a concessionary rate involving a subsidy element. It would only be possible to justify a loan from this source if the malting project is attractive from the standpoint of the Rwanda economy but is unattractive from a purely financial standpoint. Needless to say, a 3 per cent loan would considerably improve the DCF rate of return on the project.

Overseas finance may come either from official or private sources. As far as official sources are concerned, "soft" loans, i.e., loans at low rates of interest, might be obtained from a number of international agencies or a variety of aid-giving countries. At the present time it is too early to evaluate just which bodies might be prepared to provide resources for a project which might or might not take place four years from now. However, the cost of the barley growing experiments and tests on the grain represents a relatively small capital outlay in the next three years. In our opinion, the United Nations should be asked to provide a grant for the technical assistance necessary in this context.

Funds for the purchase of equipment could be obtained through any of the export credit schemes operated by the major industrial countries. The British scheme which is run by the Export Credit Guarantee Department (ECGD) carries a rate of interest of $7\frac{1}{2}$ per cent at the present time. Such credit is normally available for 80 per cent of the exported equipment repayable over 7 years from commissioning. The loan must be guaranteed by a first class bank. Other industrialised countries have broadly comparable schemes. Rwanda could probably raise a maximum of FRw 30 million in this way.

The maltings would be unlikely to attract capital from private overseas sources since these require anything from 12 to 15 per cent on a debenture-type investment and anything from 16 to 20 per cent on a pure equity investment. With a basic rate of under 8 per cent the project clearly could not sustain such terms. There are, however, two private sources that might be interested for special reasons. The first of these is the company that owns the brewery at Gisenyi. It has been stated on several occasions that the whole project depends on the malt being acceptable to the brewery, and that there can be no question of permitting malt imports into Rwanda once the maltings is set up. Consequently, the brewery has a vested interest in the project. We have already recommended that the support of the brewery should be obtained through a 10 per cent cut in the delivered price of barley. This would save the brewery some FRw 5.4 million per annum. In our view it would be reasonable to ask the brewery to put at risk no more than 3 years' savings that it stands to make as a result of the project. Even if the entire project failed after 3 years, the brewery would then be no worse off than if it had had to import malt the whole time. Every effort should therefore be made to enlist the active support of the brewery to the extent of about FRw 16 million. A guaranteed price for malt in the first three years might also prove attractive to the brewery. A second private source of funds might be an international malting company, such as those who have supplied the brewery in the past. This project could offer some protection against declining export markets.

It is premature, at the present time, to come to definitive recommendations on the proposed sources of finance. The consultants are prepared, if and when the final decision to go ahead is taken, to assist the Government of Rwanda with applications to international financial sources, and to arrange for negotiations with commercial interests.

Despite what is said in the above paragraph, we have formulated a specific financing scheme. This is for illustrative purposes, and to test the DCF rate of return. In summary it is:

(1) Equity capital held by the Intebra Company and/or an international malting company

- Authorised: FRw 16,000,000
- Forecast Issued FRw 15,862,000

(2) ECGD or equivalent loan at $7\frac{1}{2}$ per cent repayable over 7 years from date of commissioning, guaranteed by a first class bank

- FRw 30,000,000

(3) Loan by the Banque Rwandaise de Développement at 3 per cent, repayable over 10 years from date of commissioning

- FRw 24,000,000

(4) Grant of Technical Assistance from the UN or bilateral aid agency

- FRw 6,000,000

4.54 Cash Flow Estimates for Equity Investors

The financing scheme proposed for illustrative purposes in the last paragraph of the previous section enables a calculation of cash flow estimates.

The following two tables show the schedule of repayments on the two loans referred to above.

Table 4.XIII - Schedule of Repayments on a Loan by the ECGD or Equivalent of FRw 30 million over 7 years (FRw 000's)

| Year to November 30 | Amount Borrowed | Amount Outstanding | Interest Payments (1) | Capital Repayments | Total Payment |
|---|---|---|---|---|---|
| 1975 | 30,000 | -- | -- | -- | -- |
| 1976 | | 30,000 | 2,250 | -- | 2,250 |
| 1977 | | 30,000 | 2,250 | 4,286 | 6,536 |
| 1978 | | 25,714 | 1,929 | 4,286 | 6,215 |
| 1979 | | 21,428 | 1,607 | 4,285 | 5,892 |
| 1980 | | 17,143 | 1,286 | 4,286 | 5,572 |
| 1981 | | 12,857 | 964 | 4,285 | 5,249 |
| 1982 | | 8,572 | 643 | 4,286 | 4,929 |
| 1983 | | 4,286 | 321 | 4,286 | 4,607 |

Note: Rate of interest $7\frac{1}{2}$ per cent.

Table 4.XIV - Schedule of Payments on a Loan by Banque Rwandaise de Développement of FRw 24 million over 10 years (FRw 000's)

| Year to November 30 | Amount Borrowed | Amount Outstanding | Capital Repayment | Interest Payment (1) | Total Payment |
|---|---|---|---|---|---|
| 1974 (2) | 3,000 | -- | -- | -- | -- |
| 1975 | 21,000 | 3,000 | -- | 90 | 90 |
| 1976 | | 24,000 | -- | 720 | 720 |
| 1977 | | 24,000 | 2,400 | 720 | 3,120 |
| 1978 | | 21,600 | 2,400 | 648 | 3,048 |
| 1979 | | 19,200 | 2,400 | 576 | 2,976 |
| 1980 | | 16,800 | 2,400 | 504 | 2,904 |
| 1981 | | 14,400 | 2,400 | 432 | 2,832 |
| 1982 | | 12,000 | 2,400 | 360 | 2,760 |
| 1983 | | 9,600 | 2,400 | 288 | 2,688 |
| 1984 | | 7,200 | 2,400 | 216 | 2,616 |
| 1985 | | 4,800 | 2,400 | 144 | 2,544 |
| 1986 | | 2,400 | 2,400 | 72 | 2,472 |

Notes: (1) Rate of interest 3 per cent.
(2) Government loan covers all pre-operational expenses up to November 30, 1975 other than those to be covered by UN or bilateral technical assistance programme.

The next step is to calculate the tax liability of the maltings. We believe that, under the Rwandan investment code, the maltings should be entitled to favoured treatment of at least Status B.

Basically this means that the enterprise will be free of all taxes and duties on initial equipment and from all taxes on profits for the first five years of its operation. We base this belief on the fact that this was the treatment accorded to the pyrethrum plant, which in our view is an enterprise comparable to the maltings. Tax liability after five years also depends on whether or not tax losses may be carried forward and on what provisions are made for depreciation to be tax deductible. These matters need to be discussed in detail by legal and tax experts familiar with Rwandan laws. Our assumption at present is that tax losses are not carried forward and that depreciation on the entire capital, other than working capital, is deductible at 10 per cent per annum over the 10-year life of the project. Our calculation of tax liability on this basis is given in the following table.

Table 4.XV - Assessment of Tax Liability 1982-1986 (FRw 000's)

| Year to November 30 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|
| Operating surplus | 13,723 | 14,385 | 15,081 | 15,796 | 16,544 |
| Interest payable [1] | 1,003 | 609 | 216 | 144 | 72 |
| Profit before depreciation and taxation | 12,720 | 13,776 | 14,865 | 15,652 | 16,472 |
| Depreciation [2] | 6,507 | 6,507 | 6,507 | 6,507 | 6,507 |
| Taxable profit | 6,203 | 7,269 | 8,358 | 9,145 | 9,965 |
| Tax payable [3] | 2,641 | 3,121 | 3,641 | 3,965 | 4,334 |

Notes: (1) Interest element of repayments detailed in tables 4.XIII and XIV
(2) Total depreciable capital is total capital less working capital and includes contingencies. It is FRw 65,067,000.
(3) Tax is 25 per cent on first FRw 500,000, 35 per cent on second FRw 500,000, and 45 per cent on the balance.

These calculations are sufficient to enable the preparation of a complete cash flow estimate. This is given in table 4.XVI. It will be noted that in 1975 and 1976 interest payments will have to be met on loans but the plant will not be in operation. This negative cash flow is financed by a bank overdraft at 9 per cent. In 1976 the operating surplus is not quite sufficient to cover capital and interest repayments so that the overdraft is further increased. In 1978 and in 1979 the operating surplus covers loan interest and repayments but it is used entirely to reduce the bank overdraft.

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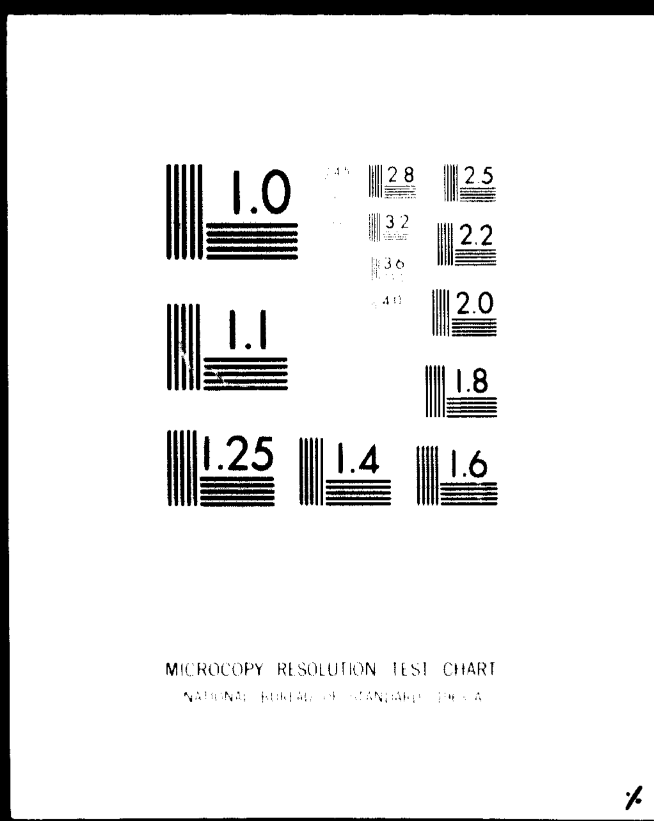
1.0
2.8
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Table 4.XVI

## CASH FLOW ESTIMATES FOR MALTINGS 1975-1986

(FRw000s)

| Year Ending Nov. 30 | Capital Payments | Operating Surplus | ECGD Finance | Banque de Dévelopment Finance | Tax Liability | Cash Flow | Overdraft | Servicing of Overdraft(1) | Net Cash Flow |
|---|---|---|---|---|---|---|---|---|---|
| 1975 | - 16,000(2) | | | - 90 | | -16,090 | 90 | | -16,000 |
| 1976 | | | -2,250 | - 720 | | - 2,970 | 3,060 | - 8 | - 8 |
| 1977 | | + 9,627 | -6,536 | -3,120 | | - 29 | 3,089 | -275 | - 275 |
| 1978 | | +10,170 | -6,215 | -3,048 | | + 907 | 2,182 | -278 | - 278 |
| 1979 | | +10,733 | -5,892 | -2,976 | | + 1,865 | 317 | -196 | - 196 |
| 1980 | | +11,322 | -5,572 | -2,904 | | + 2,846 | | - 29 | + 2,500 |
| 1981 | | +11,937 | -5,249 | -2,832 | | + 3,856 | | | + 3,856 |
| 1982 | | +13,723 | -4,929 | -2,760 | -2,641 | + 3,393 | | | + 3,393 |
| 1983 | | +14,385 | -4,607 | -2,688 | -3,121 | + 3,969 | | | + 3,969 |
| 1984 | | +15,081 | | -2,616 | -3,611 | + 8,854 | | | + 8,854 |
| 1985 | | +15,796 | | -2,544 | -3,965 | + 9,287 | | | + 9,287 |
| 1986 | + 2,975(3) | +16,544 | | -2,472 | -4,334 | +12,713 | | | +12,713 |

NOTES:
(1) Estimated at 9 per cent interest
(2) Equity outlay
(3) Residual value, for details see section 4.4

The analysis of cash flows and discounted values is given in Table 4.XVII following.

Table 4.XVII - Estimated Financial Return on Equity Invested in Maltings

The pay back period is 8.34 years.

The time-adjusted (internal) rate of return is 11.84 per cent.

Analysis of Cash Flows and Discounted Values (FRw000's)

| Year to November | Net Cash Flow | Cumulative Cash Flow | Present Value | Cumulative Present Value |
|---|---|---|---|---|
| 1975 | -16,000 | -16,000 | -16,000 | -16,000 |
| 1976 | - 8 | -16,008 | - 7 | -16,007 |
| 1977 | - 275 | -16,283 | - 220 | -16,227 |
| 1978 | - 278 | -16,561 | - 199 | -16,426 |
| 1979 | - 196 | -16,757 | - 125 | -16,551 |
| 1980 | 2,500 | -14,257 | 1,429 | -15,122 |
| 1981 | 3,856 | -10,401 | 1,970 | -13,152 |
| 1982 | 3,393 | - 7,008 | 1,550 | -11,602 |
| 1983 | 3,969 | - 3,039 | 1,621 | - 9,980 |
| 1984 | 8,854 | 5,815 | 3,234 | - 6,746 |
| 1985 | 9,287 | 15,102 | 3,033 | - 3,713 |
| 1986 | 12,713 | 27,815 | 3,713 | 0 |

A DCF rate of return of just under 12 per cent is not particularly attractive to a private investor. It is for this reason that we are inclined to feel that the brewery which stands to make far bigger gains from a reduced malt price if the project goes ahead is probably the only private investor likely to be interested on a substantial scale. Other malting and brewing interests might take up a token amount of the equity in order to protect declining export markets.

## 4.6 Economic Analysis

### 4.61 Rate of Return

The economic analysis differs from the financial analysis since it is based not on the actual prices ruling in the market but on the opportunity cost of resources, i.e. their cost in the best alternative usage. Within the scope of the present project it has not been possible to undertake a full-scale social-cost benefit analysis of the kind that might seem desirable. However, we feel it is worth making some general observations.

From the point of view of the economy, the price of barley is simply the price of the next most lucrative crop that could be grown on the same land (i.e., wheat). Although wheat and barley are both priced at FRw 8 per kilo, the yield of wheat per hectare is about 25 per cent lower than the yield of barley, so that the economic price of barley must be reduced from FRw 8 per kilo to FRw 6 per kilo, giving a delivered price of barley at the maltings of FRw 8 per kilo. On the other hand, the economic price of malt is its import price of FRw 27 per kilo, less the cost of delivery from the maltings to the brewery, which we have calculated at FRw 0.7 per kilo. This gives a malt price of FRw 26.3 per kilo. Ideally, this should be adjusted by means of a shadow exchange rate since foreign exchange is a bottleneck in Rwanda, at least at the official rate. However, this would involve a detailed study of the price and income elasticities of demand for Rwanda's imports and exports, and a study of Rwanda's tariff structure. These were outside the level of resources provided for this study, so we have assumed that the existing rate of exchange is sufficiently realistic as not to upset entirely this economic assessment.

Production costs, other than raw materials, are assumed to be reflected accurately by their market prices. The high price of expatriate labour reflects the shortage of qualified people in Rwanda. However, we make no reduction in labour costs when the expatriate manager returns to Europe, because even though the Rwandese general manager will be paid less, he could in principle be substituted for another highly paid expatriate elsewhere in the economy.

The following tables give details of the production costs and operating surplus on the shadow pricing assumptions detailed above.

Table 4.XVIII- Real Production Cost of Malt

| | Cost of 2,000 tons of malt (FRw 000's) | % | Marginal cost per ton (FRw) |
|---|---|---|---|
| Purchase of barley | 21,424 | 67.6 | 10,712 |
| Other production costs (1) | 7,395 | 23.3 | 2,045 |
| SUBTOTAL | 28,819 | 90.9 | 12,757 |
| Contingency 10% | 2,881 | 9.1 | 1,276 |
| TOTAL | 31,700 | 100.0 | 14,033 |

Note: (1) For details see table 4.V

Table 4.XIX - Real Operating Surplus of Maltings

| Year[1] | Output Metric tons | Production cost FRw 000's | Revenue FRw 000's | Operating surplus FRw 000's |
|---|---|---|---|---|
| 1977 | 2,000 | 31,700 | 52,600 | 20,900 |
| 1978 | 2,082 | 32,851 | 54,757 | 21,906 |
| 1979 | 2,167 | 34,044 | 56,922 | 22,878 |
| 1980 | 2,256 | 35,292 | 59,333 | 24,041 |
| 1981 | 2,349 | 36,598 | 61,779 | 25,181 |
| 1982 | 2,445 | 37,945 | 64,304 | 26,359 |
| 1983 | 2,545 | 39,348 | 66,934 | 27,586 |
| 1984 | 2,650 | 40,821 | 69,695 | 28,874 |
| 1985 | 2,758 | 42,337 | 72,535 | 30,198 |
| 1986 | 2,871 | 43,923 | 75,507 | 31,584 |

Note: (1) Year ending November 30.

As far as the capital costs are concerned, the proposed UN contribution is specifically tied to the malting project and, from the point of view of the Rwanda economy, it thus has a zero opportunity cost. The export credit of FRw 30 million is likewise only available for the purchase of the actual malting equipment. However, the foreign exchange used to service this debt could be used for other purposes, so, given that we are not applying a shadow exchange rate, this can be charged according to the payments schedule given in table 4.XIII in section 4.54 above. In the previous section we proposed that the balance of the capital would be supplied by the Banque Rwandaise de Développement and the Intebra company who own the Gisenyi brewery. As far as the private capital is concerned, we do know that investors in a risk activity, even in a developed country, require a DCF rate of return of 14-18 per cent. For Rwanda, the required return is probably in the range of 16-20 per cent. This is as fair a measure of the opportunity cost of the capital as it is possible to obtain. If the economic rate of return on the project is over 20 per cent, it will, in principle, be possible to satisfy private investors' maximum requirements and generate on top of that surplus resources for other development projects. Such a project would be highly desirable. If the economic rate of return on the project is under 16 per cent, it will be impossible to satisfy private investors' minimum requirements

Table 4.XX ESTIMATED FLOW OF COSTS AND BENEFITS FOR MALTING, 1974-1986 (FRw000s)

| Year Ending November 30 | Capital Movements | Operating Surplus | Export Finance | Current Benefit Flow | Overdraft | Cost of Overdraft(1) | Net Benefit Flow |
|---|---|---|---|---|---|---|---|
| 1974 | - 3,000 | | | | | | - 3,000 |
| 1975 | -37,000 | | | | | | -37,000 |
| 1976 | | | -2,250 | - 2,250 | 2,250 | | 0 |
| 1977 | | 20,900 | -6,536 | 14,364 | | 203 | 11,911 |
| 1978 | | 21,906 | -6,215 | 15,691 | | | 15,691 |
| 1979 | | 22,878 | -5,892 | 16,986 | | | 16,986 |
| 1980 | | 24,041 | -5,572 | 18,469 | | | 18,469 |
| 1981 | | 25,181 | -5,249 | 19,932 | | | 19,932 |
| 1982 | | 26,359 | -4,929 | 21,430 | | | 21,430 |
| 1983 | | 27,586 | -4,607 | 22,979 | | | 22,979 |
| 1984 | | 28,874 | | 28,874 | | | 28,874 |
| 1985 | | 30,198 | | 30,198 | | | 30,198 |
| 1986 | + 2,975(2) | 31,584 | | 31,584 | | | 34,569 |

NOTES: (1) At 9 per cent
(2) Residual capital value

**Table 4.XXI - Economic Rate of Return on Maltings**

The payback period is 4.73 years

The time-adjusted (internal) rate of return is 30.83 per cent

**Analysis of Cash Flows and Discounted Values (FRw000s)**

| Year to November | Net Cash Flow | Cumulative Cash Flow | Present Value | Cumulative Present Value | | Present Values Using Discount Rate of 20% |
|---|---|---|---|---|---|---|
| 1974 | - 3,000 | - 3,000 | - 3,000 | - 3,000 | | - 3,000 |
| 1975 | -37,000 | -40,000 | -28,281 | -31,281 | | -30,833 |
| 1976 | 0 | -40,000 | 0 | -31,281 | | 0 |
| 1977 | 11,911 | -28,089 | 5,319 | -25,962 | | 6,893 |
| 1978 | 15,691 | -12,398 | 5,356 | -20,606 | | 7,567 |
| 1979 | 16,986 | 4,588 | 4,431 | -16,175 | | 6,826 |
| 1980 | 18,469 | 23,057 | 3,683 | -12,492 | | 6,185 |
| 1981 | 19,932 | 42,989 | 3,038 | - 9,454 | | 5,563 |
| 1982 | 21,430 | 64,419 | 2,497 | - 6,957 | | 4,984 |
| 1983 | 22,979 | 87,398 | 2,046 | - 4,911 | | 4,453 |
| 1984 | 28,874 | 116,272 | 1,965 | - 2,946 | | 4,663 |
| 1985 | 30,198 | 146,470 | 1,571 | - 1,375 | | 4,064 |
| 1986 | 34,569 | 181,039 | 1,375 | 0 | | 3,877 |
| | | | | | **TOTAL** | 21,243 |

without transferring resources from other projects and this type of project would not justify government support. If the rate is between 16 per cent and 20 per cent, development resources will be neither created nor consumed by the project, and the decision whether or not to undertake it is marginal.

In the light of these guidelines, it is possible to evaluate the economic return of the proposed maltings project. The estimated flow of costs and benefits is given in table 4.XX below. It will be noted that no provision is made for tax since this is simply a transfer payment and not a real cost to the project. The discounted values are analysed in table 4.XXI below. It will be seen that the project carries a very high discounted rate of return of nearly 31 per cent, or put another way, it has a net present value of FRw 21,243,000 at a discount rate of 20 per cent. This is a measure of the resources that would be created for the economy by the project. It can be seen, therefore, that while the project may be only marginal from a financial standpoint it is highly attractive from the economic standpoint.

4.62 Balance of Payments Implications

The exercise in the previous section attempted to show the overall economic return of the project from the point of view of Rwanda. It is possible, however, to examine its impact more specifically.

It will have an important effect on the balance of payments by substituting domestically produced malt for malt currently imported. The actual gross saving would start at FRw 54 million annually with an output of 2,000 tons and rise to FRw 77,517,000 at the end of 10 years. Against this, most of the capital would need to be imported. Out of the total of FRw 74 million only a small part of the construction costs and one or two miscellaneous items could be locally supplied. This is unlikely to amount to more than FRw 14 million, leaving some FRw 60 million to be imported. In addition, some of the production costs will be spent on imports. Expenditures on fuel and insurance will be entirely imports and about 70 per cent of labour costs will be across the exchanges. An examination of Rwanda's national accounts shows that imports account for about 38 per cent of the GDP generated in the cash economy, so that other expenditures by the maltings, by raising incomes in other sectors will lead to increased imports. Finally, most of the profit made by the maltings will be paid across the exchanges to the foreign owners. It is not expected, however, that barley farmers will have such a high propensity to import and we have assumed a 20 per cent import content on this expenditure.

In the following table, we attempt to quantify the import content of production costs in 1977, the first year of operation of the maltings.

Table 4. XXII - Import Content of Production (FRw 000's) 1977 Forecast

| | Production Expenditure | Import % | Import Expenditure |
|---|---|---|---|
| Purchase of barley | 26,780 | 20 | 5,356 |
| Crop finance | 1,707 | 40 | 683 |
| Fuel | 2,040 | 100 | 2,040 |
| Electricity and water | 447 | 40 | 178 |
| Insurance | 347 | 100 | 347 |
| Labour | 2,554 | 70 | 1,788 |
| Other costs | 300 | 40 | 120 |
| SUBTOTAL | 34,175 | 30.7 | 10,512 |
| Contingency 10% | 3,418 | 30.7 | 1,051 |
| TOTAL | 37,593 | 30.7 | 11,563 |

Assuming that the import content of the operating surplus is roughly the same proportion as foreign capital is to total capital (i.e., 66 per cent), and assuming that the Rwandan share of the operating surplus has an import propensity of 40 per cent, the proportion of the operating surplus spent on imports would be 79 per cent. In 1977 this would amount to FRw 7,607.

Thus in 1977 the net balance of payments effect would be:

| | FRw 000's |
|---|---|
| Gross import saving | 54,000 |
| Import content of production | -11,563 |
| Import content of surplus | -7,607 |
| | 34,830 |

This figure of approximately FRw 35 million would increase year by year in line with the expected growth in the output of malt. Thus after two years the project will have saved sufficient foreign exchange to pay for the FRw 60 million of capital imports, and in the following eight years there would be a total foreign exchange saving of a minimum of FRw 300 million, and probably substantially more than this in practice. It should be stressed that this estimate is based on extremely conservative assumptions.

4.63 Effect on Cash Income

In section 1.1 it was pointed out that the major objective of government policy in Rwanda was to expand the cash incomes and to transfer people from subsistence agriculture to the cash economy. It is worth noting that this project will provide an income to farmers of FRw21,424,000 in 1976 which is no less than FRw5,356,000 more than they could earn from alternative crops on the same land. This cash income will rise steadily with the expected rise in malt production. To the extent that farmers open up new land for barley production, the growth in cash incomes will be even more. Several thousand farmers will benefit.

4.64 Effect on Government Revenue

It may be of interest to note the effect on government revenues of the project. The Banque Rwandese de Développement is being asked to provide funds at 3 per cent interest. In our estimation this is a subsidy of about 6 per cent. The government is also providing free land and free extension and research services but it is not possible to quantify these. The gain to government revenue will come from tax paid by the maltings, details of which were given in table 4.XV above.

The following table details the net effect on government revenue of these factors. It will be noted that there is a net gain to the government revenues of FRw8,192,000 over the life of the project despite the tax concessions proposed. Discounted to present values this table yields a rate of return of 12.56 per cent.

Table 4.XXIII - Effect of Maltings Project on Government Revenue (FRw000s)

| | Interest Subsidy | Tax Revenue | Net Effect |
|---|---|---|---|
| 1975 | 180 | | - 180 |
| 1976 | 1,440 | | -1,440 |
| 1977 | 1,440 | | -1,440 |
| 1978 | 1,296 | | -1,296 |
| 1979 | 1,152 | | -1,152 |
| 1980 | 1,008 | | -1,008 |
| 1981 | 804 | | - 804 |
| 1982 | 720 | 2,641 | +1,921 |
| 1983 | 576 | 3,121 | +2,545 |
| 1984 | 432 | 3,611 | +3,179 |
| 1985 | 288 | 3,965 | +3,677 |
| 1986 | 144 | 4,334 | +4,190 |
| TOTAL | | | +8,192 |

The project is therefore fairly attractive even from the narrow standpoint of government revenue. The overall conclusion of this analysis that the project is so attractive to the Rwanda economy that the government could well afford to give even greater incentives than we have suggested above to secure the essential co-operation of the brewery.

## 5. ORGANISATIONAL ASPECTS

### 5.1 Projected Programme and Timetable for Establishment of Maltings, 1971-1976

As a result of our assessment of the raw material, described in section 2, we have suggested that initiation of the malting project should await a detailed assessment of the situation with regard to the suitability of Rwandan barley for malting, which it is estimated will occupy three or four years. A provisional timetable for this assessment, followed by the sequence of events leading to the installation of the maltings, is shown below:

| Event No. | Details | Month | Year |
|---|---|---|---|
| 1. | Appointment of agronomist experienced in growing of barley. | October/ December | 1971 |
| 2. | Define regions from which barley is to be collected for analysis and seek co-operation of farmers in project. Ensure adequate supplies of pure seed available for tests. | January/ March | 1972 |
| 3. | Sow barley and arrange for future analyses and malting of barley at harvest in September. | April | 1972 |
| 4. | Collect data on soil, climate, growth performance, etc. | April/ September | 1972 |
| 5. | Harvest barley and dry off samples for analysis. | September | 1972 |
| 6. | Analyse barleys by physical, chemical and germination tests. | September/ December | 1972 |
| 7. | Micro-malting trials. Collate all barley trial analyses, formulate programme and make arrangements for new season's trials. | January/ March | 1973 |
| 8. | Collate micro-malting trials results. | April | 1973 |

| Event No. | Details | Month | Year |
|---|---|---|---|
| 9. | Sow new season's barley and repeat work of 1972/73 season. | April/ September | 1973 |
| 10. | Repeat work of 1972/73 season. | September<br>April | 1973<br>1974 |
| 11. | Brewing trials | April/June | 1974 |
| 12. | Collate brewing trial results. | July | 1974 |
| 13. | Repeat whole of work of 1973/74 season | September<br>July | 1974<br>1975 |
| 14. | Collate analyses of 3 years' barley growing and malting trials and present results for decision to be made on whether or not to proceed with malting project. | April | 1975 |
| 15. | Decide whether or not to proceed with malting project. | May | 1975 |
| 16. | If decision taken to go ahead with malting project, call for first tenders. Engage malting manager and secretary. Set up harvested barley collection scheme and arrange for adequate supplies of new seed to be available for sowing April 1976. Arrange for building of managers' and assistant managers' houses | June | 1975 |
| 17. | Award contract, draft detailed specification, and agree to plan of operation. | September/ November | 1975 |
| 18. | Preparation of site. | December | 1975 |
| 19. | Provision of services to site. Construction of foundations and bases to malt house and storage bins. | January/ March | 1976 |
| 20. | Delivery of building equipment. | March | 1976 |
| 21. | Delivery of storage equipment. Sow barley. | April | 1976 |
| 22. | Erection of malt house steel work. | March/ April | 1976 |
| 23. | Delivery of malt house machinery. | May | 1976 |

| Event No. | Details | Month | Year |
|---|---|---|---|
| 24. | Construction of malt house boxes. | May | 1976 |
| 25. | Erection of 8 storage bins. | May/June | 1976 |
| 26. | Placement of malt house machinery. Cladding of malt house. | June | 1976 |
| 27. | Appointment of Assistant Maltings Manager and 2 laboratory technicians. Asst. Manager repairs to Europe for training. | July | 1976 |
| 28. | Erection of malt house machinery. Installation of services in malt house. Testing of grain handling and drying equipment. | July/ August | 1976 |
| 29. | Engage 5 skilled labourers. | September | 1976 |
| 30. | Harvest and drying of barley. Erect remaining 4 storage bins. Test steeping equipment. | September/ October | 1976 |
| 31. | Asst. Manager returns from Europe. | October | 1976 |
| 32. | Carry out full tests on malting plant - dummy runs. | November | 1976 |
| 33. | Carry out first steep and commence malting. | December | 1976. |

## 5.2 Tentative Start-up Schedule for the Maltings

A typical sequence of events in the use of the maltings is shown below. Final details will largely be governed by the actual condition of the barley following the 1976 harvest.

| | | |
|---|---|---|
| **Day 1** | 0600 - 0730 | transfer 25 ton barley to steep vessel. |
| | 0730 - 0745 | fill steep vessel with water at 18°-20°C. |
| | 0745 - 0800 | float off skimmings. |
| | 0800 - 0815 | rouse grain with compressed air. |
| | 1000 - 1015 | rouse grain with compressed air. |
| | 1200 - 1215 | rouse grain with compressed air. |
| | 1400 - 1430 | drain. |
| | 1630 - 1645 | $CO_2$ extraction; repeat every 2 hours for 15 minutes during air-rest. |

| | | |
|---|---|---|
| **Day 2** | 0600 - 0615 | fill steep vessel with water at 18°-20°C. |
| | 0615 - 0630 | rouse grain with compressed air. |
| | 0815 - 1830 | rouse grain with compressed air. |
| | 1015 - 1030 | rouse grain with compressed air. |
| | 1245 - 1315 | drain. |
| | 1515 - 1530 | $CO_2$ extraction; repeat every 2 hours for 15 minutes during air rest. |
| **Day 3** | 0000 - 0015 | fill steep vessel with water at 18°-20°C. |
| | 0015 - 0030 | rouse grain with compressed air; repeat every 2 hours for 15 minutes during steep. |
| | 1000 - 1100 | drain. |
| | 1100 - 1130 | transfer grain to germination/kilning box 1. |
| | 1130 - 1200 | level grain bed with turner, pass conditioned air through bed at 16°-18°C. |
| **Day 4** | 0600 - 0730 | transfer 25 ton barley to steep vessel. |
| | 0730 - 0745 | fill steep vessel with water at 18°-20°C. |
| | 0745 - 0800 | float off skimmings. |
| | 0800 - 0815 | rouse grain with compressed air. |
| | 1000 - 1015 | rouse grain with compressed air. |
| | 1130 - 1200 | turn grain in box 1 - take sample for moisture determination. |
| | 1200 - 1215 | rouse grain in steep vessel. |
| | 1400 - 1430 | drain steep. |
| | 1630 - 1645 | $CO_2$ extraction of steep; repeat every 2 hours during air-rest. |
| | 2330 - 0000 | turn grain box 1. |
| **Day 5** | 0600 - 0615 | fill steep vessel with water at 18°-20°C. |
| | 0615 - 0630 | rouse steep with compressed air. |
| | 0815 - 0830 | rouse steep with compressed air. |
| | 1015 - 1030 | rouse steep with compressed air. |
| | 1130 - 1200 | turn grain box 1. |
| | 1245 - 1315 | drain steep. |

| | | |
|---|---|---|
| | 1515 - 1530 | $CO_2$ extraction; repeat every 2 hours for 15 minutes during air-rest. |
| | 2330 - 0000 | turn grain in box 1. |
| **Day 6** | 0000 - 0015 | fill steep vessel with water at 18°-20°C. |
| | 0015 - 0030 | rouse steep with compressed air; repeat every 2 hours for 15 minutes during steep. |
| | 1000 - 1100 | drain steep. |
| | 1100 - 1130 | transfer grain from steep to germination/kilning box 2. |
| | 1130 - 1200 | box 2 - level grain bed with turner; pass conditioned air through bed at 16°-18°C. |
| | 2330 - 0000 | turn grain in box 1. |
| **Day 7** | 0600 - 0730 | transfer 25 ton barley to steep vessel. |
| | 0730 - 0745 | fill steep vessel with water at 18°-20°C. |
| | 0745 - 0800 | float off skimmings. |
| | 0800 - 0815 | rouse steep with compressed air. |
| | 1000 - 1015 | rouse steep with compressed air. |
| | 1130 - 1200 | turn grain in box 2 - take sample for moisture determination. |
| | 1200 - 1215 | rouse grain in steep vessel. |
| | 1400 - 1430 | drain steep. |
| | 1630 - 1645 | $CO_2$ extraction of steep; repeat every 2 hours during air-rest. |
| | 2330 - 0000 | turn grain in box 1. |
| **Day 8** | 0030 - 0100 | turn grain in box 2. |
| | 0600 - 0615 | fill steep with water at 18°-20°C. |
| | 0615 - 1630 | rouse steep with compressed air. |
| | 0730 - | switch off conditioned air to box 1 - start kilning - air on at 45°C. |
| | 0815 - 0830 | rouse steep with water at 18°-20°C. |
| | 1015 - 1030 | rouse steep with compressed air. |
| | 1130 - 1200 | turn grain in box 2. |
| | 1245 - 1315 | drain steep. |
| | 1515 - 1530 | $CO_2$ extraction; repeat every 2 hours for 15 minutes during air-rest. |

| | | |
|---|---|---|
| | 2130 - | increase 'on' air temperature in box 1 to 60°C. |
| | 2330 - 0000 | turn grain in box 2. |
| **Day 9** | 0000 - 0015 | fill steep vessel with water at 18°-20°C. |
| | 0015 - 0030 | rouse steep with compressed air; repeat for 15 minutes every 2 hours. |
| | 0130 - | increase 'on' air temperature in box 1 to 80°C. |
| | 0730 - | switch off kiln furnace to box 1. |
| | 0800 - 1000 | discharge kiln-dried malt from box 1 and transfer to storage via dresser and weigher. |
| | 1000 - 1100 | drain steep. |
| | 1100 - 1130 | transfer grain from steep to box 1. |
| | 1130 - 1200 | box 1 - level grain bed with turner; pass conditioned air through bed at 16°-18°C. |
| | 2330 - 0000 | turn grain in box 2. |

**Day 10** The cycle continues the operations of day 10, being the same as those of day 7, but for box 1 read box 2 and vice versa, whilst the operations of day 13 will be exactly as described for day 7.

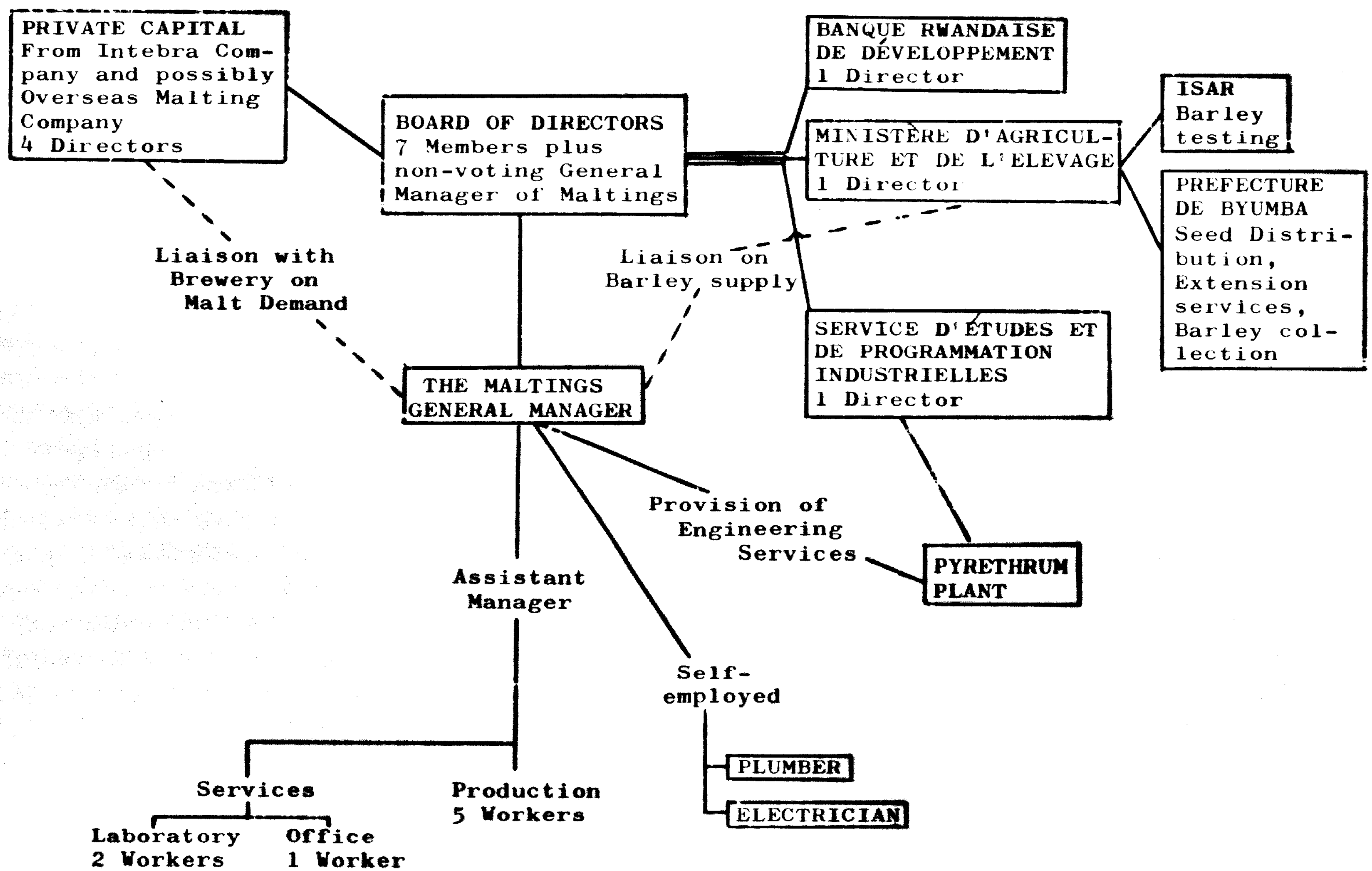
5.3 Proposed Organisational Structure

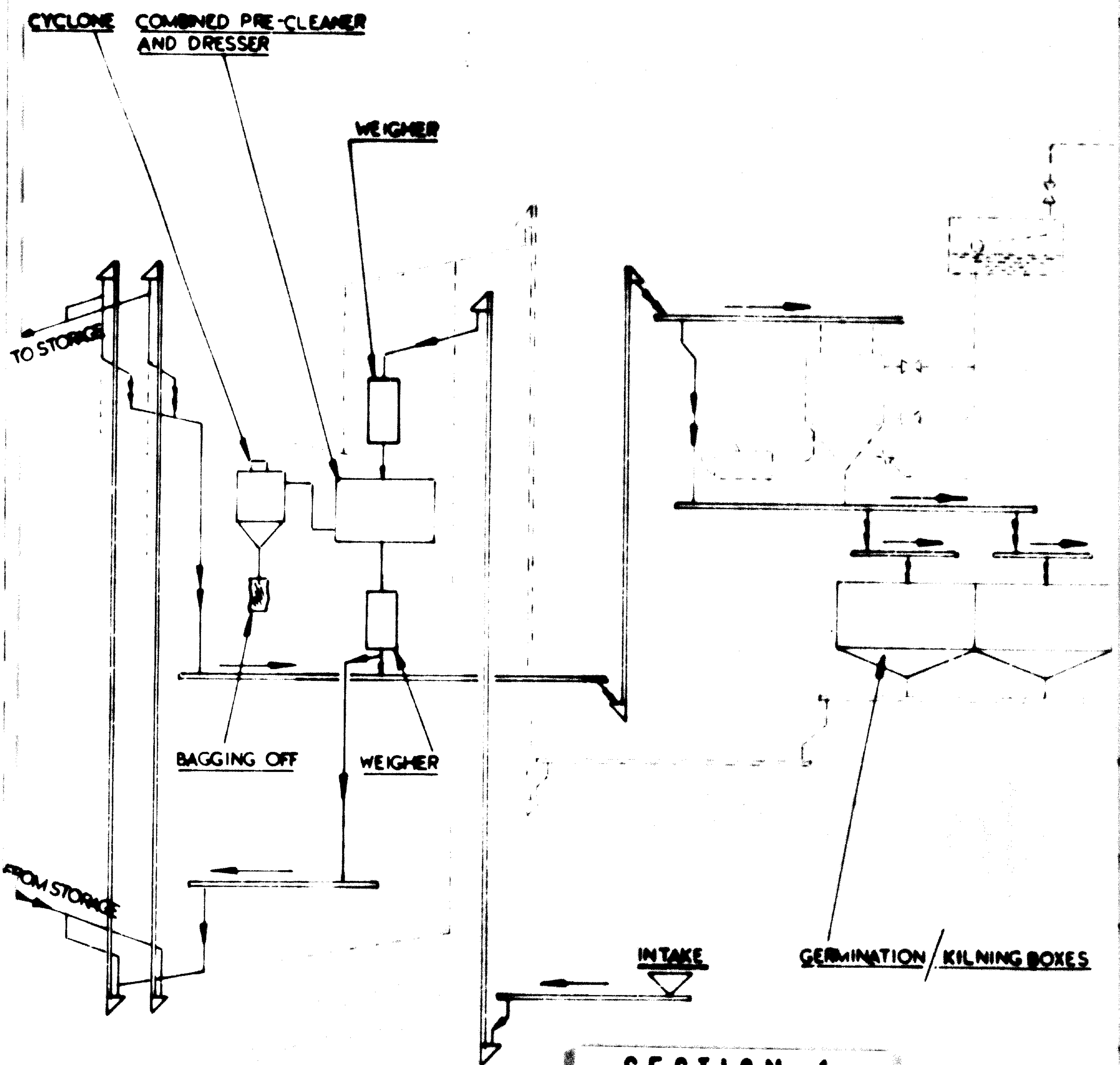
The following self-explanatory table shows the expected organisation of the maltings. The plant would be under the control of a Board of Directors on which all interested bodies would be represented. We envisage that the holders of the equity capital would have a majority control of the Board, appointing a total of four members. The remaining directors would all be government representatives and would consist of a representative of the Banque de Développement which would be contributing loan finance to the project, a representative of the Ministère d'agriculture et de l'elevage which should provide both research and extension facilities for the barley, and the Service d'Études et de Programmation

Industrielles which would be indirectly concerned with the project through its sponsorship of the pyrethrum board.

The maltings would be under the control of a general manager who would be an ex officio but non-voting member of the board. He would liaise as required with the Ministère d'agriculture et de l'elevage, the Service d'Études et de Programmation Industrielles, and the brewery.

Table 5.I.- Organisation of Maltings



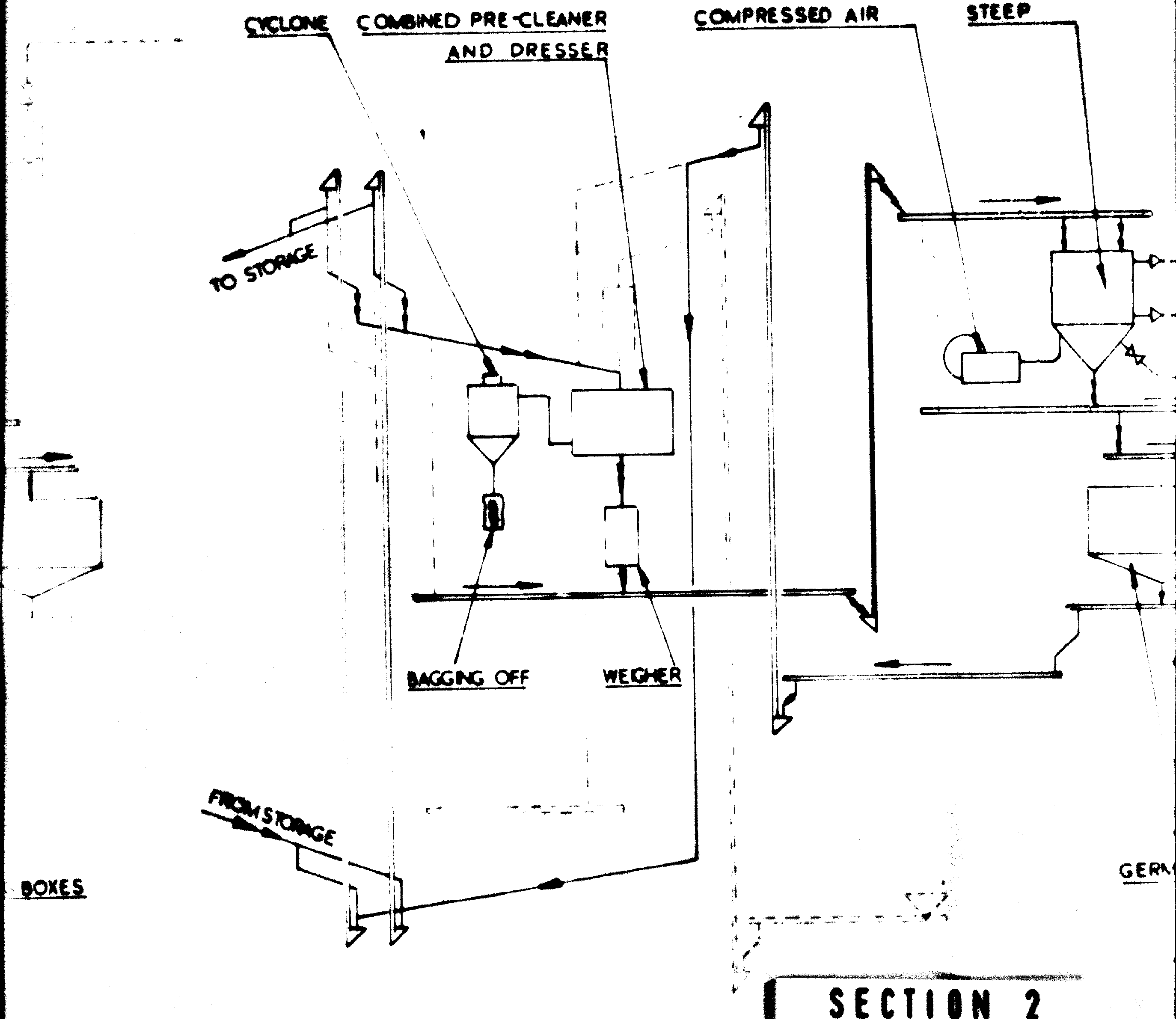



## SECTION 1

① GREEN BARLEY FROM INTAKE TO STORAGE OR KILNING BOXES (DRYING)

② GREEN BARLEY FROM STORAGE TO KILNING BOXES

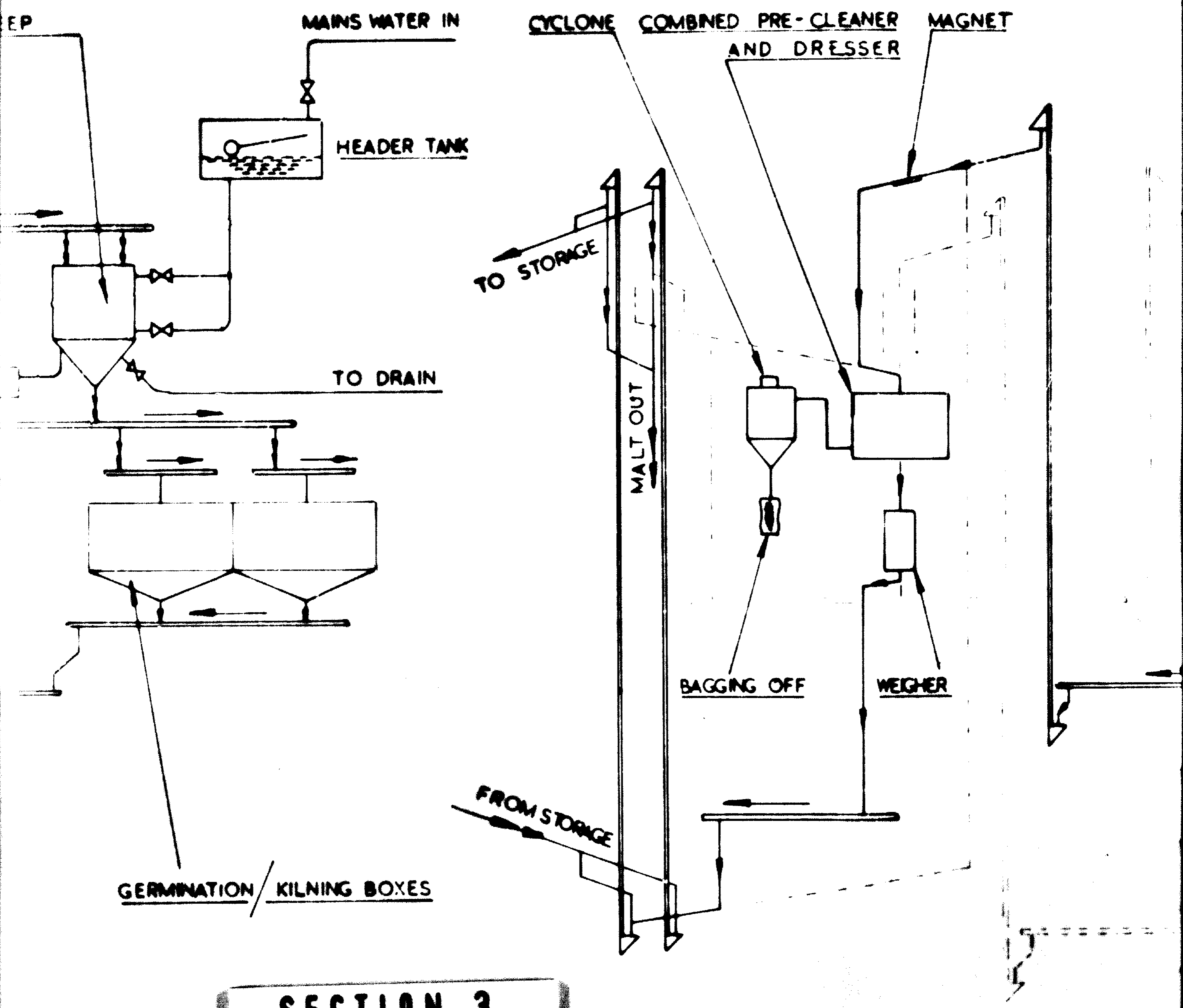
FIG 1




SECTION 2

③ BARLEY FROM KILNING BOXES TO STORAGE →

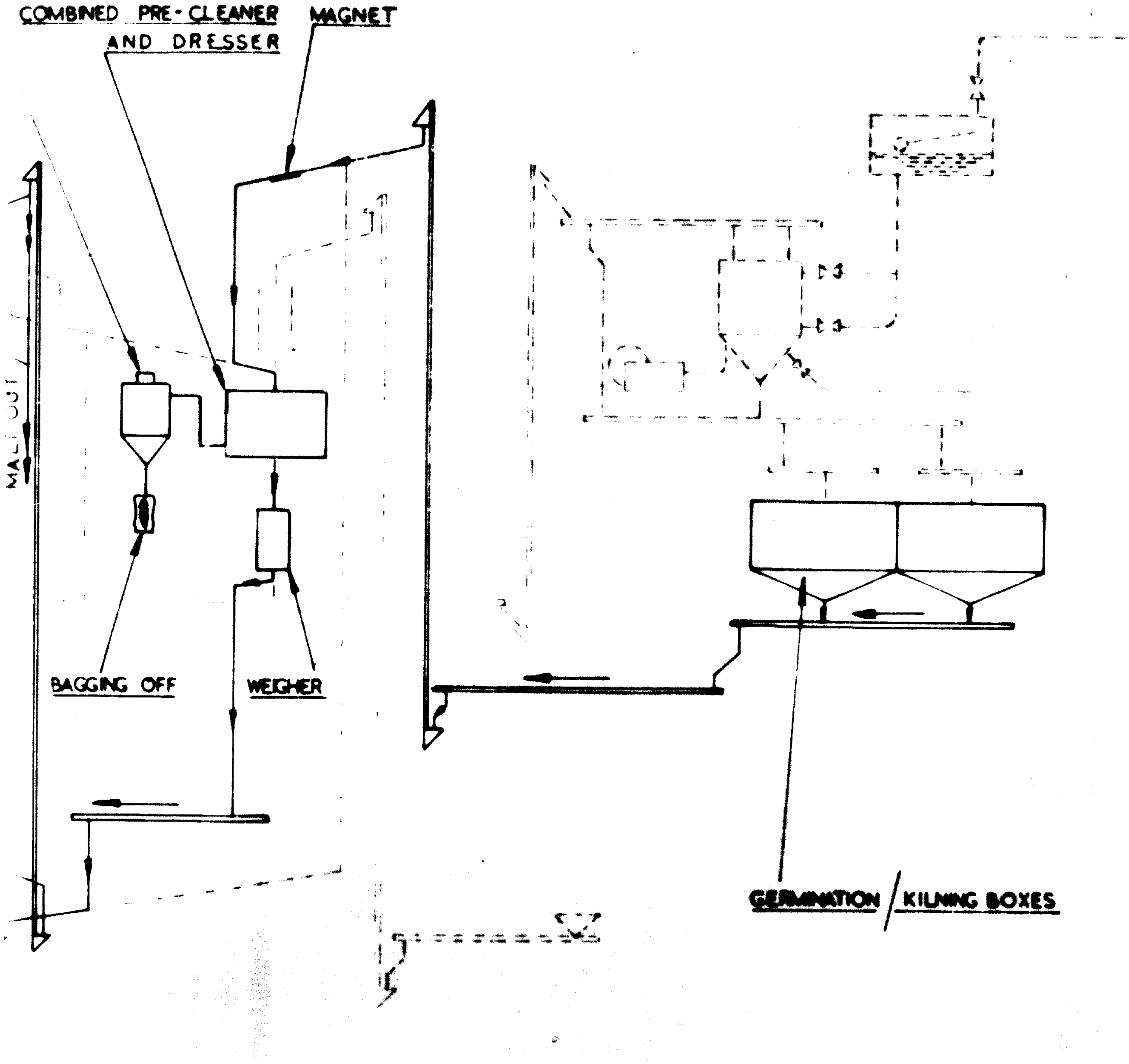
④ BARLEY FROM STORAGE TO KILNING BOXES →→




## SECTION 3

(5) MALT FROM KILNING BOXES TO STORAGE

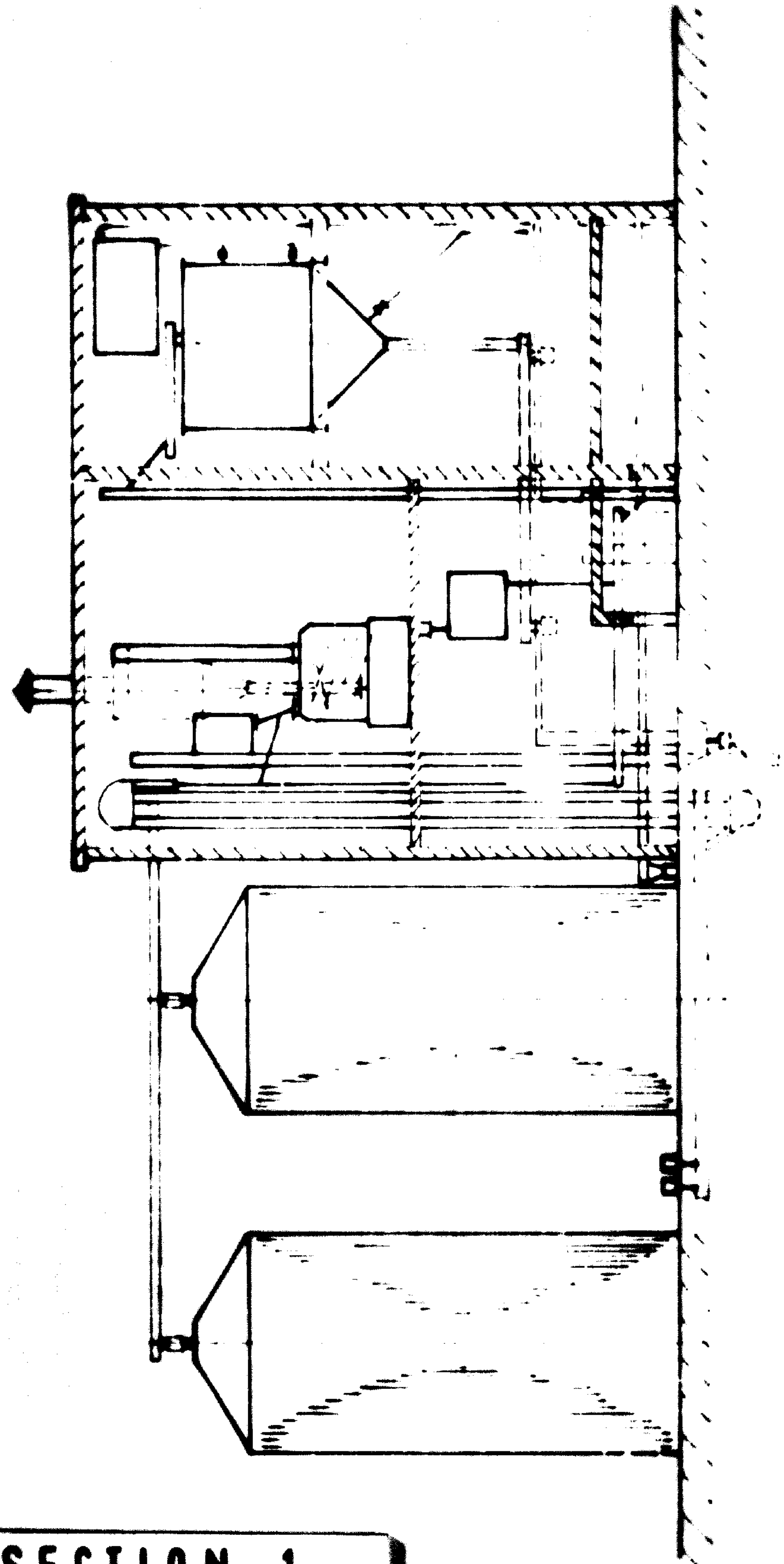
(6) MALT FROM STORAGE TO MALT OUT




MALT FROM KILNING BOXES TO STORAGE

MALT FROM STORAGE TO MALT OUT

# SECTION 4



SECTION 1

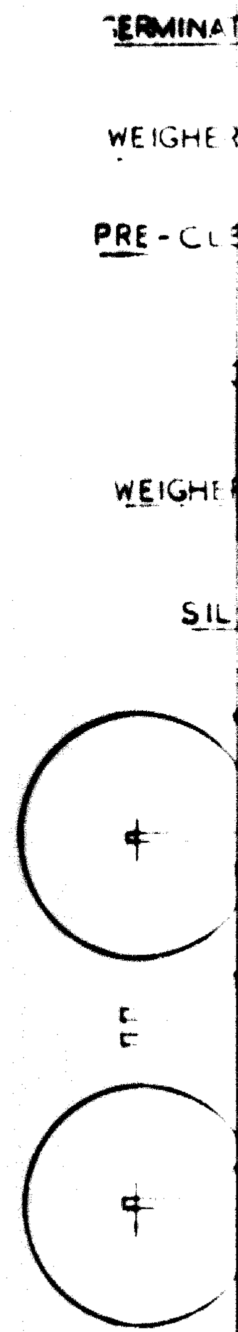
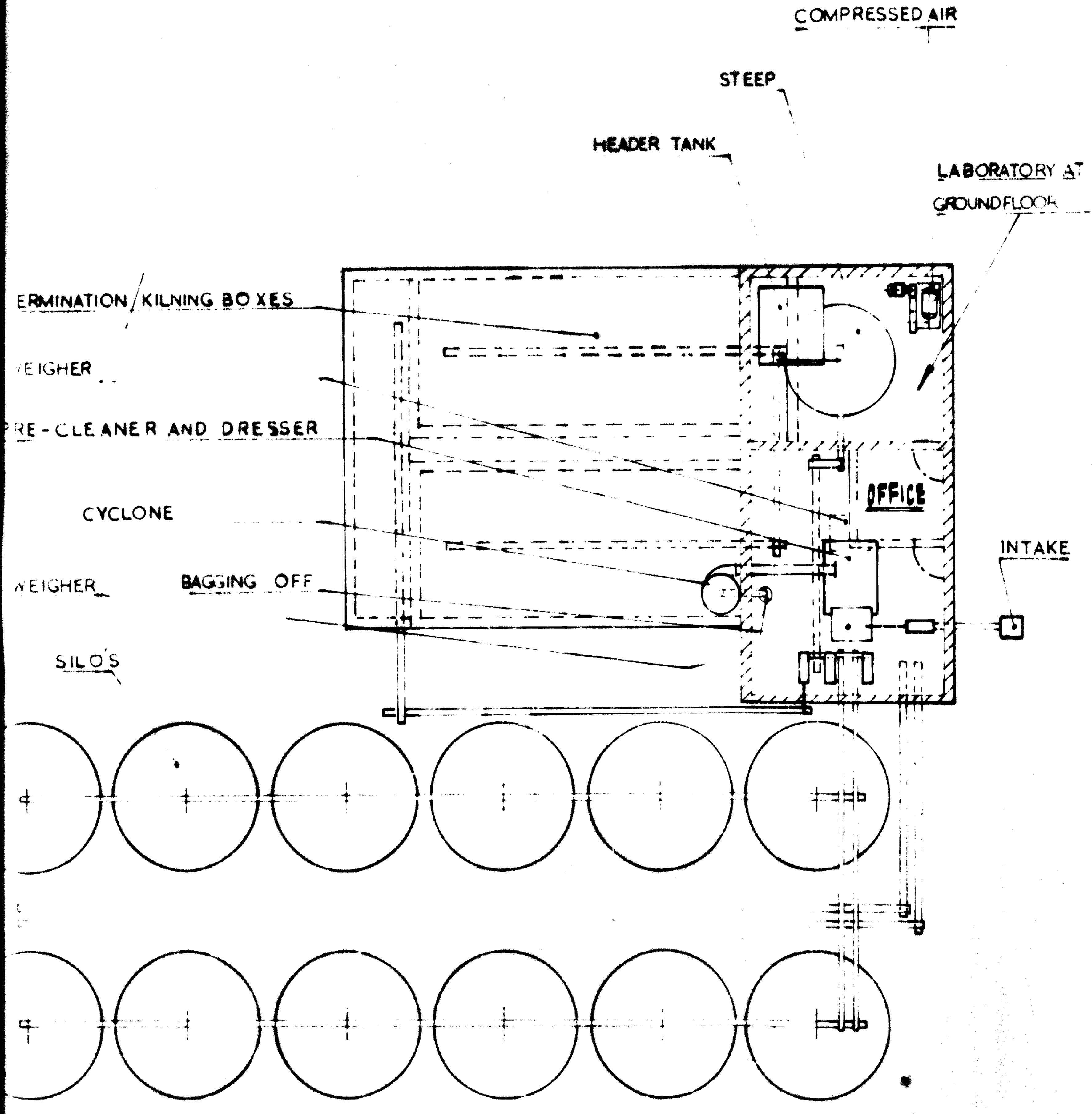
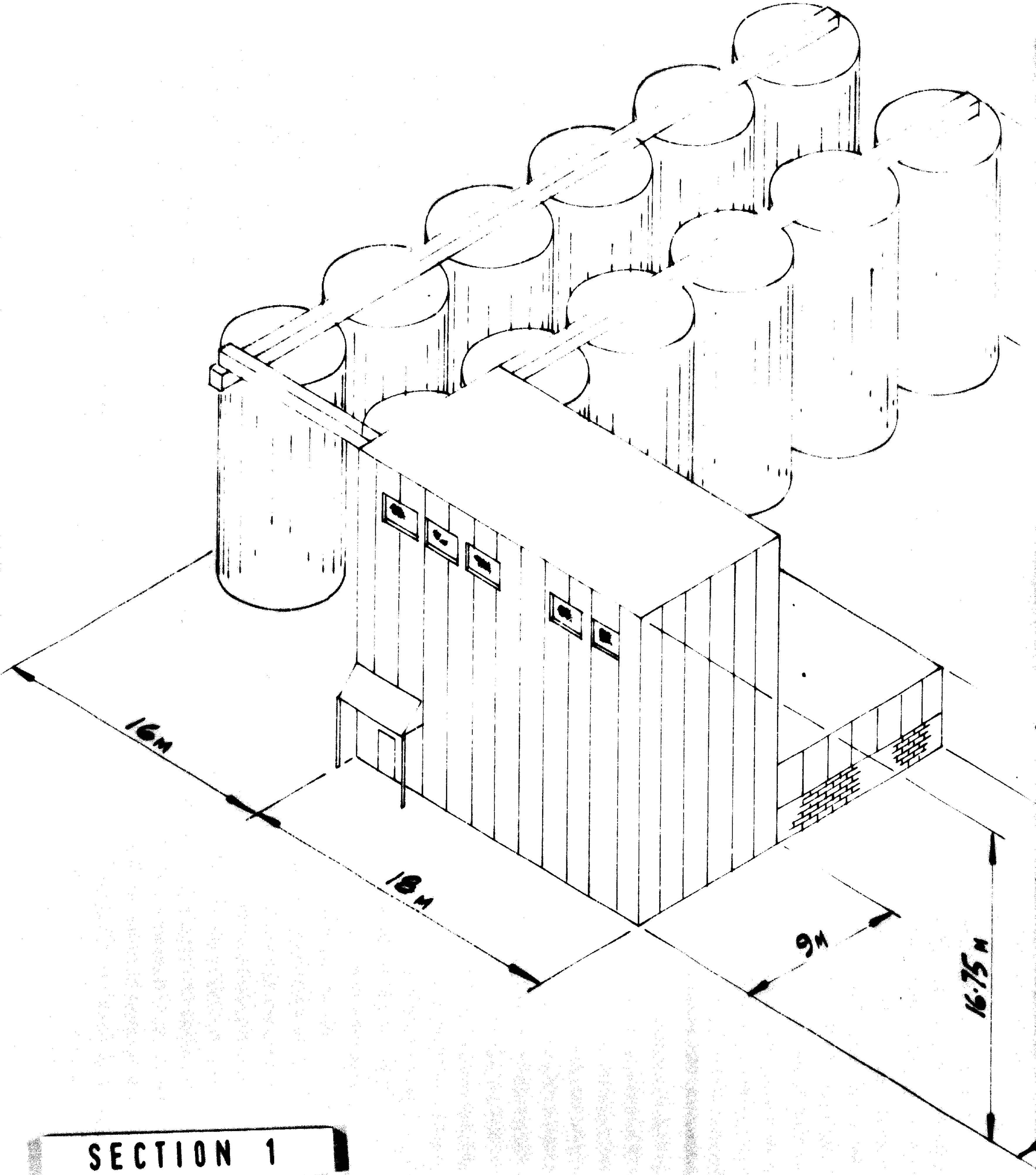


FIG 2

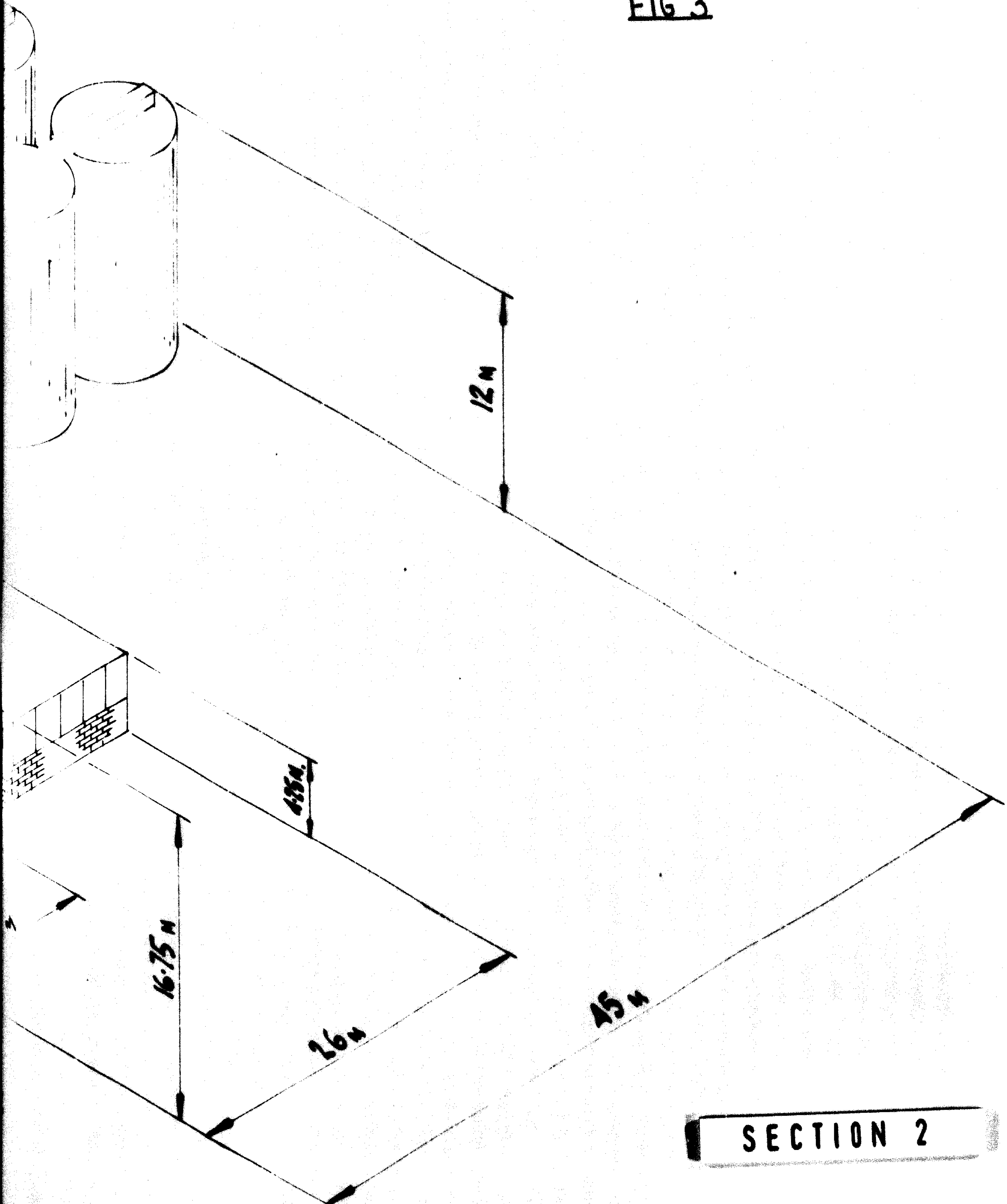



SECTION 2



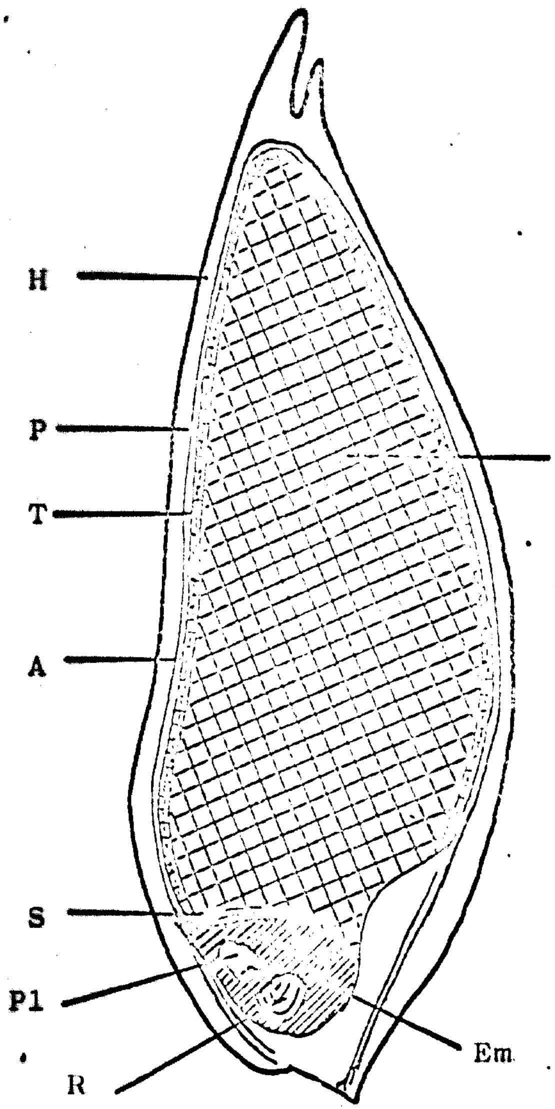

SECTION 1

FIG 3




SECTION 2

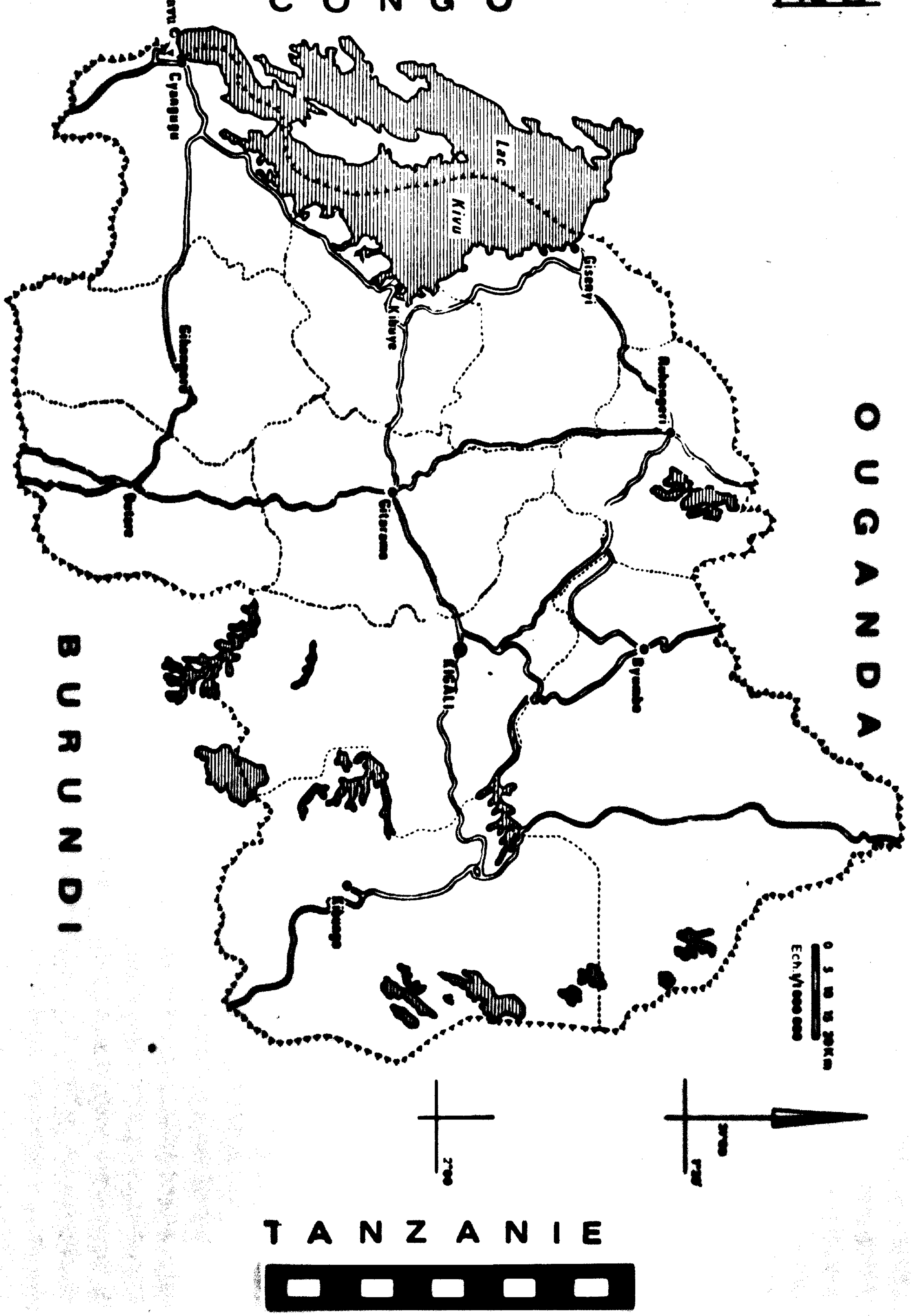
<u>The Barley Corn</u> <u>FIG 4</u>




H - Husk
P - Pericarp
E - Endosperm
T - Testa
A - Aleurone Cells

S - Scutellum
Pl - Plumule
R - Radicle
Em - Embryo

FIG 5


CONGO
Lac
Kivu
Cyangugu
Kibuye
Gisenyi
Ruhengeri
Gitarama
KIGALI
Byumba
OUGANDA
BURUNDI
TANZANIE

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