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DEVELOPMENT OF THE ESSENTIAL OILS INDUSTRY IN ETHIOPIA

SI/ETH/90/802

ETHIOPIA

Technical report: Findings, work performed and recommendations*

Prepared for the Government of Ethiopia
by the United Nations Industrial Development Organization

Based on the work of M. B. Narashima, process technologist in essential oils production

Backstopping Officer: T. De Silva
Chemical Industries Branch

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* This document has not been edited.

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CONTENTS

Introduction

"Many higher plants accumulate extractable organic substances in quantities sufficient to be economically useful as chemical feed stocks or raw materials for various scientific, technological and commercial applications. Natural plant substances are employed, either directly or indirectly by a large number of industries. Economically important plants serve as sources of industrial oils, essential oils, resins, tannins, saponins, gums, dyes, pharmaceuticals and many speciality products."

Ethiopia is rich in flora, both aromatic and medicinal plants, variation in altitude and climate make it possible to introduce plants not indigenous to the country.

This potential could be exploited to industrially produce not only essential oils and aroma chemicals but isolates and pharmaceutical intermediates from medicinal plants.

"Number of plants indigenous to Africa from where they are collected and shipped to the manufacturing facilities in developing countries. The value added to obtain pure active principles from plant is, at least ten times the value of crude extracts and subsequently, the high valued plant products are sold back to the developing countries, including Africa at high prices. This increases the pressure on the scarce foreign exchange resources of developing countries."

In Ethiopia development of essential oil industry could be developed in stages:

- Steam distillation of aromatic plants - spontaneous and plantation and sale of crude essential oils.
- Fractionation - sale of deterpenated oils and pure isolates
- Chemical processing to obtain low volume - high value aroma chemicals

Ethiopia, where aromatic plants can be grown in commercial quantities, could start with the first two stages with simple technologies and equally simple equipment. After gaining adequate experience and confidence, could embark on the production of aroma chemicals.

Back Ground

Science and Technology Division of N.C.C. has short and long-term programmes with the establishment of essential oil industry, which could utilise rural sector participation.

It has plans to grow select essential oil bearing plants at different agro-climatic zones and conduct survey of availability of naturally growing aromatic plants. Towards meeting these goals the N.C.C. has:

- Established a moderately equipped laboratory at Addis Ababa.
- Has a farm of 80 ha at Wendo Guenet.
- Acquired a tractor with trailer.
- It has planted various essential oil bearing plants on its farm.
- Procured a mobile distillation plant which is already located at Wendo Guenet.

- Procured a mobile distillation plant which is already located at Wendo Guenet.
- Surveyed and collected some naturally growing aromatic plants viz, E. Globulous, Thyme, Basil, Coriander, Spear mint, Ginger etc.
- These were analysed for oil content and composition of the oils.
- A mini-lab is already functioning at Wendo Guenet.

Purpose of the Project

Assessment of available raw materials, infrastructure in Ethiopia and formulation of optimum technology options.

Post Title: Process Technologist in Essential Oils Production (SI/ETH/90/802/11-01).

Duties

The Expert shall assess the existing conditions of the essential oils project and assist in implementing appropriate operational practices for obtaining essential oils from various aromatic plant species.

Assess and streamline activities in progress at N.C.C.

Assess the existing essential oils unit at Wendo Guenet

1. Evaluate conditions of the machinery and equipment and recommend equipment to be modified and or purchased to attain the determined capacity.

2. Describe the process adopted with the aid of flow diagrams.

3. Identify and list out with adequate specifications, laboratory and or pilot plant scale machinery and equipment for secondary processing of essential oils.

4. Perform other duties in connection with the study of the project within competence.

(Job description attached (Annex I.)

Summary

The Expert on mission fielded from 29 June 1992 to 7 Nov., 1992, was attached to the National Chemical Corporation, Addis Ababa. He carried out the following functions in collaboration with the counterpart scientists and engineer of the Corporation.

1. Refurbished a running but sick industrial unit under the control of N.C.C. Identified and successfully solved production bottle-necks and increased the production by "significant amount and considerable energy savings."

2. The comments of the General Manager of the Factory "we highly appreciate the results achieved through the efforts of the expert." The Expert identified the prevailing production bottle necks and increased the production by significant amount - considerable energy savings."

3. Assessed the activities of the Science and Technology Division of N.C.C.

4. Identified areas of weakness (ie) the area of fractional distillation of essential oils.

5. Designed and got a glass fractionation column fabricated.

6. Assessed the existing essential oil distillation plants at Wendo Guenet and recommended suitable modifications to one of the two units and drawn flow diagrams indicating the general unit operations of the pilot plants.

7. Identified and listed out with adequate specifications of the laboratory and pilot plant for secondary processing of essential oils.

8. Prepared a project proposal for secondary processing of essential oils.

9. Identified the equipment for optimum production capacity of essential oils.

10. Designed essential oils distillation plants of 2, 3 and 5 tonnes of green herb/batch. Worked out the bill of materials.

11. Designed 400 l essential oils fractional distillation pilot plant and worked out the bill of materials.

12. Trained only engineer of Science and Technology Division of N.C.C. in the theory of fractional distillation and in the design of pilot plant for fractionation of essential oils.

13. Study visit of 10 factories in Ethiopia under the control of N.C.C. and Food Corporation and extended appropriate

on the spot advise.

14. Participated in the panel discussion on "Transfer of Technology in the Chemical sub-sector" organized by the Chemical Society of Ethiopia.

15. Estimated the cost of production of essential oils.

16. Collected international standards for essential oils.

17. Back-ground material on essential oils.

Outputs : (Findings, observations, and work performed).

(a) Prepared a report entitled "PROSPECTS FOR THE DEVELOPMENT OF ESSENTIAL OIL INDUSTRY IN ETHIOPIA" and submitted to the Government of Ethiopia. For details please see Annex : II

(b) Prepared a project proposal to set up an essential oils refining unit/secondary processing unit at WENDO GUENET. For details please see Annex : III

(c) Worked out "ALTERNATE APPROACHES TO PROCESSING OF ESSENTIAL OILS". For details please see Annex : IV

(d) Estimated cost of Production of Some Essential Oils. Please see Annex : V

(e) Design and Engineering.

(i) Designed a Laboratory model all glass Fractionation column, and got it locally fabricated in glass For details please see Annex : VI

(ii) Design of essential oils fractionation pilot Plant. For details please see Annex : VII

(iii) Worked out the bill of materials required for the fabrication of the fractionation pilot plant. For details please see Annex : VIII

(iv) Design of Field Distillation Plant. For details please see Annex : IX

(v) Prepared bill of materials required for the fabrication of the field distillation plant. For details please see Annex : IX

(f) Refurbishing of a running (Sick) Factory :

Refurbished a running but sick industrial unit under the control of N.C.C. Identified and successfully solved production bottle-necks and increased the production by "significant amount and considerable energy savings." The comments of the General Manager of the Factory "We highly appreciate the results achieved through the efforts of the expert." The Expert identified the prevailing production bottle necks and increased the production by significant amount - considerable energy savings." For details please see Annex : X

(g) Participated in a panel discussion - Technology Transfer in the chemical sub-sector : At the invitation of the Chemical Society of Ethiopia, the Expert on mission participated in a "Panel discussion" on the Transfer of Technology on Aug 8, 1992, at the premises of the Addis Ababa University. For details please see Annex : XI

(h) Assisted N.C.C. in obtaining relevant literature on essential oil manufacturing and further processing and passed on the literature to the project counterparts.

(i) Assisted N.C.C. in the collection of standard analytical and quality control procedures from Essential Oil Association of U.S.A. Inc. and passed on the same to the Project counterparts.

Conclusions

It is concluded that:

1. With distinct geoclimatic regions in which a large variety of aromatic plants are grown and can be cultivated in Ethiopia.

2. "That a short and long term strategy is necessary for the development of essential oil industry in Ethiopia and that such a strategy should encompass the role of R & D in the following fields:

   - Screening of wild flora
   - Improving yield potential of essential oil crop plants of established value.
   - Improvement of processing technology.
   - Quality assessment methods.
   - Prospects for development of essential oil bearing crops by genetic manipulation."

3. It is feasible to establish an essential oil industry in the country.

4. Initially a single mobile distillation unit could move from site to site (natural flora and plantations) to produce crude essential oils.

5. It is feasible to transport the crude essential oils to centrally located secondary processing plant to produce refined essential oils and pure isolates.

6. At a later stage, installation of static distillation plants with independent boilers at various zones or satellite planation could be established.

7. It is concluded that for all round development of plant based industry in Ethiopia, it is considered necessary to set-up a specialised institute (National Institute for Medicinal and Aromatic plants - NIMAP) for this purpose, under Technical Assistance Programme of UNIDO/UNDP.

8. That N.C.C. extend its activities naturally to cover various aspects of industrial utilization of medicinal plants.

9. That collaboration with national and international institutes specialising in these areas for speedy development of phyto-chemical industry in the country.

10. That very good quality engineering infrastructure for the fabrication of industrial chemical plant and equipment exists in the country.

11. That its design capability to undertake fabrication of such plants needs re-inforcement.

12. That this capability could be acquired through international training.

13. It is concluded that to develop self reliance in the industrial development of Ethiopia, including phytochemical industry, its existing engineering infrastructure should be fully exploited.

14. That even if the country has to import necessary steels and stainless steels for the purpose.

Recommendations:

1. The development of essential oil industry in Ethiopia could be developed in stages:
   - Steam distillation of aromatic plants - spontaneous and planation and sale of crude essential oils.
   - Fractionation of essential oils - sale of deterpenated oils and pure isolates.
   - Chemical processing of essential oils to obtain low volume - high value aroma chemicals.

Ethiopia, where aromatic plants can be grown in commercial quantities, could start with the first two stages with simple technologies and equally simple equipment. After gaining adequate experience and confidence, could embark on the production of aroma chemicals.

2. To set-up secondary processing of essential oils.
   - Deterpenated Essential Oils
   - Pure isolates
   - Aroma chemicals

   Project proposal already submitted.
3. To establish a National Institute of Medical and Aromatic plants on lines of CIMAP in India.
4. Extend R & D activities to medicinal and insecticides bearing plants
5. It is further recommended that a full fledged national institute NIMAP be created under the Technical Assistance Programme of UNIDO/UNDP, with the requisite inputs such as:
   - Additional modern equipment for R & D and quality control.
   - Poly-functional pilot plant.
   - International training of national scientific and technical personnel.

- Scientific and technical books and journals.
- Audio visual and office equipment.

6. Collaboration with national and international institutes for quicker development of essential oils and medicinal plants based industry in Ethiopia.
7. To create design and engineering cell to develop simple designs of field distillation and other chemical plant and equipment.
8. Recruit and train at least two chemical engineers and one mechanical engineer to man design and engineering cell and plant operations.
9. Maximum use could be made of existing E.O. distillation plants at Wendo Guenet by working at full capacity for 24 hrs/day.
10. This is expected to effect considerable saving in fuel consumption.
11. Regular maintenance would prevent total breakdown of the machines.
12. Existing plant capacity would be inadequate to meet the future plantations.
13. Designs of 2t, 3t & 5t per batch (of green herb) of distillation plants are provided. Drawings elesewhere in the report.
14. To make optimum use of the distillation and fractionation facilities diversification of products made is recommended.

    It would merely involve cleaning up the equipment thoroughly before the use for the new product is made.
15. "Direct exportation of plants as such to developed countries for earning foreign exchange is a soft option. With very little processing, the value added to the country's product would be tremendous."

Persons contacted

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ANNEX I

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PROJECT IN THE GOVERNMENT OF ETHIOPIA

JOB DESCRIPTION

Post title: Process technologist in Essential oil production

Duration: 4 man/months

Date required: ASAP

Purpose of Project:
Assessment of available raw materials, infrastructure and formulation of optimum technology options

Duties: The expert shall assess the existing conditions of the essential oils project and assist in implementing appropriate operational practices for obtaining essential oils from various aromatic plant species. His specific duties would be to:-

1. Assess and streamline activities in progress initiated by NNC.
2. Assess the existing essential oils unit at Wendo Guenet and
   i) Evaluate conditions of the machinery and equipment and recommend equipment to be modified and/or purchased to attain the determined capacity.
   ii) Evaluate the existing technology by comparing it with available alternative technologies and recommend the most appropriate,
   iii) describe the process adopted with the aid of flow charts, indicating in detail the different stages of production.
   iv) Indicate and describe quality standards, as per the requirements of identified importing houses and recommend system of quality control to be adopted including listing of equipment and mode of sequence of operation and appropriate product handling, storing and packaging.
   v) Assist in preparing manpower requirement including the necessary level of skill of each activity.
3. Identify and list out machinery and equipment with the necessary specifications for the determined optimum production capacities for each process type recommended and quality control requirements.
4. Prepare material and energy balances for the processing of the following and other products that may be recommended:
   - Lemongrass Oil
   - Citronella oil
   - Geranium oil
   - Vetiver oil
   - Patchouli oil
   - Eucalyptus (citriodora, globulous, etc) oil
   - Basil oil
   - Lime oil and other similar products

5. Assist in working out the cost of production of each of the above listed oils.
6. Identify and list out with adequate specifications laboratory and/or pilot plant scale machinery and equipment for secondary processing of essential oils.
7. Work out with sufficient elaboration the process description for secondary processing of essential oils, list out machinery and equipment for a determined capacity of same with the necessary specifications; advise on advantages of further processing essential oils.
8. Impart his know-how on NCC counterparts/assistants in the form of on-the-job training.
9. Assist NCC in obtaining relevant literature on essential oil manufacturing and further processing.
10. Assist in the preparation of the comprehensive report on the development of the essential oil industry.
11. Perform other duties in connection with the study of the project within this competence.

Qualifications:

A chemical engineer/chemist with very wide knowledge in essential oil processing and operating conditions with sufficient experience to identify machinery and equipment, auxiliaries and other inputs required for essential oil production. The candidate should have experience in running essential oil factories.

Language: English

Background information:

Ethiopia wishes to develop agro-industries, as is well known, however, traditional crops such as coffee and cotton face extremely difficult marketing conditions. Hence the urgent need to identify and develop non-traditional agro-industries.

Essential oils have been identified as one such commodity. On the supply side it has been noted that the country has a wide variety of climatic zones and a large rural population that needs employment. As far as demand is concerned a cursory examination indicates that the markets should be available both locally and abroad.

To date the Ethiopian Government has taken several steps to try to develop the industry. The National Chemical Corporation (NCC) has:-

i) Acquired 80-100 hectares of/and for conduction agronomic research. Some of it has already been planted to eucalyptus citriodora, lemongrass and geranium.
ii) obtained a tractor and a trailer for farm work.
iii) Been seeking to reactivate an oil processing plant at Wendo Guenet; (In this connection it should be noted that under an umbrella project DP/ETH/80/013), Industrial Project Development, technical assistance was provided in 1983 to assist in the rehabilitation of this plant).
iv) purchased a mobile distillation plant which has already arrived in Ethiopia.

What is lacking and urgently needed to fully supplement NCC's efforts is expertise in regard to agronomy, processing and marketing for the industry.

To overcome this constraint the Ethiopian Government, on an urgent basis, sought technical assistance from UNIDO. The fact that the mobile distilling plant has already arrived in the country only serves to emphasize the immediacy of the need.

ANNEX II

Prospects for the development of essential oil Industry In Ethiopia

Ethiopia is endowed with distinct geo-climatic regions, in which a large variety of essential oil bearing plants, viz., Eucalyptus globulus, Eucalyptus citriodora, lemongrass, palmarosa, geranium, thyme, basil etc. are grown and can be cultivated in the country.

Essential Oil industry is an agro-based industry and can utilize rural sector participation in the collection, cultivation and harvesting of raw materials and to some extent even in the field distillation activities.

At present no industry exists in the country to process aromatic plants on industrial scale to produce crude essential oils, let alone pure isolates and aroma chemicals.

The entire needs of these chemicals in the country are met by imports.

Aromatic plants including spices are largely grown in the developing countries. This sector forms a significant part of the agricultural production and exports in many of these countries. In such countries the income of a large number of peasants/farmers is by growing these plants as secondary products.

Some developing countries like India, Srilanka, through R&D efforts have developed appropriate technologies and inexpensive, versatile and mobile plants for the distillation of essential oils.

Sufficient data on cultivation, pest control, post harvest technologies of aromatic plants and quality control of essential oils is available with some of these countries.

Production of major Essential Oils in the developing countries:

Essential oil	Country	Annual Production Tonnes
Lemon grass oil	India	800
	Srilanka	5
Palmarosa oil	India	60
E.Citriodosa oil	India	25
E.Geobulus oil	India	50
Geranium oil	Egypt	50
	India	10
Patchouli oil	Indonesia	500
Vitiver oil	Indonesia	85
	India	10

Science and Technology Division of National Chemical Corporation, Addis Ababa, has short and long range programmes, to survey natural flora, adaptation and cultivation of some selected aromatic plants, distillation quality control of essential oils and market survey.

Based on market potential the following plants are being planned to be cultivated at Wondo Guenet:

- Geranium
- Palmarosa
- Coriander
- Spearmint (mentha spicata)
- Sage (salvia officinalis)
- Basil (ocimum basilicum)
- Thyme
- Mentha piperita

It has at its premises, a moderately equipped R&D Laboratory and quality control instruments built with the assistance of SAREC (Swedish Agency for Research Cooperation with Developing Countries).

It also has developed 80 ha of farms at Wondo Guenet some 265 km south of Addis Ababa. There exists two essential oil plants at the site of this farms. The one (1 ton/Batch) set up by the French settlers in 1967 and the other, a mobile distillation plant procured by the corporation from India (1 ton/Batch of green herb). The former is functional and the later needs some changes, to make it static distillation plant. The flow-diagrams of these units are annexed.

There is a wide scope for expansion of production activities either by extending the farm lands or by organizing an out growers supply scheme in cooperation with the peasents at the vicinity of the farm.

Wondo Guenet besides its present activities has potential to develop into a nerve centre, to serve as a base for research and development activities for agronomic, distillation, secondary processing,organizing production and refining essential oils to make oils of international standard, value added aroma chemicals and market them internationally.

Towards achieving these goals, the existing nucleous at NCC laboratory, and with Wondo Guenet farms and distillery is considered, ideally suited to up grade it into a national institute, which could be named as National Institute of Medicinal and Aromatic plants in short NIMAP on the lines of "CIMAP" in India, to act as R&D centre in the development of not only essential oil industry, but also medicinal plants based industry with a mandate to undertake:

- Survey of wild flora in different geo-climatic zones in the country.

- To assess the quality and quantity of spontaneous flora.

- To conduct distillation of promising aromatic plants by use of mobile distillation units

- Assess the yield and quality of oils

- Selection of suitable plant species and collection of planting materials.

- Establishment of herbarium with authentic plant specimens.

- Introduction and adaptation of selected planting materials, genetic manipulation/nybridisation for higher crop yield, oil content and quality of oils.

The aromatic plants as well as medicinal plantss (when extended to cover medicinal plants) selected for industrial use based on world wide demand and whose oils command best international prices, whould be cultivated at the same location, where these are naturally grown, since the yeild and quality of oil from a given plant material depends on the local conditions such as soil, climate, altitude etc.

- Development of simple technologies for the distillation of aromatic plants and secondary processing for the production of pure isolates.

Although steam distillation of aromatic plants is well known and simple, but data on optimum conditions, viz., time of distillation, steam rate etc., needs to be worked out on individual plant mateiral, since every plant mateiral is unique by itself and can not be generalized.

Higher steam rate and larger periods of distillation beyond optimum levels render the production of essential oils uneconomical.

- To establish field distillation units based on due assessment of availability (both spontaneous and plantation) at various geo-climatic zones in the country involving the local peasants for collection, cultivation and even in field distillation.

- Establishment of field distillation stills near the plantations/ natural habitat reduces the cost of transportation of a large bulk of green herb, wilting and some times fermentation and consequent deterioration in the quality of distilled oils.

These zones could form a network of aromatic plantation and distillation plants in the country.

A centrally located essential oils fractionation unit and secondary processing plant at Wondo Guenet is envisaged. Crude oils from several zonal field distilleries could be brought to the centre to produce pure isolates or enriched components that could be exported at higher values.

- Development of design and engineering capability

- Capability to build simple equipment and make them available for field distillation operations.

- Adequate capability in the maintenance of the distillation plants.

The cost of essential oil distillation plants and equipment very widely, depending on the capacity, material of construction and the country of its orign.

A distillation plant of the capacity of one tonne of green herb per batch made of stainless steel, with an appropriate boiler costs about US$ 100,000 to 150,000 in France U.K.

Distillation stills as big as $5m^3$ - $10m^3$ volumes are used for the distillation of mentha arvensis, lemongrass, Eucalyptus Citriodora, Java citronella etc.

The Expert on mission on various occasions, designed and fabricated essential oils distillation plants of $1m^3$ to $5m^3$. The material of construction for making distillation stills used on all accasions was mild steel and the vapour line, shell and tube condenser, separator, receiver were all made of Aluminium. Aluminium is also considered suitable as material of construction for bulk storage of essential oils, except storage of essential oils containing phenolic compounds, in which case storage tanks made of stainless steel could be used.

This method if followed could reduce considerably the cost of field distillation. However, stills made of mild steel should be used quite frequently to prevent formation of rust.

Yet another factor the Expert would like to emphasize is that building basic infrastructure, to design, simple appropriate plants and equipment based on optimisation studies and fabrication of such units indigenously would save not only time and money but also valuable foreign exchange.

It is gratifying to note the installed engineering infrastructure is available in Addis Ababa itself to under-take fabrication of chemical plant and equipment.

It may require some reinforcement in the area of design of chemical plants capability. This could be achieved by appropriate national and or international training programme of its engineers.

A cooperative society may be set-up at each zone with the local enterpreneurs and peasants as members, who undertake collection, cultivation and distillation of essential oil. NIMAP, could extend general guidance in selection of plants, planting materials, cultivation techniques, plant protection, setting-up of field distillation of essential oils, type of fuel for steam generation (use of sun dried spent marc as supplementary fuel is considered very useful and economical)

The cooperative societies could sell the crude essential oils to NIMAP at mutually agreeable price, but lower than the ruling market price, in consideration for the services rendered by NIMAP.

NIMAP should create adequate:

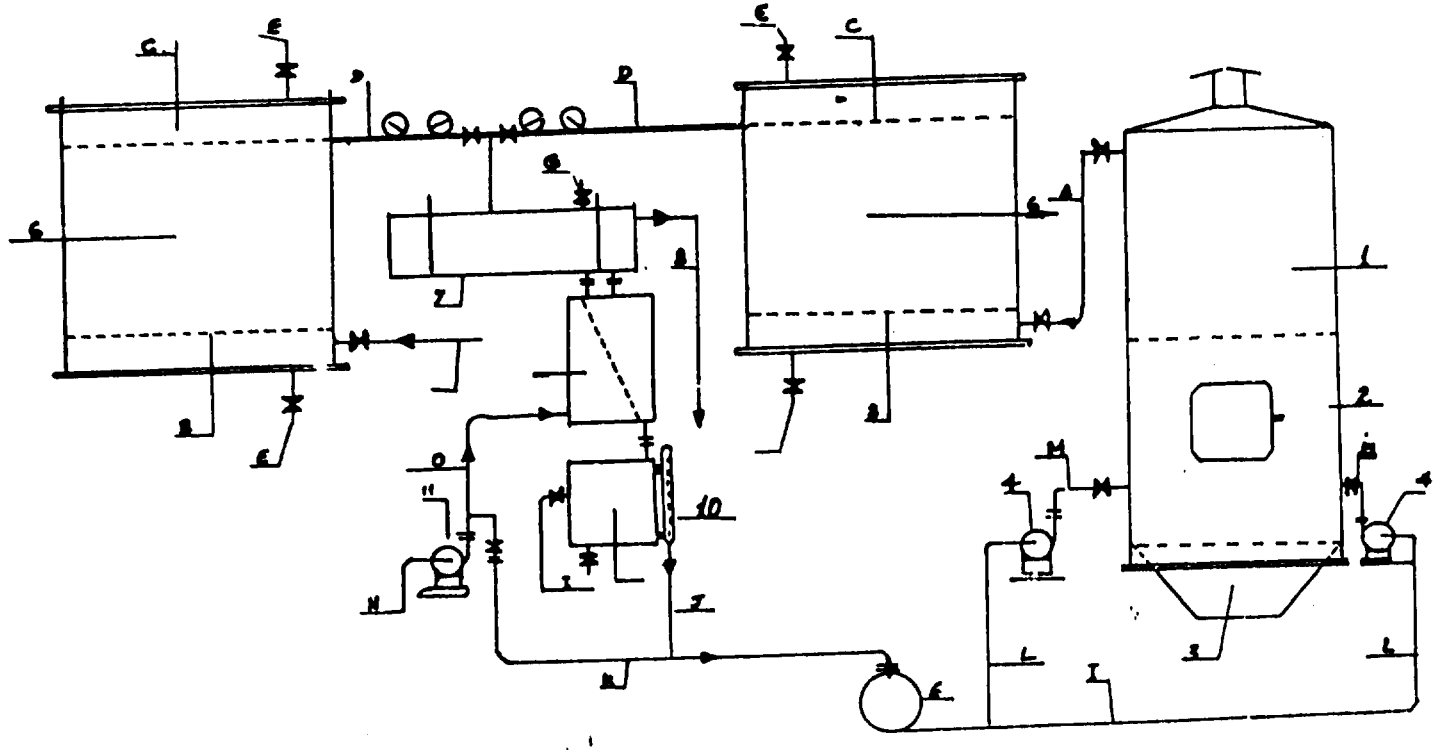
- Storage capacity to store various types of E.Oils and cold rooms.
- Marketing crude E.Oils
- Fractionate E.Oils for making pure isolates
- Manufacture aroma chemicals
- To establish contacts with worldwide users of E.Oils, isolates, aroma chemicals.
- Could develop expertise and analytical techniques to predict the worldwide trend in demand & supply of individual oils, pure isolates, aroma chemicals etc.
- Extend appropriate advise based on demand and supply.

In short there is a need to establish R&D infrastructure in several disciplines viz., agro-botanical studies to cultivate aromatic plants, pest control, setting up extension service to help farmers who grow aromatic plants, studies to develop high yielding and disease resistant varieties of seeds, to develop design and engineering capability to fabricate, not only distillation plants but equipment required for secondary processing of essential oils viz., fractionation columns, reactors etc. and the need to ensure that essential oils produced meet international standards.

The need to develop indigenous capability to use locally produced essentilal oils.

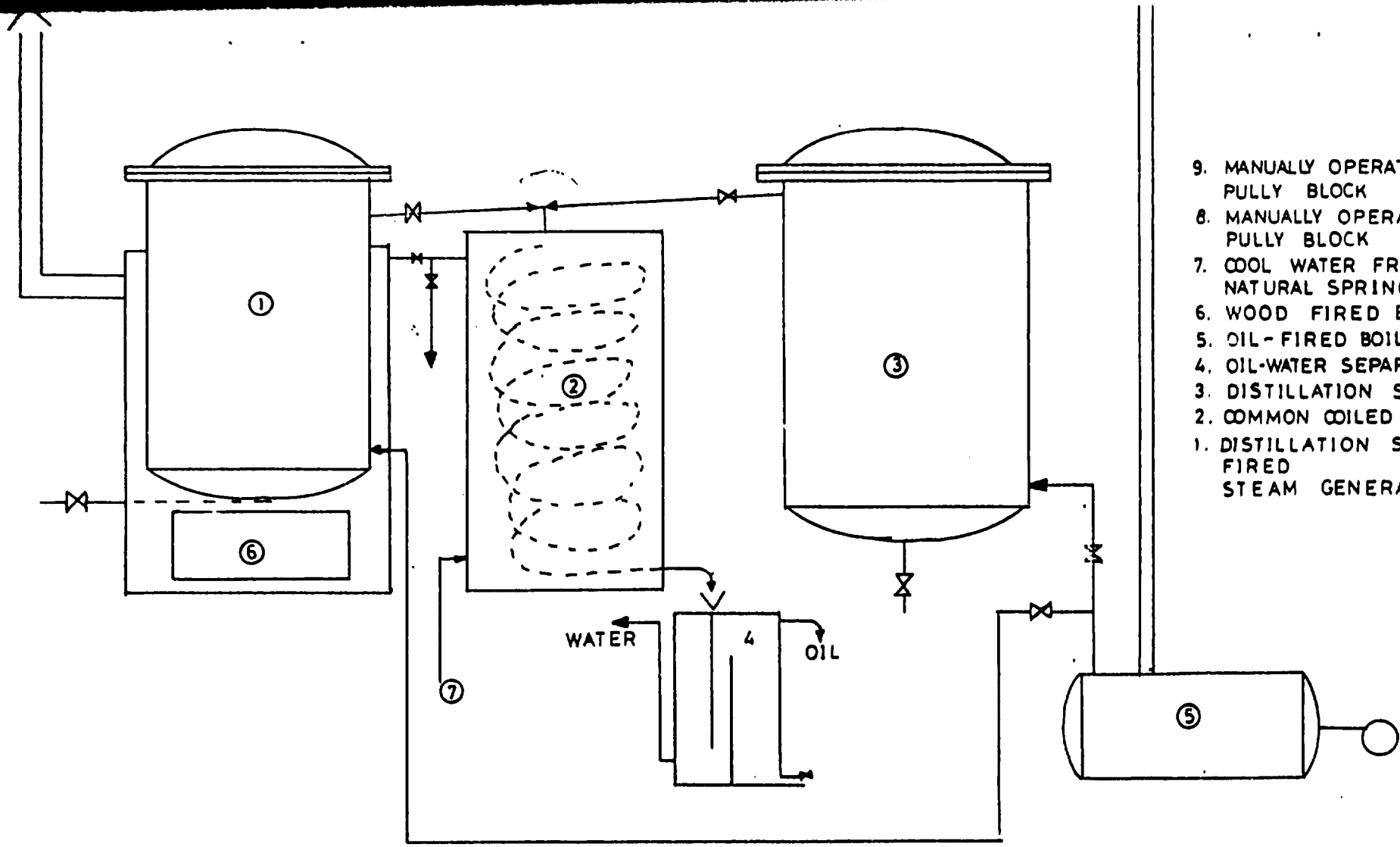
To achieve these objectives for the quicker development of essential oil industry in Ethiopia establishment of National Institute NIMAP is recommended and its cooperation and collaboration with the following relevant organization is considered very necessary.

- Institute of Agricultutal Research (IAR)
- Agricultural College (AWASSA)
- Concerned departments of Addis Ababa University
- Ethiopian Food Corporation
- Wondo Guenet College of Forestry



11	COLD WATER PUMP	E	3/4"	NB	MAKE UP WATER TO S	Q	2" WATER OUTLET
10	OIL WATER SCALE	F	1/4"	NB	CONDENSED WATER TO S	P	2" COOLING WATER TO T
9	SEPARATOR	I	3/4"	NB	ESSENTIAL OIL OUTLET	O	2" COOLING WATER DELIVERY
8	COOLER	H	1"	NB	CONDENSATE OUTLET	N	2" NB WATER COOLING SUCTION
7	CONDENSOR	G	1/4"	NB	CONDENSER VENT	M	1" NB WATER FEEDING TO D
6	EXTRACTORS	F	3/4"	NB	DRAIN	L	1" NB SUCTION LINE FROM S
5	BOILER FEED WATER TANK	E	3/4"	NB	VENT OUTLET		
4	BOILER FEED WATER PUMP	D	1 1/2"	NB	VAPOUR OUTLET		
3	ASH HOPPER	C	1"	NB	VAPOUR SPARGER		
2	BOILER FURNACE	B	1"	NB	STEEM SPARGER		
1	BOILER	A	1 1/2"	NB	MAIN STEAM		

FLOW DIAGRAM OF MOBILE ESSENTIAL OIL DISTILLATION UNIT



FLOW DIAGRAM ESSENTIAL OIL DISTILLATION PLANT
WONDO GUENET ETHIOPIA.

MB/IV

ANNEX III

PROJECT PROPOSAL TO SET UP AN ESSENTIAL OILS REFINING UNIT/SECONDARY PROCESSING UNIT AT WONDO GUENET, ETHIOPIA

Summary

Ethiopia is endowed with distinct geoclimatic regions, in which a large variety of essential oil bearing plants are grown and are being cultivated in the country.

National Chemical Corporation has developed a farm of 80 hectares at Wondo Guenet, some 265 km south of Addis Ababa, and has distillation plants capable of steam distilling about 2 tonnes of green herb per batch.

The Corporation also has at its premises in Addis Ababa, a moderately equipped R & D Laboratory with some quality control instruments.

N.C.C. has not been able to market about 2 tonnes of lemongrass oil, as well as other oils produced by it, because of their sub-standard quality.

It is therefore, proposed to set-up a pilot plant facility at Wondo Guenet for refining crude essential oils produced in the country to produce not only essential oils of international standard but also value added aroma chemicals and fragrances.

Buildings with adequate supply of electricity and water to house these units are available at Wondo Guenet.

Addl. Equipment required	Approximate Cost (U.S.$)
1. Laboratory model, all glass high efficiency fractional distillation unit (about 40 NTU) complete unit with support steel structure, installation and commissioning. (please see the main report for details)	60,000
2. Glass-lined/All glass, stirred reactor pilot plant 100 litres/ batch. Complete unit with support steel structure, install ation and commissioning. (please see the main report for details)	60,000
3. Accessories to be imported for a stainless steel fractional distillation pilot plant. Design of this pilot plant would be provided by expert on mission (Processing Technologist in	

Essential Oils production) 10,000
This pilot plant is expected
to be fabricated at Addis Ababa.
Basic engineering infra-structure
is available in the capital city.

4. S.S. Super centrifuge 100 l/hour ..10,000

5. S.S. Centrifugal pumps 100 l/hour
10 m head (two) .. 3,000

6. International Expert (2 man-months).24,000
7. Miscellaneous & contingency 7,000

TOTAL 174,000
Expected unspent funds from the running
project SI/ETH/90/802 ..... 20,000 *

* This figure provided by the project coordinator.

Budget proposal 154,000

PROJECT PROPOSAL TO SET-UP PILOT PLANT FOR REFINING OF ESSENTIAL OILS/SECONDARY PROCESSING AT WONDO GUENET, ETHIOPIA.

With a variety of distinct geoclimatic regions, Ethiopia has various exotic and indigenous essential oil bearing plants and can be cultivated on a commercial scale to diversify domestic produce to enhance earning of foreign exchange.

The development of agro-based industry on essential oils is expected to create additional potential for employment and benefit with inputs of appropriate technologies and involvement of rural sector in the cultivation and harvesting of raw material and in field distillation activities.

French settlers in Ethiopa have established in 1967 a farm for the cultivation of essential oil bearing plants and an essential oil distillation plant at Wondo Guenet, which stands for "Heavenly place" in Amharic language, is at an altitude of 1900 M., AMSL and some 265 km south of Addis Ababa.

The farm and the distillation plant were in operation till 1974. The activities were suspended the same year due to some socio-political reasons.

In the year 1987, the farm and the plant came under the control of National Chemical Corporation (NCC) who earnestly renovated the farms. It acquired some surrounding land-it has now 80 hectares-added a tractor with a trailer and purchased a mobile distillation plant of about 1000kg/batch of green herb. It has developed the farms and planted eucalyptus citriodora on 40 hectares, lemongrass on 20 hectaree, geranium on 0.5 hectare palmarosa on 0.5 hectare and has flexible plans, to vary acreage under each plantation to suit the demand of essential oils in the international market.

The Corporation has plans to cultivate Java citronella, Mentha piperita, sweet Basil, Vetiver etc.

The old plant has two mild steel stills (120 m/m dia; 160m/m high and 150m/m dia, 250 m/m high) capable of distilling 300-400kg and 500-600kg of green herb per batch respectively.

The top cover of the smaller still and vapour lines of both the stills are of copper and partly M.S., while the top cover of the larger still is made of stainless steel, together jointly connected to a common stainless steel coiled condenser, immersed in a M.S. cylindrical tank. The condensate leads into a galvanised iron separator.

Perennial cool water stream flowing from the hills located on the eastern part of the farm diverted through a system of channels and G.I. pipes forms the source of cool water to the condenser. A part of the warm water let out from the condenser is fed into the wood fired steam generator.

Steam generated in the diesel oil fired boiler is connected to both the stills through a G.I. pipe, while the smaller still is encased in a wood fired boiler to generate steam for distillation.

The expert accompanied by the project coordinator and an engineer visited Wondo Guenet in August 92. Visited the farms and thoroughly assessed the old and the new distillation plants and also carried out a couple of batches of distillation in the wood fired still, using freshly harvested palmarosa herb.

- The first batch charged with 308 kg of green herb yield 0.2% in about 2.5 hrs and the second batch charged with 400 kg of the same herb, occupying the same volume, yielded 0.34% of oil.

- These experiments emphasises the importance of packing well of the herb in the still and steady supply of steam at the rate of 2 litres/minute.

- It is suggested that the larger still, steam pipe, vapour lines and top covers of both the stills should be well insulated to minimize heat losses and reduce time of distillation and fuel consumption.

- To replace the G.I. water-oil separator with one made of stainless steel. This unit is available at the site.

- It was observed that the wood fired boiler takes about 2.5 to 3 hrs (from cold start) to generate steam.

- Valuable time and precious fuel could be saved if the stills are operated three shifts per day during harvest season.

- The furnace of the boiler encasing the smaller still is suitable for use of wood as fuel.

- To add a water de-ioniser to boiler feed water.

These suggestions were explained to the counterpart members.

The new plant, based on three hundred working days perannum and three shifts per day is capable of handling 500 MT. of eucalyptus leaves, terminal branchlets and citronella grass.

It consists of two mildsteel stills. each of 1500 mm dia and 1500 high with top and bottom hinged type doors, provided with steam sparger at the bottom and "vapour outlet 40mm NB & nozzle with sparger fabricated from 25 NB pipe having 6mm dia collection holes at the top"

The two stills are connected to a common "shell and tube condenser of 4.8 m2 overall heat transfer area". Vapour in shell type condenser, its shell, tube plates, baffles are made of M.S. and tubes are made of de-oxidised copper.

A coiled type cooler of 0.8 m2 (surface area) is provided to cool the condensate. The material of construction of contact surface part (coil) is made of deoxidised copper and that of shell is made of M.S.

All these units are securely mounted on a trailer frame of 2.75 m x 7.0 m fabricated from M.S. Channels and chequered plates. The trailer in turn is mounted on 8 tyred wheels for mobility.

To make the plant self contained, the following have also been mounted on the same trailer:

- A steam boiler with feed pumps capacity (not specified) presumably sufficient to operate two stills simultaneously. One pump as a stand by.
- A diesel generating set of 15KVA capacity.
- A control panel.
- Twin tube light fixtures.
- Cooling water circulation pump of 100 lpm at 10m head.

The expert concurs with the opinion of the corporation authorities that due to the heavy weight of the whole assembly and uneven terrain of the essential oil growing areas, it may not be practical to use this unit as a mobile unit.

However, it is the considered opinion of this Expert that this mobile unit could be used at Wondo Guenet if the following modifications are made.

Distillation stills:

- Bottom hinged type door to be permanently closed.
- To be mounted on plain cement platform between the Boiler shed and French distillation plant.
- Disconnect the existing vapour sparger and weld a separate vapour outlet of 75mm dia NB pipe preferably in stainless pipe, (at the top end)
- A separate condenser to each distilling unit. (Two of several stainless steel coils lying in the yards of Gulele Soap Factory, Addis Ababa could be made use of for this purpose.)
- An independent s.s. separator to separate essential oil/water coming from each condenser.
- M.S. structure with a mono sail over the middle of the two stills at a height of 3.5m above the cement platform, and the use of 2 ton capacity 4 way (up and down, to and fro) electric hoist would facilitate quick and efficient discharge of the spent marc.

The boiler and generator could be installed in the existing boiler shed. There is enough space to accommodate these accessaries.

The Expert brought to the notice of the project authorities that he during the current mission, can assist the authorities in effecting these modification, install and commission the new plant. The most suitable location for this is next to existing distillation plant at Wondo Guenet.

With the commissioning of this plant, the Corporation would be in a position to distill three different aromatic plant materials at the same time, and would yield adequate quantities of crude essential oils.

A small (about 100l) locally fabricated mobile distillation unit is available at Wondo Guenet. This needs some modifications. The necessary modifications have been explained to the counterpart engineer. With this modified mobile distillation still, it would be possible to conduct "agronomic and process research of selected essential oil bearing plants at different agro-economical zones on experimental plots". These stations could thus develop a national network of aromatic plantations and distillation units in the suitable agro-ecological zones.

Simple appropriate technology thus developed could be transferred to the peasants.

The activities of the Wondo Guenet plant is supported by R & D activities conducted at a small but moderately equipped laboratory at the premises of the NCC Addis Ababa.

The laboratory is equipped with various glass apparatus for distillation, extraction, evaporation etc. It also has a moderate quality control laboratory and has the following instruments:

- Gas Chromatograph
  Varian Model 3700
  Integrator and Recorder
- UV/VIS spectrophotometer
  PYE/UNICAM SPG-450
- pH meters
- TLC apparatus with UV lamp
- Analytical Balances
- Lovibond Colorimeter
- Jouan Centrifuge
- Hoover melting
  point apparatus
- Abbe Refractometer
- Moisture tester balance (OHAUS)

This laboratory is equipped with the assistance of SAREC (Swedish Agency for Research Cooperation with developing countries).

The lemongrass oil (yield 0.3-0.5%) produced at Wondo Guenet has citral content of about 60-67%, where as the international market demands oil with minimum of 75% citral.

Eucalyptus globulous which is grown widely, when distilled on lab scale, yielded about 1% oil with about 70% 1,8 cineol far short of international standard of 80%, the same thing goes with that of the oils obtained from Eucalyptus Citriodora, Palmarosa, Geranium etc.

Science and Technology Division of National Chemical Corporation, which is actively pursuing R & D programmes on industrial utilization of essential oils both at laboratory and Wondo Guenet Farms and Factory has been planning to cultivate the following essential oil bearing plants at Wondo Guenet:

Geranium
Palma Rosa
Coriander
Spearmint
Sage
Rosemary
Basil
Eucalyptus citriodora
Mentha piperita
Thyme

It is expected to produce about 15 tonnes of various essential oils per annum. The essential oils produced at Wondo Guenet plant has:

Oil	Composition	
Lemongrass	60-67%	Citral
E.citriodora.....	60-65%	Citronellal
Geranium.....	25-30%	Rhodinol
Palmarosa.....	19-21%	Acetate
	52-58%	Geraniol

International Standard Organisation (ISO)
Lemongrass oil (Cymbopogon citratus)
Citral content..... minimum 75% (ISO 3217,1974(E))
Eucalyptus citriodora
Citonellal ..... minimum 70% (ISO 3044,1974(E))
Geranium Oil
Cironellal (Rhodinol) Bourbon
min.... 42%
max.... 55%
Ester value after acetylation min ..205
max ..230 (ISO 4731,1978(E))

Current Spot Prices in the London Market is given below:

		US $ /KG
Lemongrass Oil	Indian	13.25
	Guatemalan	9.25
(minimum citral content 75%)		
Palma Rosa Oil	Indian	18.00
	Brazilian	24.00
Geranium Oil	Chinese	33.50
Coriander Oil	Russian	70.00
Spearmint Oil	Chinese	16.00
	.....	23.00
Sage Oil (Officinalis)		42.00

Essential oils produced at Wondo Guenet generally do not measure upto internationally marketed quality to fetch ruling market prices.

The workshop on Essential Oil Industry (organised jointly by UNIDO, Govt. of India, ESCAP Nov.- Dec. 81 Lucknow, India, Page 38) recommanded that "another area for R & D in processing is, secondary processing of essential oils. In a country like India considerable progress has been made in this direction and there are a number of industries producing perfumery, cosmetics and flavour chemicals, utilising citronella oil, lemongrass oil, palma rosa oil".

"There is no reason why every producer country should not strive to export natural perfumery chemicals, essential oils as well as spice products, in place of crude raw materials."

"Scientists in the developing countries should be in a position to solve simple problems by experimentation, so that in the future their countries are able to earn more foreign exchange by exporting finished products, which can claim to satisfy the most stringent quality requirements. There is now justification for many of the developing countries in terms of R & D for production of perfumes, cosmetics and flavouring compounds from natural sources."

When aromatic plants are steam distilled and the resulting essential oils are separated from water phase, the oil phase undoubtedly contain,traces of moisture and some suspended impurities.

It is suggested that the essential oils produced at Wondo Guenet be subjected to secondary processing to produce essential oils of International standard quality and also to produce value added aroma chemical fragrances.

The first part is to fractionate crude essential oils to produce desired components in relatively pure form and blend it with the parent essential oil to enrich it to the desired international level or fractionate all the crude oil to remove low boiling terpenes to produce terpeneless essential oils.

Pure isolates or fractions obtained from fractionation of essential oils often command greater value than the oils themselves.

The second is to subject the crude essential oils to react with other chemicals to produce valuable aroma chemicals. It is noted that there is no indigenous production of aroma chemicals and fragrances. Its requirements are being met by imports the end products of essential oils. This facility is intended to serve to establish indigenous production of essential oils and aroma chemicals.

There is a good demand for geraniol in the manufacture of good quality perfumes.

Palmarosa oil contains about 58% geraniol and 14% geranyl acetate, terpenes and minor components constitutes the rest.

To obtain high grade geraniol of 94 to 95% purity, Palmarosa oil is reacted with dilute alkali to hydrolyse the geranyl acetate to geraniol, followed by fractionation under vacuum.

The traces of moisture if not removed reduces the shelf life of essential oils due to oxidation, hydrolysis and resinification, offsetting the quality of essential oils.

The most efficient method of removal of water and suspended impurities is by centrifugation in a super centrifuge.

The proposed secondry processing of essential oils is shown in the enclosed flow diagram (Annexed)

The storage tanks in stainless steel and all the units of fractional distillation plant can be fabricated locally, however stainless steels, valves, reflux dividers, internal packings, have to be imported.

The expert on mission (SI. ETH. 90. 802) and a counterpart engineer are currently engaged in the design of these units.

It may however be emphasised that indigenous development of design and engineering capability leading to fabrication of chemical plant and equipment is a complusive need of the developing countries, even if these countries have to import the necessary stainless steel raw materials.

These capabilities when developed is expected to:

- reduce the project implementation time
- save considerable foreign exchange
- confidence and moral booster to the engineers and technologists
- Provide indigenous component in the implementation of new projects.

To meet the demands of domestic industry and export market of high quality essential oils and aroma chemicals, it is considered very essential to add following laboratory and pilot plant equipments to the already existing essential oil processing facility at Wondo Guenet:

1. All glass, high efficiency laboratory fractionation column, vacuum operation

2. Pilot plant(1) stainless fractionation column, packed with high efficiency knitted ss wire mesh ("Knitmesh")
   Capacity : 400 litres/batch
   - Vacuum operation

3. Pilot plant(2) Glass lined/all glass stirred reactor
   capacity : 100litres/Batch
4. S.S. Super centrifuge 100 l/hour

General specifications of the needed equipment :

1. Laboratory model all glass fractional distillation unit.

   - Column of 1m height packed with high efficiency grid/flexi-grid packings (efficiency equivalent to about 40 NTU)

   - Interchangeable reboilers of 1,2 & 5 litres with suitable port holes for vapour outlet, charge inlet, vacuum, thermometers, etc. and fittings.

   - Suitable heating mantle with regulator to control and monitor temperature

   - Digital indicating thermometers with sensors, to monitor the temperatures of the reboiler, vapour, reflux etc.

   - Reflux distributor, its control and monitoring instruments

   - Condensers & reflux preheater

- Cold trap
- Receivers
- Inter connecting glass tubing valves, cocks, other necessary fittings.
- Suitable vacuum pump, intended operating vacuum in the system is 2 to 3 mm Hg.
- Vacuum control, monitoring and measuring instruments.
- Tubular steel structure and fittings to mount the column and its accessories.

The cost of the complete unit including erection and commissioning is about ..... US$ 60,000.-

2. PILOT PLANT (1)

Stainless steel fractionation column, packed with high efficiency knitted stainless steel wire mesh (knit mesh) with accessories

Capacity : 400 litres/Batch

Expert on mission can provide the design of this unit and help in its fabrication locally, provided NCC authorities made available all the stainless steel and mild steel materials required. The necessary installed engineering infra-structure is available in Addis Ababa.

In case this unit is indigenously fabricated, the following accessories have got to be imported:

- Knitted stainless steel wire mesh packing
- Reflux distributor, control and measurement, suitable for high vacuum operation.
- Stainless steel valves, suitable for high vacuum operation.
- Digital indicating thermometers/thermocouples.
- Vacuum gauges.
- High vacuum pump.
- Electrical heating mantle.

The cost of these accessories is about ..... US$ 10,000.-

PILOT PLANT(2)

Glass lined/all glass stirred reactor: Capacity 100 litre.

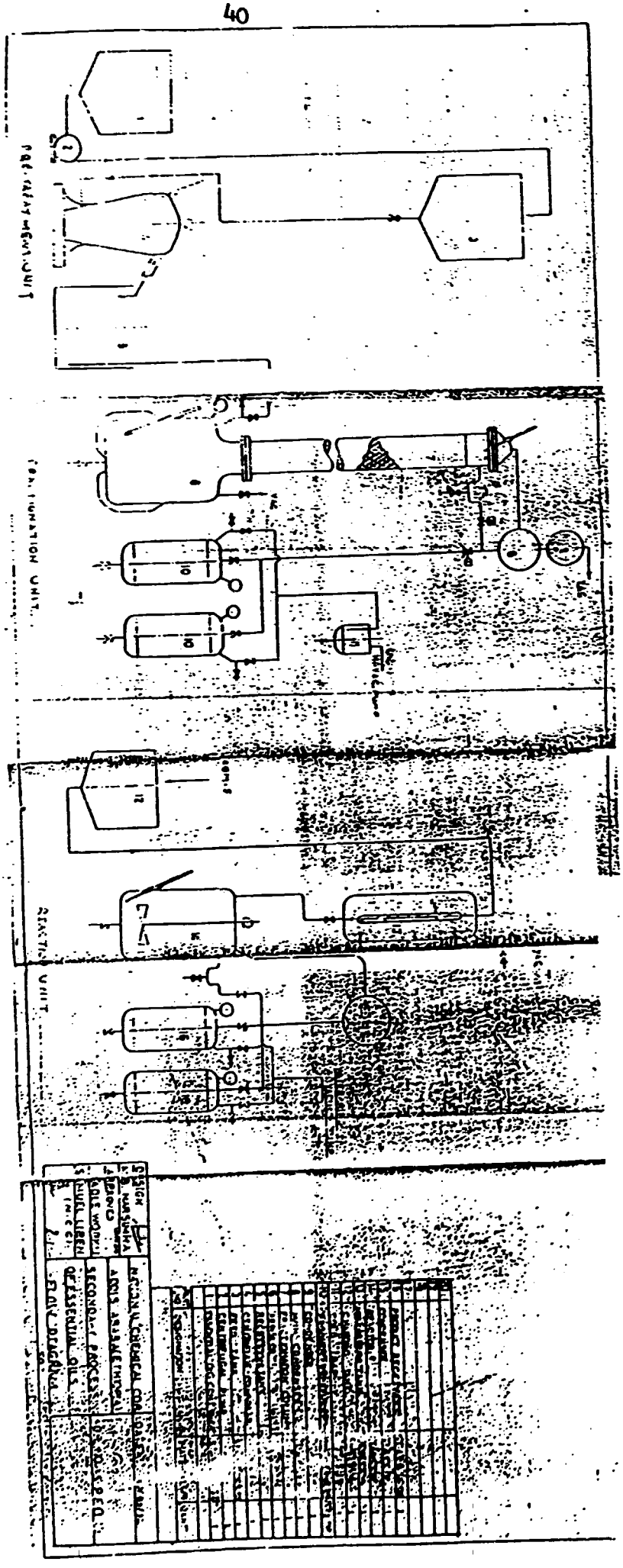
- Stirred reactor, with heating/cooling arrangement, Variable speed.
- Heating control, monitoring and digital indicating measuring instruments.
- Reactants measuring arrangement.
- Condenser(s)
- Arrangement for refluxing and or collection of condensate.
- Condensate collection vessels(two)
- Interconnecting tubing, valves, cocks, etc.
- Vacuum pump
- Vacuum control, monitoring and measurement control.
- Tubular steel structure and fittings to mount the reactor and its accessories.

	US $
The cost of the complete unit including erection and commissioning is about.....	60,000.00
4. SS super centrifuge for separation, and clarification (less than 1% fine solid content) capacity 100 l/hour.....	10,000.00
5. SS centrifugal pumps, capacity 100 l/hour, total head 10 metres (two)	3,000.00
6. Miscellaneous and contingency	7,000.00
7. International expert (2man months).....	24,000.00
Total for items 1 to 7	174,000.00
Expected unspent funds from the running Project SI/ETH/90/802	20,000.00 *
Budget Proposal	154,000.00

* This figure, provided by the project coordinator

An electrically operated Boiler (yet to be commissioned of the capacity of (50kg/hour) is already available with NCC.

Buildings necessary to these units are available with adequate electricity and water supply at Wondo Guenet.



ANNEX IV

Alternate Approaches to Processing

1. Integrated plant consisting of herb distillation, fractionation and aroma chemicals.
2. Central plant for fractionation and aroma chemicals to serve satellite field distillation.
3. Central plant for fractionation with mobile distillation units.

The second option is to have a central facility for the distillation and secondary processing to serve satellite plantations. The plant can be located close to the plantation for quick processing to avoid deterioration. This option reduces transporting large bulk of plant materials.

However, this option entails the establishment of distillation plant with independent boiler for every satellite plantation, requiring large financial investment.

The third option, which is slight variation to the second option is that a single mobile distillation unit could move from site to site (natural and or plantation) to produce crude essential oils.

The crude essential could subsequently be processed at a central place viz., Wendo Guenet.

Taking into consideration the present state of essential oil processing in Ethiopia, the third option is the best alternative.

At a later stage when the industry is sufficiently developed to sustain, additional investment in the installation of static distillation plants with independent boilers at various zones or satellite planation could be considered.

The existing mobile distillation unit with modification suggested elsewhere in the report could be used for this purpose.

For operating the third option the combination of forest wood and dried spent marc is the most economical choice of fuel for operating the boiler of mobile distillation plant as well as the static field distillation plants.

ANNEX V

ESTIMATED COST OF PRODUCTION OF ESSENTIAL OILS *

1. Production of Lemon grass oil.

Average yield of green herb per ha per annum (max. 6 harvests/year) . . . . 60,000 kg

Yield of oil at 0.5 % v/w from 20 ha of plantation. . . . . 6,000 l

Existing distillery capacity . . 2 tonnes/shift

Batch time (charging, distillation, discharging...4 hrs. 3 shifts/day,(i.e.) 12 t green herb/day, 12x6x48 (12 t/day x 6 day/week x 48 weeks/year). . .3456 t/year

Estimated cost of investment	US $
1. Equipment	25,000.00
2. Land @ 3000 Birr/ha;	12,000.00
3. Plantation @ 1142 Birr/ha . . .	4,568.00
4. Buildings	10,000.00
Total . . .	51,568.00

Estimated cost of production	US $
1. Farm maintenance and harvesting @ 360 Birr/ha/year	1,440.00
2. Fuel consumption 0.67 cu.m/batch @ 60 Birr/cu.m ; 600x0.67x60/5.0 .	4,824.00
3. Labour and supervision 5 labour/shift of 8 hrs @ 2 Birr/day/labour	612.00
5x3x2x6x17(5 labour x 3 shifts/day x 2 Birr/day x 6 day/week x 17 weeks)	
4. Supervision : 20 % on cost of labour Supervision	122.40
5. Depreciation	
Equipment @ 10 % on cost of equipment 25,000/10 x 17/48	885.42
Plantation (Life 5 years).	913.60
Building @ 5 % on cost of building 10,000/20 x 17/48	117.08
6. Interest on capital investment @ 9.5 % per annum 51,560/100 x 9.5 x 17/48	1,734.80
Total (1 to 6). . . .	10,648.90

Cost of production of 1 litre lemon grass oil 10,648.90/6000 . . . . . 1.77

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* based on farming figures provided by N.C.C.

2. Estimated cost of production of palmarosa oil

Presently under 0.5 ha experimental plantation
Projected acreage during the next 2-3 years: 20 ha
Estimated yield of green herb/annum (20): 1200 tonnes
Estimated production of palmarosa oil
@ 0.3 % v/w . 3600 litres
Estimated cost of production same as in the
case of lemon grass oil, (i.e.) US $ 13,812.70
Cost of production of i litre of oil
13.812.70/3600 = ... US $ 3.84

3. Estimated cost of production of Geranium oil

Presently under 0.5 ha experimental plantation
Projected acreage during the next 2-3 years : 20 ha
Estimated yield of green herb/annum/ha : 40 tonnes
Estimated yield from 20 ha : 800 tonnes
Production of geranium oil @ 0.1 % v/w : 800 litres
Number of weeks of distillation
6 Batches/day, 6 day/week : 800/12 x 6 : 11 weeks
Estimated cost of investment
same as in the case of lemon grass oil : US $ 51,560.00
Estimated cost of production US $
a. Farm maintenance and harvesting
@ 360 Birr/ha year 1,440.00
b. Fuel consumption (400 batch)
400 x 0.67 x 60/5.0 . . . . . 3,216.00
c. Labour and supervision
Labour 5 x 3 x 2 x 6 x 11 . . . . . 1,980.00
Supervision 20 % of labour cost: 396. . 2,376.00
d. Depreciation
-Equipment : 25,000/10 x 11/48 . . . 573.00
-Plantation (life 5 years) 913.60
-Building 10.000/30 x 11/48 . . . . . 114.00
e. Interest on capital investment :
@ 9.5 % for 11 weeks
51,560/100 x 9.5 x 11/48 . . . . . 1.122.50

Total (a to e). . . . 9,755.70

Estimated yield of oil . . . . . .800 litres
Estimated cost of one litre of oil :
9,755.70/800 . . . . . 12.20

4. Production of E.citriodora oil

Plantation . . . . . 40 ha
Average yield of green leaves with
branchlets per ha per annum . . . . . 40 tonnes
. . . . 1,600 tonnes/40 ha
Yield of oil at 1 % v/w . . . . 16,000 litres

Estimated cost of investment	US $
1. Equipment	25,000.00
2. Land 40 ha : 3000 x 40/5 . . .	24.000.00
3. Plantation @ 1358 Birr/ha/annum 1358 x 40 /5 . . .	10,864.00
4. Building	10.000.00
Total	**69,864.00**
Estimated cost of production	
a. Farm maintenance and harvesting @ 594 Birr/ha year	4,752.00
b. Fuel Number of batches for distillation :800 800 x 1.00 x 60 /5	9,600.00
c. Labour and Supervision 5 labour/shift of 8 hrs 2 Birr/day/labour 5 x3x 2x 6x 22.5 /5	810.00
Supervision 20 % of labour . . .	162.00
d. Depreciation	
Equipment 25,000/10 x 22.5/48	1,171.90
Plantation (10 years life)	1,086.40
Building	234.40
e. Interest on capital investment 69,864/100 x 9.5 x 22.5/48	3,111.10
Total . . .	**20.928.00**
Estimated cost of production of 1 litre of oil	1.31

Plant	Herb yield kg/ha/year	Oil yield %	Time for maturity	Time of distilling per batch	Fuel consumption cub.m	Investment till maturity per ha/year	Maintenance and harvesting per ha/year
Lemon grass Life 4-5 Years	60,000	0.5	3 Months for 1st harvest subsequently 2 months	2hrs & 30min	1.67-2.67	Various cultural practices 692 Birr Material 200 Birr Tractor rent 250 Birr Total 1142 Birr	Harvesting and maintenance 360 Birr
Palmarosa Life 4-5 Years	60,000	0.3		2hrs & 30min	1.67-2.67	Same	Same
Geranium Life 4-5 Years	50,000	0.1		2hrs & 30min	1.7-2.7	Same	Same
E.Citriodora Life 10-15 Years	40,000	1.0		2hrs & 30min	1.84-2.84	Various cultural practices 508 Birr Material 600 Birr Tractor rent 250 Birr Total 1358 Birr	592 Birr

SOURCE: Science and Technology Dept. of N.C.C

ANNEX VI

(e) DESIGN AND ENGINEERING

(i) Laboratory model all glass Fractionation Column

The small laboratory at the premises of N.C.C., serving the needs of distillation and extraction of plant materials and analysis of the oils for their constituents. What was lacking in the laboratory and urgently needed was a laboratory model all glass fractionation assembly to conduct studies on fractional distillation of various essential oils and to establish optimum conditions for the isolation of pure isolates from indigenous essential oils, before being scaled-up to pilot plant and production levels. Pure isolates obtained by fractionation of essential oils often command higher prices than the oils themselves.

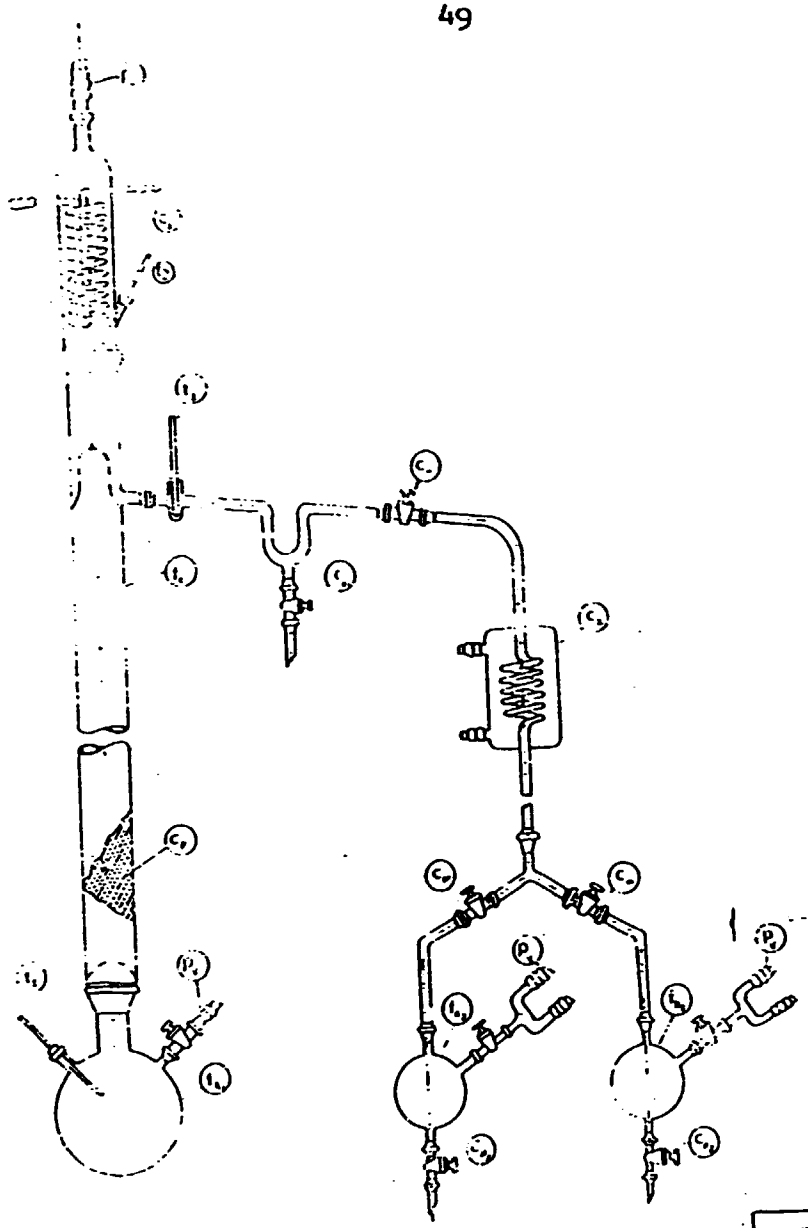
Since procurement of a commercially available laboratory model may entail long delay, and with a view to fill-up the existing vital gap, the expert on mission, designed a one litre per batch column of one metre height and got it fabricated locally under his supervision. A novel feature of this column was that resin free glass wool fibre was used as internal packing (contacting) material in the column.

Due provisions have been made to measure temperatures of reboiler, vapour and reflux. Preheating of reflux to a temperature equal to that of vapour, to maintain near adiabatic conditions in the column, necessary for efficient fractionation of binary, and multi component mixtures.

In the absence of a suitable automatic reflux distributor, manually operated distributor has been incorporated.

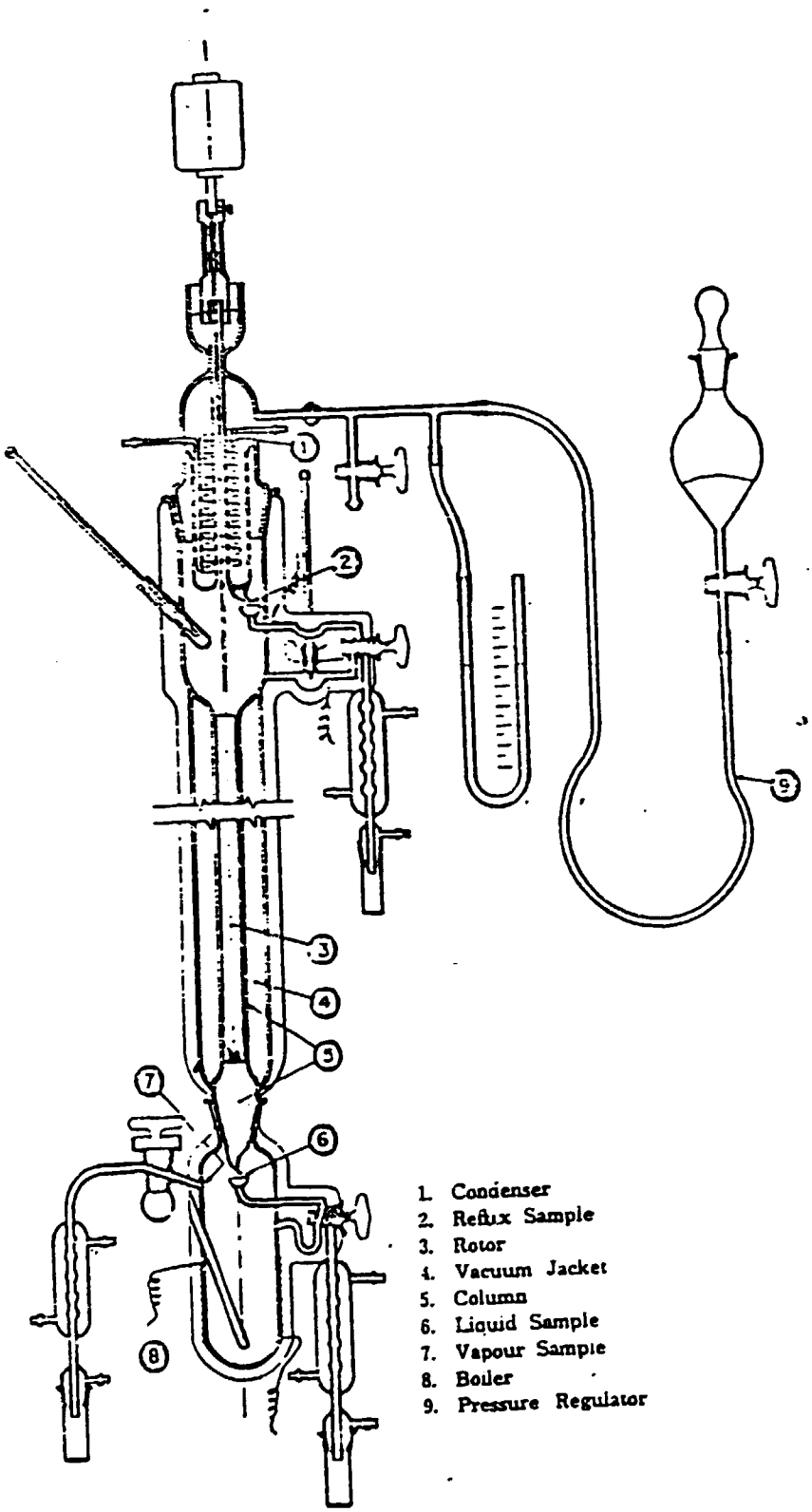
A copy of the drawing of this unit as well as a copy of the drawing of a spinning band column, which the expert had designed earlier are enclosed.

Generally spinning band columns are very efficient in the separation of close boiling mixtures into relatively pure components, but suffers from the limitation of small operation capacity, since the annular space between the rotor and inside of the column body (the space available for contacting up-rising vapours and down coming liquid) is restricted to a few milimeters only. Nevertheless, it is considered as very useful "tool" in the laboratory as "high efficiency fractionation column."



PART	DESIGNATION	MATERIAL	PIECE
P_1	VACUUM PORT	GLASS	3
C_1	STOP COCK	"	3
C_2	COOLER	"	1
C_3	CONDENSER	"	1
C_{3a}	PRODUCT DISCHARGE	"	2
C_{3b}	DISCHARGE PORT	"	1
$t_{1,2,3}$	THERMOMETERS	GLASS	3
C_4	COLUMN PACKING		—
f_1	FRACTIONATING COLU.	"	1
f_{2a}	RECIVING FLASK	"	2
f_{2b}	REBOILER FLASK	GLASS	1

M.B.	NATIONAL CHEMICAL		DATE
ERASMUS	CORP.		4-8-92
SCALE	LAB SCALE E. SERIES		
	OIL FREED		



1. Condenser
2. Reflux Sample
3. Rotor
4. Vacuum Jacket
5. Column
6. Liquid Sample
7. Vapour Sample
8. Boiler
9. Pressure Regulator

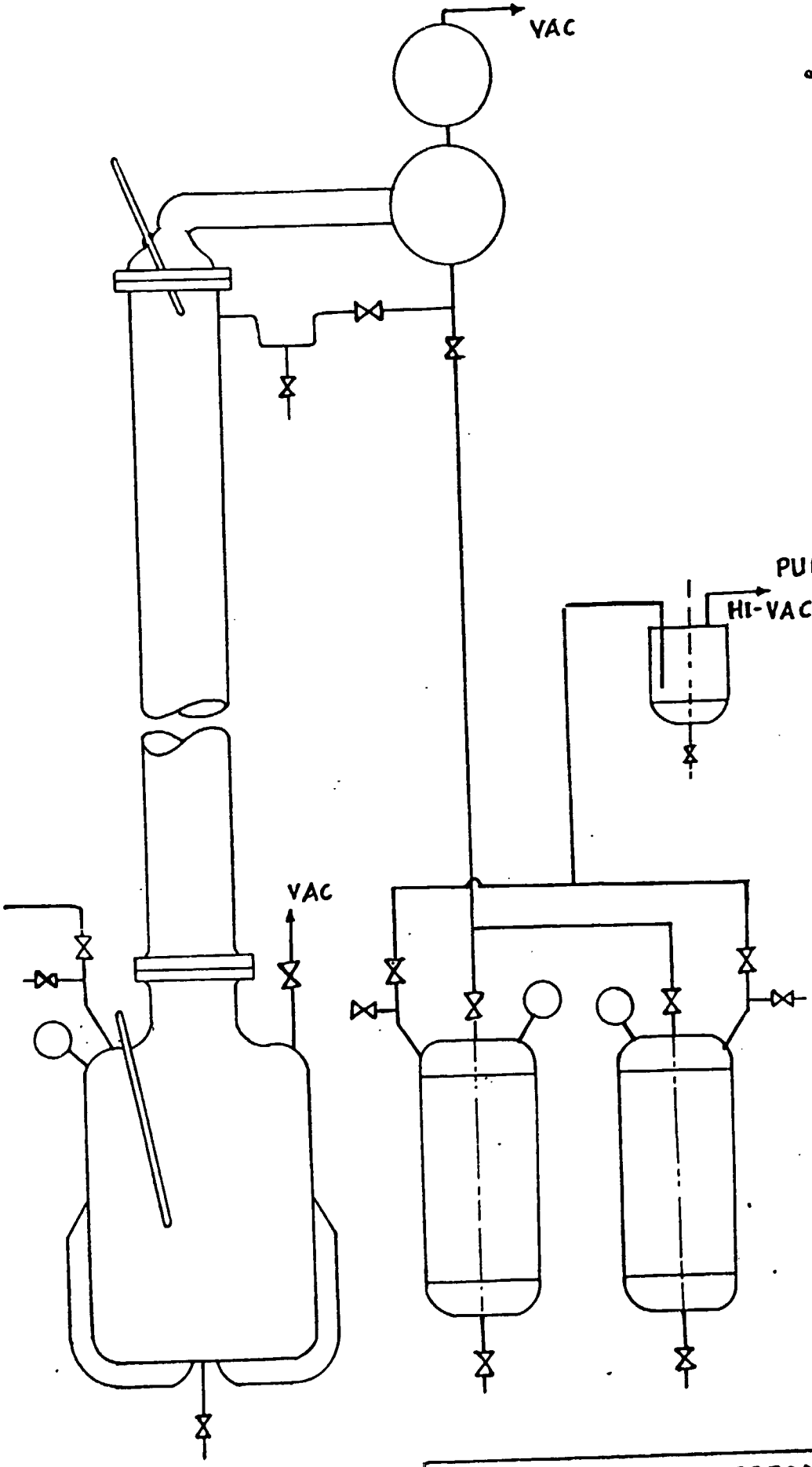
Spinning Band Column

(ii) Design of Essential Oils Fractionation Pilot Plant

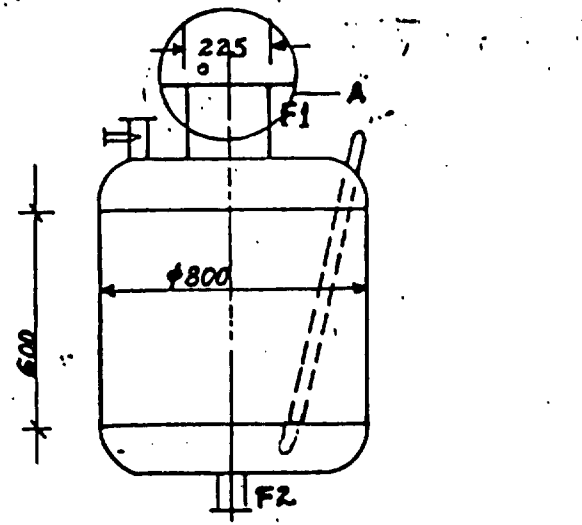
As mentioned elsewhere in the report that good quality engineering infrastructure is available in the capital city (Addis Ababa) itself. What is lacking is the appropriate design capability of chemical plant and equipment.

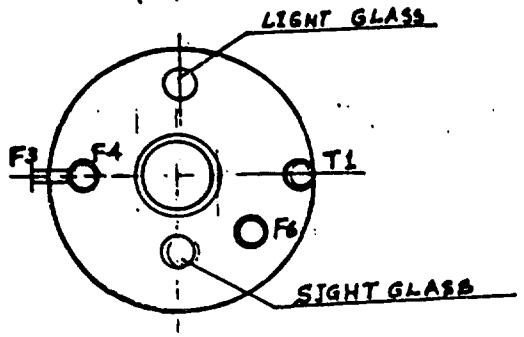
With the twin objectives of providing a suitable design for indigenous fabrication of a fractionation column and quicken incubation time in the production of pure isolates from the indigenous essential oils, the expert on mission has worked out a detailed design of 400 l capacity fractionation pilot plant.

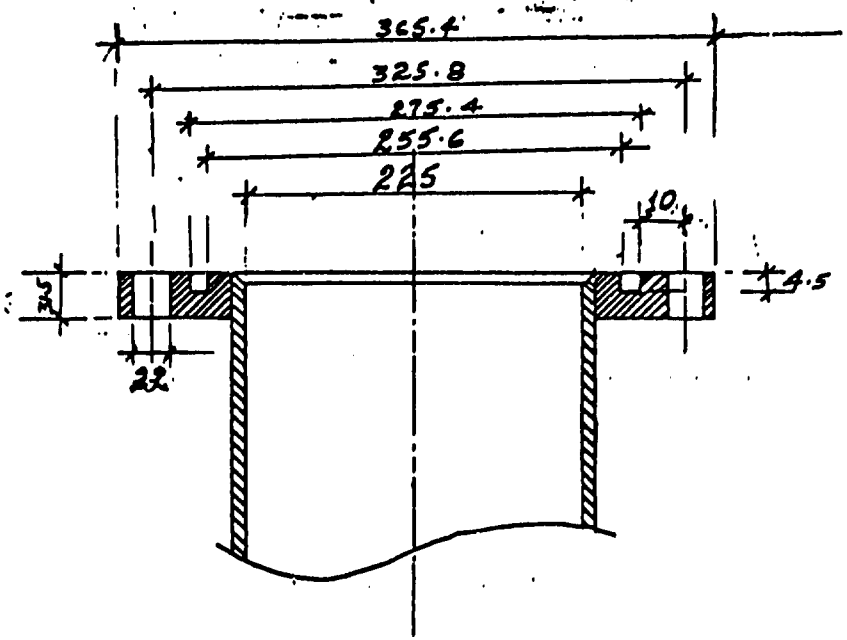
The design drawings enclosed.



NATIONAL CHEMICAL CORPORATION / A.A ETHIOPIA
ESSENTIAL OIL FRACTIONATIO UNIT
DESIGNED BY M.B. NARASIMHA /UNIDO/
DRAWN BY T. ABEBAW /NCC/
DRG. Nº .1OF 1 Oct. 1992







DETAIL - A

FLANGE	DN	APPLICATION
F1	225	VAPOUR OUTLET
F2	37	PRODUCTION OUTLET
F3	12.5	VAC. BREAK
F4	25	PRODUCT INLET
F5	25	VACUUM LINE
F6	12.5	MANOMETER
T1	12.5	THERMO WELL

NATIONAL CHEMICAL CORPORATION A.A ETHIOPIA

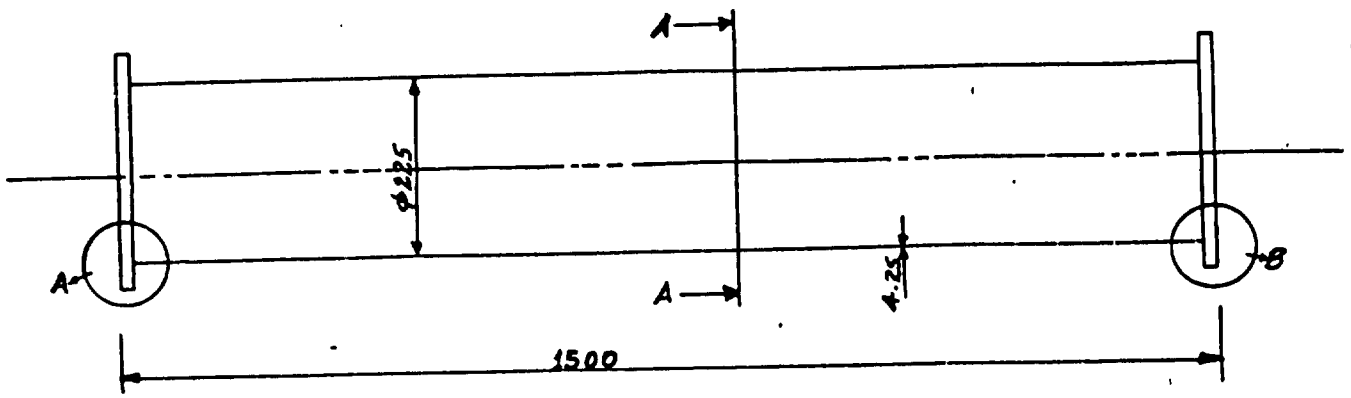
ESSENTIAL OIL FRACTIONATION UNIT- REBOILER

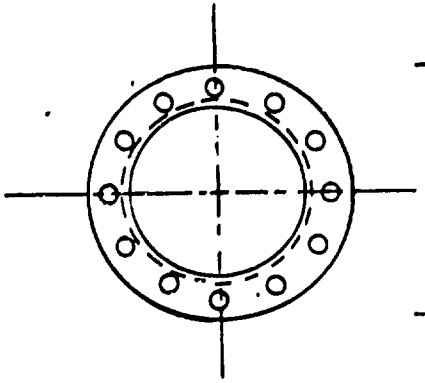
DESIGNED BY M.B. NARASIMHA /UNIDO/

DRAWN BY ABEBAW /NCC/

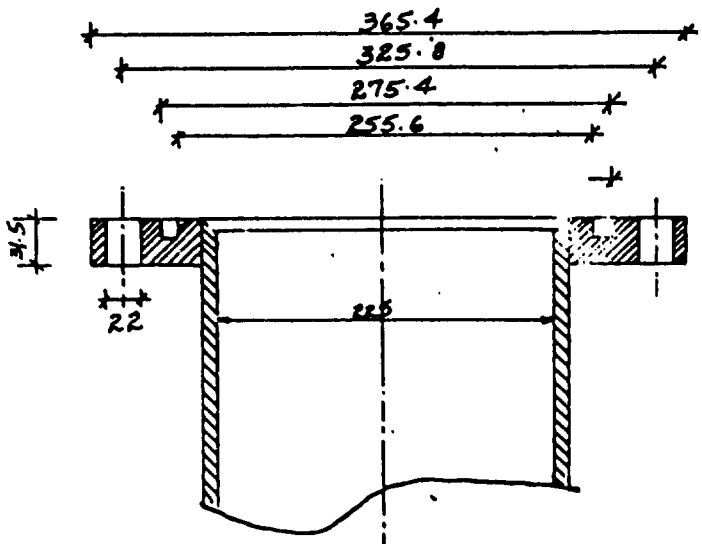
DRG. No. 2 OF 7 Oct. 1992

2 PCS

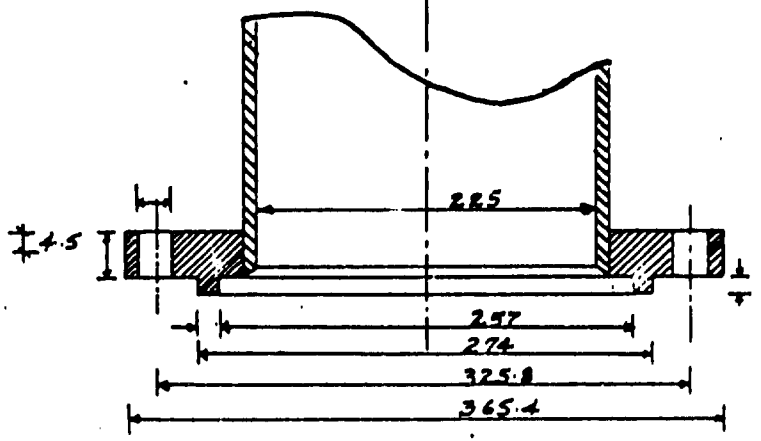




SECTION A-A

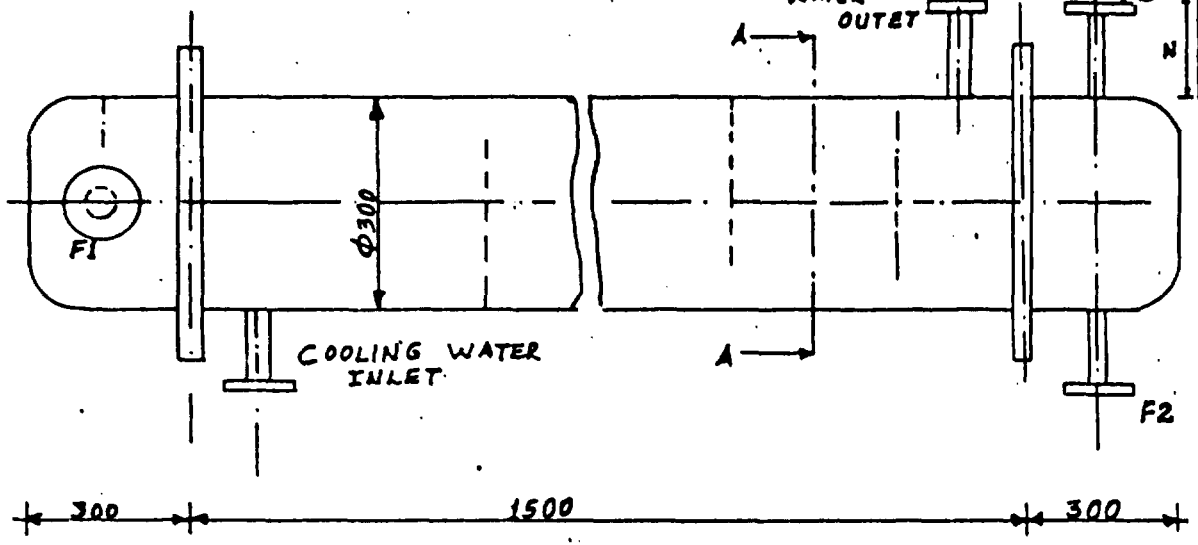


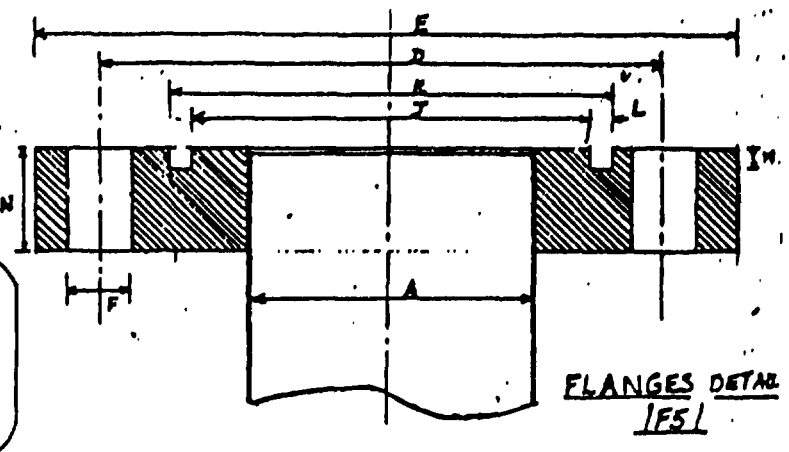
DETAIL-A



DETAIL-B

NATIONAL CHEMICAL CORPORATION ETHIOPIA	A.A
ESSENTIAL OIL FRACTIONATION COLUMN	
DESIGNED BY M.B. NARASIMHA /UNIDO/	
DRAWN BY T. ABEBAW /NCC/	
G. NO. 3.0E7	Oct. 1992

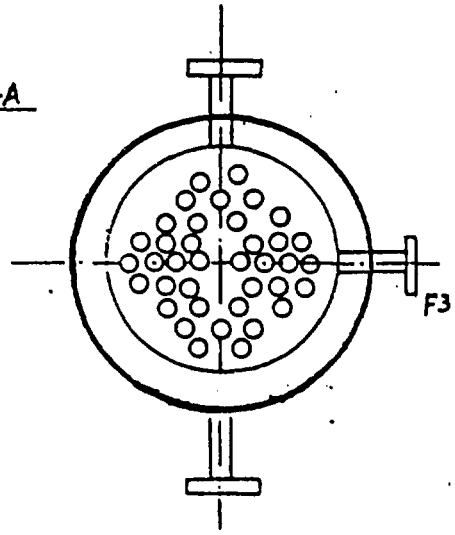




FLANGES DETAIL (F5)

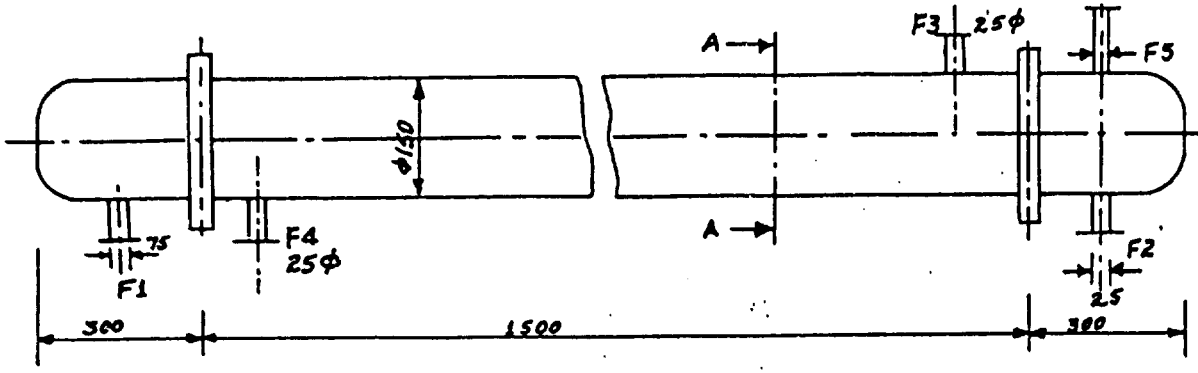
FLANGE	DN	APPLICATION
F1	150	VAPOUR INLET
F2	37	PRODUCT OUTLET
F3	150	CONDENSATE INLET

SECTION A-A

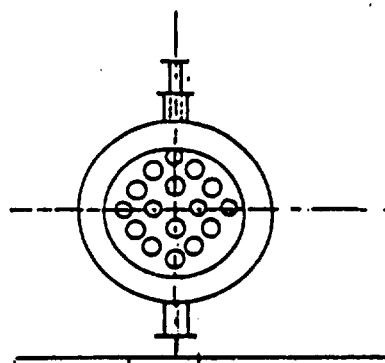


FLANGES	A	D	E	F	J	K	L	M	N
F1	150	241	279.5	22	189	205	8	5	30.4
F2	37	97.4	125.0	13.5	51.8	64.4	6.35	5	21.7
F3	75	152	190	17.5	106	119	6.35	5	29

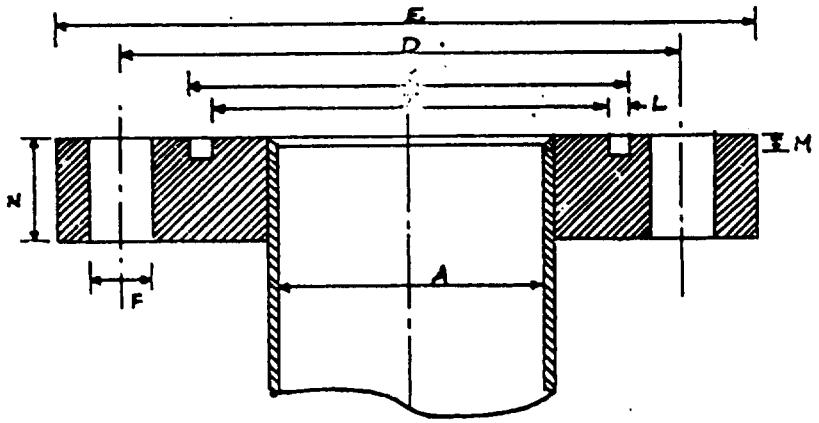
NATIONAL CHEMICAL CORPORATION A.A ETHIOPIA
ESSENTIAL OIL CONDENSER I
DESIGNED BY M.B. NARASIMHA /UNIDO/
DRAWN BY T. ABEBAW /NCC/
DRG. NO 5 OF 7 Oct. 1992



SECTION A-A



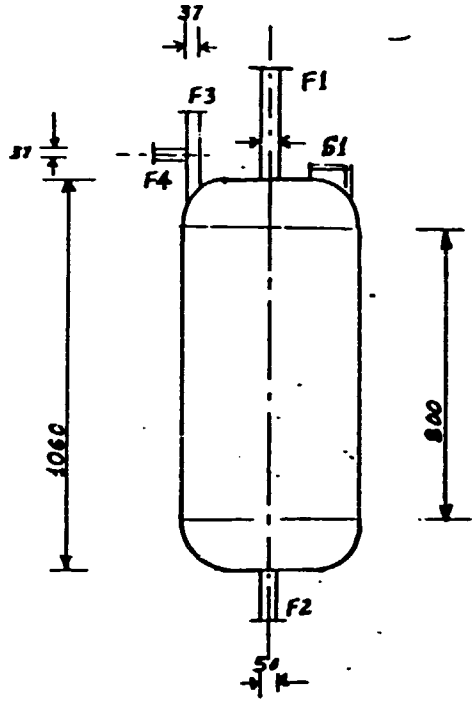
FLANGE	DN	APPLICATION
F1	75	VAPOUR INLET
F2	37	PRODUCT OUTLET
F3	25	COOLING WATER INLET
F4	25	COOLING WATER INLET
F5	25	NON-CONDENSABLE OUTLET

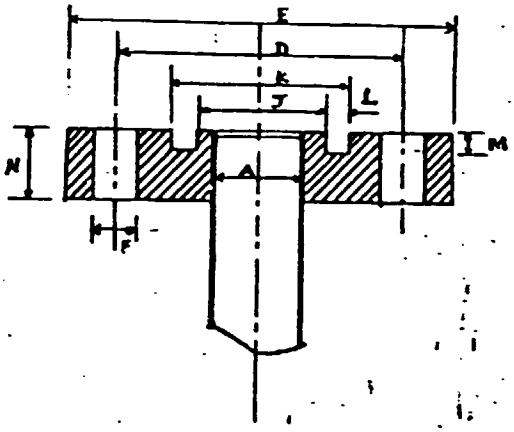


FLANGES	A	D	E	F	J	K	L	M	N
F1	75	152	190	17.5	106	119	6.35	5	29
F2	37	97.4	125.6	13.5	51.8	64.4	6.35	5	21.7
F5	25	79.4	108	13.5	36.5	49.2	6.35	5	19

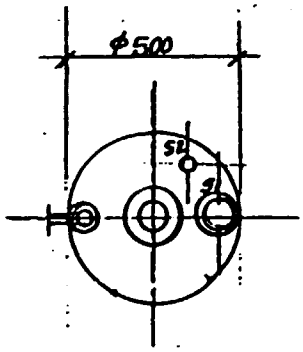
FLANGES DETAIL (F1)

NATIONAL CHEMICAL CORPORATION A.A ETHIOPIA	
ESSENTIAL OIL CONDENSER II	
DESIGNED BY M.B. NARASIMHA	(UNIDO)
DRAWN BY T. ABEBAW	(NCC)
DRG. NO 6 OF 7	OCT. 1972





DETAILS OF A FLANGE (F3)

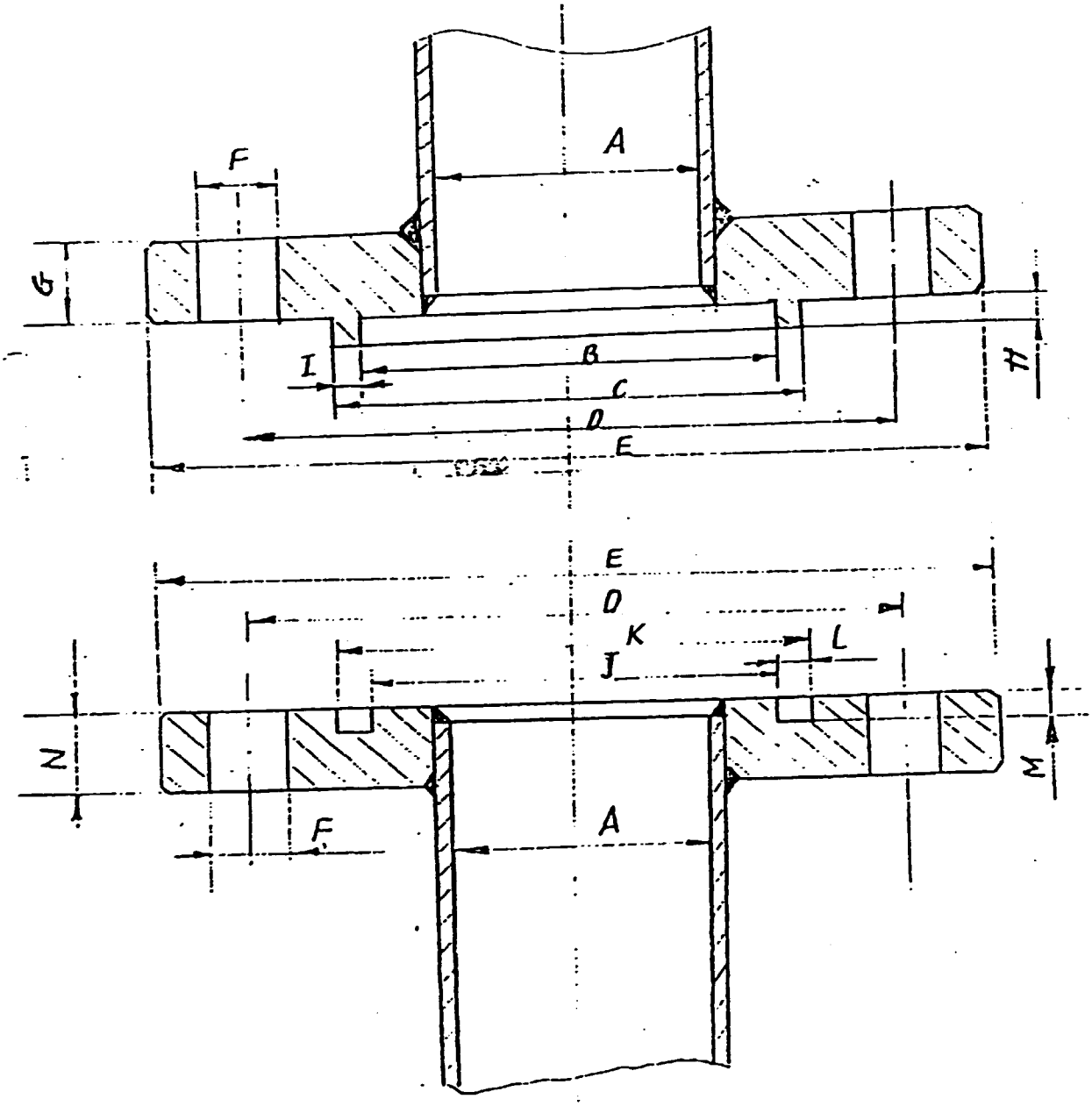


FLANGE	DN	APPLICATION
F1	37	PRODUCT INLET
F2	37	PRODUCT OUTLET
F3	25	VACUUM LINE
F4	12	VACUUM BRAKE
G1	50	SIGHT GLASS
S2	12	VACUUM GAUGE PORT

FLANGE	A	D	E	F	J	K	L	M	N
F1 & F2	37	97.4	125.6	13.5	51.8	64.4	6.35	5	21.7
F3	25	79.4	108	13.5	36.5	49.2	6.35	5	19
F4	12	58	85.4	13.5	22.8	35	6.35	5	15.4

FLANGES SIZE TABLE (mm)

NATIONAL CHEMICAL CORPORATION	A.A ETHIOPIA
ESSENTIAL OIL RECIEVER	
DESIGNED BY M.B. NARASIMHA	UNIDO
DRAWN BY T. ABEBAW	NCC
DRG. No 7 OF 7	Oct. 1992



NOZZLE FLANGES

(Small tounge & Groove Type)

M.S. Narasimha

A		B	C	D	E	F	Bolt size	No. of Bolts	G	H	I	J	K	L	M	N
inches	mm					Bolt hole ø										
1/2	13	25,4	34.9	60.4	89	13.5	M12×40	4	11	5	4.75	23.8	36.5	6.35	5	16
3/4	20	33.4	42.9	70	98.5	13.5	M12×50	4	12.7	5	4.75	31.8	44.5	6.35	5	17.
1	25	38	47.5	79.4	108	13.5	M12×50	4	14	5	4.75	36.5	49.2	6.35	5	19
1 1/4	32	47.6	57.1	89	117.5	13.5	M12×50	4	16	5	4.75	46	58.7	6.35	5	21
1 1/2	40	54	63.5	98.5	127	13.5	M12×60	4	17.5	5	4.75	52.4	65.1	6.35	5	22
2	50	73	82.5	120.7	152.5	17.5	M16×60	4	19	5	4.75	71.5	84.2	6.35	5	24
2 1/2	65	85.7	95.2	140	178	17.5	M16×75	4	22	5	4.75	84.1	96.8	6.35	5	27
3	80	108	117.5	152.5	190.5	17.5	M16×75	4	24	5	4.75	106.5	119.2	6.35	5	29
3 1/2	90	120.7	130.2	178	216	17.5	M16×75	8	24	5	4.75	119.1	131.8	6.35	5	29
4	100	131.5	144.5	190.5	228	17.5	M16×75	8	24	5	6.5	130	146	8	5	29
5	125	160.3	173.3	216	254	22	M20×80	8	24	5	6.5	158.8	174.8	8	5	29
	150	190.5	203.5	241	279.5	22	M20×85	8	25.4	5	6.5	189	205	8	5	30
8	200	238	254	298,5	332.8	22	M20×90	8	28.5	5	8	236.5	255.5	9.5	5	33
10	250	285.5	304.5	362	406	24	M20×90	12	30	5	9.5	284	306	11	5	35
12	300	343	362	432	483	24	M20×100	12	32	5	9.5	341.5	363.5	11	5	37

NOZZLE FLANGES

(Small tounge & Groove type)

Material Carbon Steel 10 kg/cm²

All dimensions in mm unless other wise specified

ANNEX VIII

Bill of Materials

Fractionation Column
Material of Construction: Stainless steel type 316 unless otherwise stated

S.No.	Item	Qty	Dimensions	Remarks
1	Cylindrical Wall	one	O.D.800x600x5	
2	Dished Top	one	O.D. 800 x 5	
3	Flanged Vapour Outlet	one	O.D. 225 x 3	Tongue & Groove Flange S.S.Collar, M.S. Back Flange
4	Light and Sight Glass Assembly	Two	DN 80 x 100	
5	Pipe T-Nozzle	one	NB 25 Flanged	Tongue Groove Flange S.S. Color, U.S. Back Flange
6	Pipe T-Nozzle	one	NB 12 Flanged	" "
7	Dished Bottom	one	O.D. 800x5	
8	Pipe Nozzle	one	NB 50	Tongue & Groove Flange S.S. Collar, M.S. Back Flange
9	Heating Mantle	Two	7.5 Km	Nichrome or any other suitable wire
10	Regulators	Two		Copper wire
11	Ball Valve Teflon Seat	one	N.B 50 Flanged	Tongue & Groove Flange S.S. Collar, M.S. Back flange
12	Ball Valves Teflon Seat	Four	N.B. 25 Flanged	" "
13	Digital indicating Thermometer	Two	0.250	S.S. Sheet

Fractionation Column Reboiler
Drg. No. FC - 1 of 7
Material of Construction: Stainless Steel type 316 unless otherwise stated

S. No.	Item	Qty	Dimensions	Remarks
1	Cylindrical Wall	two	O.D. 225x1500 Flanged x 3	Tongne & Groove Flange S.s. Collar and U.S. Back Flange
2	Reducer Bend 90 C	one	O.D. 225x150x3 Flanged	" "
3	Reflux divider	one	for NB 25	Including Electronic timer
4	Packing material	180 ltr	Wiremesh/knitmesh	

Packed Column Section: Drg. No. FC - 2 of 7
Drg. No. FC - 3 of 7..

Fractionation Column
Material of Construction: Stainless Steel type 316 unless otherwise stated

S.No.	Item	Qty	Dimensions (mm)	Remarks
1	Cylindrical Wall	one	OD 300x3x1500	Tongne & Groove Flange SS Collar, M.S. Back flange
2	Cylindrical Wall (Bonnet)	Two	OD 300x3x300	" "
3	Tube plate	Two	OD400x20	" "
4	Tubes	Forty	NB25 x 1 x 1550	
5	Baffle Plates	Six		
6	Pipe Nozzle	one	NB 150x3x150 Flanged	T & G SS Collar, M.S Back Flange
7	Pipe Nozzle	one	NB75x3x150 Flanged	" "
8	Pipe Nozzle	Two	NB 25 Flanged	M.S. Back Flange

Condenser I
Drg. No. FC-4 of 7

S. No.	Item	Qty	Dimensions (mm)	Remarks
1	Cylindrical Wall	one	OD 160x2x1500	Tongne & Groove Flange ss collar, M.S. Back flange
2	Cylindrical wall (Bonnets)	Two	OD 160x2x200	" "
3	Tube plate	Two	OD 250x20	" "
4	Tube	Twenty	NB 25x1x1500	" "
5	Baffles	Six		
6	Pipe Nozzle	one	NB75x3x150	T & G Flange SS Collar, M.S. Back Flange
7	Pipe Nozzle	one	NB25x1x150	" "
8	Pipe Nozzles	Two	NB 25	M.S. Back Flange

Condenser II
Drg. No. FC-5 of 7

Fractionation Column
Material of Construction: Stainless Steel type 304 unles otherwise stated

S. No.	Item	Qty	Dimension	Remarks
1	Cylindrical Wall	one	OD450x3x550	
2	Dished top	one	OD450x3	
3	Dished bottom	one	OD450x3	
4	Pipe T-Nozzle	one	NB25x2 Flanged	Tongue & Groove Flange SS collar; M.S. Back Flange
5	Pipe T-Nozzle	one	NB12x2 Flanged	" "
6	Pipe Nozzle	one	NB25 Flanged	" "
7	Ball Valves (Teflon Seat)	Four	NB 25 Flanged	" "
8	Ball Valves (Teflon Seat)	Three	NB12 Flanged	" "
9	Sight and Light Glass Assembly	Two	DN80	
10	Interconnecting	25m	NB25	
11	Interconnecting	20m	NB12	
12	Pipe	1m	NB 50	
13	Vacuum Ganfles	Three	1/2" -1 to+bar	Brass

Receivers Required = Two
DRG No FC-6 of 7

1. Support Structure
   Material of Construction M.S

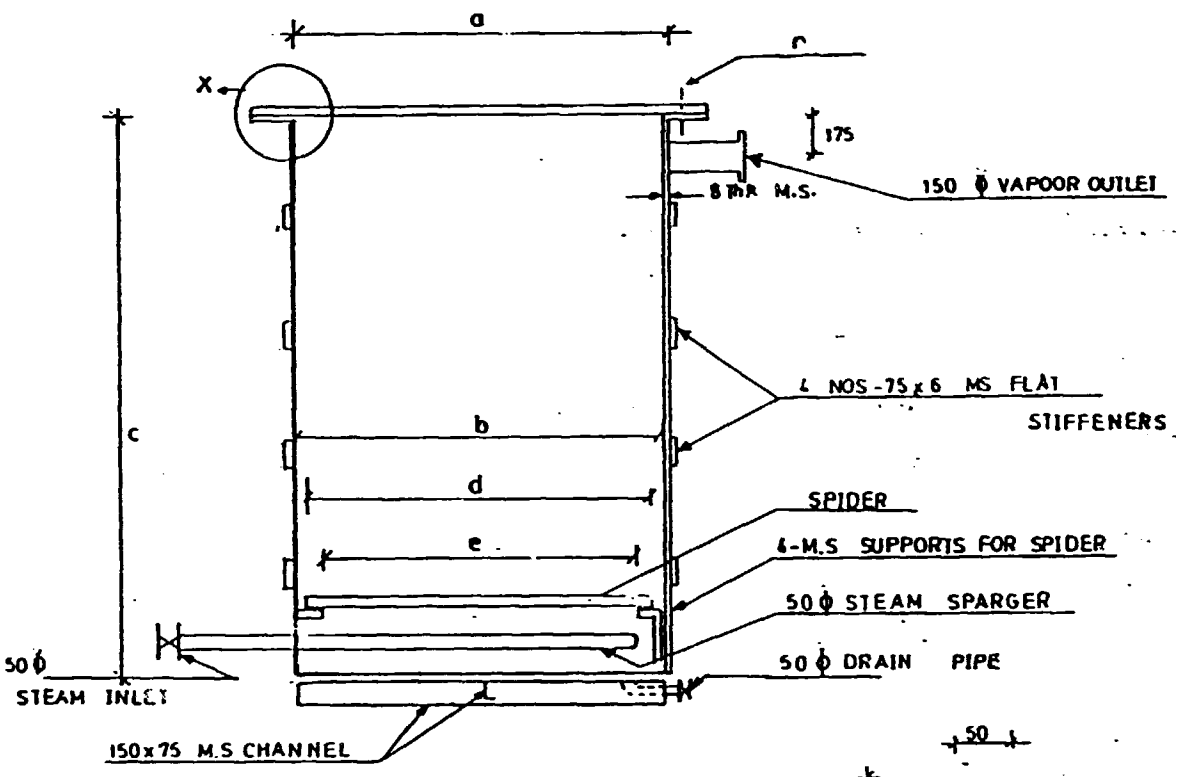
2. Vacuum: Oil displacement pump with suitable trap

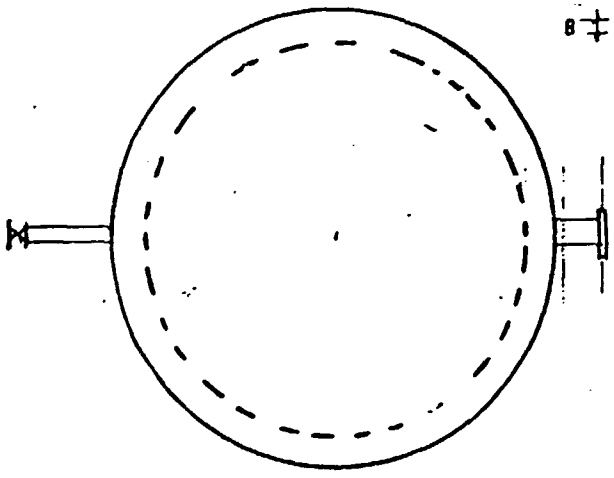
3. Insulation: Glass wool of 50mm thick. Units to be insulation
   - Reboiler including dished bottom & Dished top
   - Column Sections
   - Reducing Board
   - Vapour line

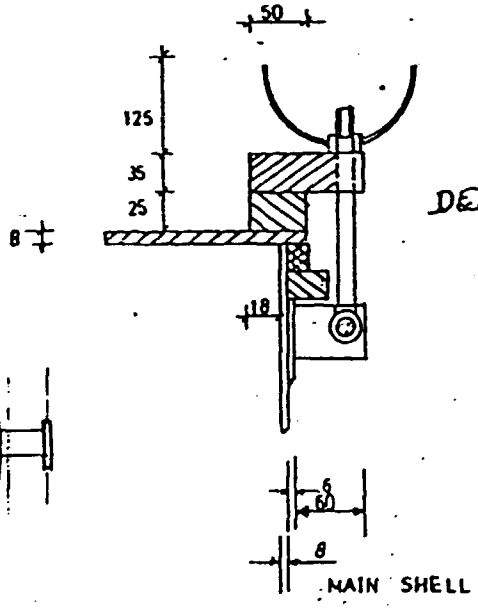
(iv) Design of Field Distillation Plant.

Bill of Materials required for the fabrication of the field distillation plant.

The drawings and bill of materials enclosed.





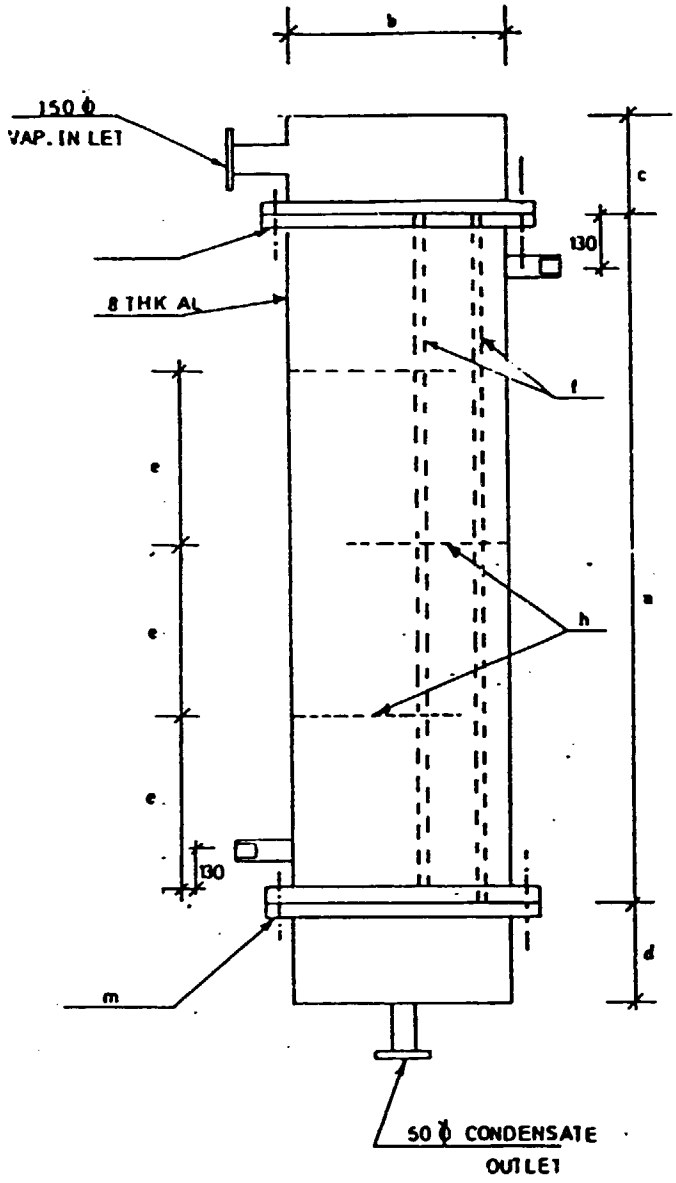


NOTE: SUITABLE OH MONORAIL & ELECTRIC 4-WAY HOIST NECESSARY

CAPACITY	a ϕ	b ϕ	c	d ϕ	e ϕ	n
2 tonnes	1750	1850	2500	1800	1650	20
3 t	2100	2000	3200	1950	1800	24
5t	2500	2400	3800	2350	2200	28

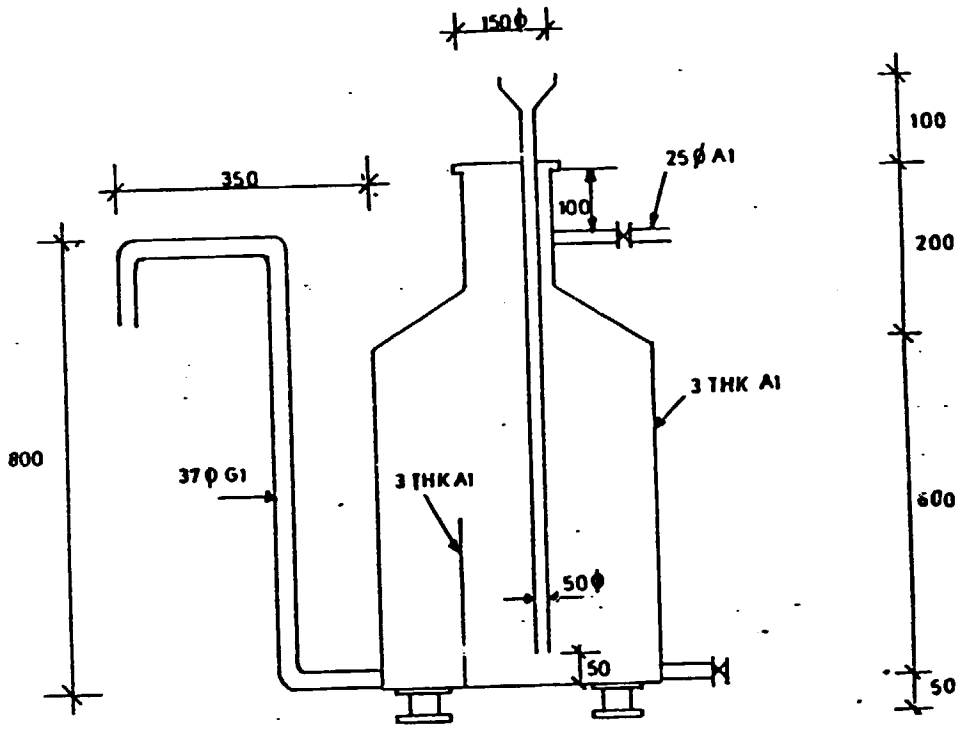
n-19 ϕ SWIVEL BOLTS

NATIONAL CHEMICAL CORP. A.A. ETHIOPIA
ESSENTIAL OIL DISTILLATION STILL
DESIGNED BY M.B. NARASIMHA /UNIDO/
DRWN BY T ABEBAW /NCC/
DRG. No. 1 OF 3 Oct. 1992



m	20 NOS BOLTS M16 BOLTS HOLES on	500 536 586ϕ	PCD
	520ϕ 20Th	576ϕ 20Th	626ϕ 20Th
l	Al Tube Plate	Al Tube Plate	Al Tube Plate
h	TRANSVERSE -3 NOS.	BAFFLES WITH 25% CUT	
f	250Dx 12 GAl 80 Tubes on 37Δ pitch	250Dx12G 104 Al Tubes on 37Δ pitch	250Dx12G 134 Al Tubes on 37Δ pitch
e	400	450	500
d	150	150	150
c	250	250	
b	420ϕ	470ϕ	520ϕ
a	1600	1800	2000
	2 ton	3 ton	5 ton

NATIONAL CHEMICAL CORP. A.A. ETHIOPIA
ESSENTIAL OIL CONDENSER
DESIGNED BY M.B. NARASIMHA (UNIDO)
DRWN BY T ABEBAW (NCC)
DRG. No. 2 OF 3 OCT. 1992



NOTE ALL DIMENSIONS ARE IN mm.

NATIONAL CHEMICAL CORP. A.A ETHIOPIA
ESSENTIAL OIL SEPARATOR
DESIGNED BY M.B. NARASIMHA /UNIDO/
DRWN T. ABEBAW /NCC/
DRG No. 3 OF 3 1992

Bill of Materials Required for the Fabrication of some Pilot Plants

- 100l field distillation skill
- 60l capacity fractionation column
- 100l capacity reactor for aroma chemicals

At the request of the project coordinator and accompanied by him, the expert visited some of the factories located in Addis Ababa, Nazareth and Ziway functioning under the control of N.C.C., located some serviceable but not utilized items which could be turned into some good functional pilot plants as mentioned above.

At the premises of Gulele Soap Factory

The following are some of the discarded parts of an Italian made continuous soap making plant:

- Jacketed stainless steel vessel of about 400 mm diameter and 2 m long.
- Multiple coils made of 25mm dia stainless steel pipe.
- Stainless steel vessels of 10 l. each
- Light and sight glass assemblies with toughex glasses.
- Loose circular touphex glasses (assorted sizes)
- Stainless steel sheet of 5mm thick bent at right angles 300x300x2000 mm.
- Assorted stainless steel pipe for pieces.
- Glass wool

At the premises of Repi Soap Factory

- Stainless steel cylindrical tanks of about 1400 l capacity with dished bottom and flanged dished top with internal ss coils.
- Stainless steel vessel of about 1201 capacity with stirrer and 0.5 H.P. motor
- Stainless steel pipes of 75 mm dia., 50 mm dia. 37 mm dia. and 25 mm dia

At the Premises of Alkyd Resin Factory

- Stainless steel pipes of 75mm dia, 50 mm dia, 25 mm dia and 12 mm dia
- M.S. pipes of 25 by 12 mm dia
- S.S. values (flanged type) 25 mm dia and 12 mm dia
- M.S. values
  25 mm dia, 12 mm dia
- S.S. collared flanges suitable for the following pipes
  75 mm dia, 50 mm dia, 25 mm dia and 12 mm dia.
- M.S. flanges suitable for 25 mm dia by 12 mm dia pipes.

At the premises of caustic soda factory at Ziway.

- Stainless steel sheets
- stainless steel collared flanges (assorted sizes)
- 600 mm dia cylindrical portions (cut off portions assorted lengths)
- Stainless steel pipe cut off portions (assorted lengths).

ANNEX X

REPI SOAP FACTORY

Refurbishing of a running factory

At the request of the then Manager of the above factory, under the administrative control of National Chemical Corporation, its General Manager verbally requested, the expert (SI/ETH/90/802/11-01) to extend necessary help to the factory. Accordingly the expert on mission prepared a work plan, given below and systematically worked at the factory and refurbished it successfully.

July 31, 1992

Repi Detergent Factory

Suggested work plan for refurbishing Repi Det. Factory

* To study the present production operations-step by step
* To optimize each operation-stage by stage
* To effect energy economy
* To add a few instruments; thermometers, pressure gauges
* To effect overall stream-lining of production

This does not include det. tablet making operations.

Duration: It may take about 3-4 weeks of time, provided all the requirements are made available in time.

(signed)

M.B. Narasimha

Copy to: 1. The General Manager, NCC

2. Dr. Tadele Worku (Project Coord. SI/ETH/90/602)

3. The Manager, Repi Soap Factory

By careful study of all the operations and processes step by step and suitably modifying and optimising each operation and proper insulation of process & service lines. it was possible to increase the production of detergent powder from a monthly average of 6.5 t/24hrs to a monthly average of 9.5 t/24hrs. These measures also resulted in considerable savings in the energy consumption. The Factory is now producing det powder of standard grain size with less pollution in the production area and consequently less loss of product.

Factory Background: Repi Soap Factory, established under the name Bianil Ethiopia S.C. (date unknown) to produce detergent powder and bar. The designed and attainable capacities of the factory were also unknown at the time of nationalisation in Feb. 1975.

The annual production of powder and bar during the year 1989-90 was 1899 tonnes. During the same year the "Factory Profile" indicates that "full attainable capacity of the production (current) detergent powder per shift is 2.05 tonnes and in 24 hours is 6.15 tonnes" (photo copy of Factory Profile pp 1-3 enclosed).

Most of the basic raw materials required in the production of detergent powder and bar, except sodium silicate are imported.

The Factory has under its permanent rolls 253 staff members and 9 under temporary employment.

Status before refurbishing

Flow diagrams enclosed.

Dodecyl benzene sulfonic acid (DDBSA) in 200 l barrels are hoisted to the second floor and manually charged into the overhead tank (2).

A 33 % caustic soda solution is prepared in a dissolving tank (1) also located on the same floor as DDBSA overhead tank.

DDBSA from OH tank and 33 % caustic soda from (1) are fed into calibrated tanks (4) and (3) respectively by gravity. A calibrated (OH) water tank (5) is also located adjacent to these tanks.

141 kg of DDBSA and 106 l of water are fed by gravity into the stirred neutralizer, to this is added slowly 54 litres of 33 % caustic soda under stirring.

The reactants and water are continuosly added to the neutralizer in the same proportion. The neutralized DDBSA outflows into the stirred paste aging tank. This procedure is continued till the neutralized mass reaches a volume of about 1000 l. The paste in the aging tank is tested for free alkali. The pH of the paste is adjusted by addition of DDBSA or alkali solution depending on free alkali content, thereafter the paste is aged for a couple of hours, while keeping the stirrer running.

While the paste is being aged in the tank (7), about 350-400 litres of water is charged into the slurry

preparation tank (10) and boiled, to this boiling water, keeping the stirrer on, 200 kg of sodiumtripolyphosphate, 120 kg (40 %) sodium silicate, 150 kg sodium sulphate, 6 kg sodium carboxy methyl cellulose, 1.6 kg urea and 1.6 kg of optical brightner are added manually and stirred, while continued to heat until homogeneous solution is made.

300 kg of aged paste weighed in overhead weighing tank (9) is charged, to the hot solution in the slurry preparation tank (10) and stirred into a uniform slurry. This slurry is then passed through a wire mesh strainer, held by an operator and charged into one of the slurry aging tanks (heated and stirred) (12),(13) or (14). The final slurry contains about 50-60% water, at temperature 60-80 ^{o}C, pH 9 to 10.5. The water content and temperature of the slurry, two important parameters in spray drying, were never maintained at constant values.

The slurry is then pumped through a high pressure metering pump through fine filter and homogenizer and sprayed (e) at the top of the spray dryer (d). One or two nozzles (out of four) of two mm. dia. were used at any time during spray drying operation.

All the tanks, including paste preparation, and aging tanks, slurry preparation and aging tanks, interconnecting piping, homogenizer, process piping from high pressure pump to the top of spray dryer (about 25 m.

high) were not insulated, eventhough slurry temperature was 60-80°C and ambient temperature was about 6 to 10°C. This resulted in not only heat losses, but thermal imbalances in the spray dryer resulting in low production and varying bulk densities of the detergent powder.

The slurry before being sprayed was preheated in concentric steam jacketed pipe ring encircling the top of the spray dryer. Final temperature of the slurry was not known.

Hot air mixed with flue gases at about 250 °C from oil fired furnace fed into the spray dryer, counter-currently to the spray of the slurry.

Powder obtained from the dryer was screened in a vibratory sieve (m), the lumps obtained from (m) and fines from cyclon separators(f) were used in the detergent tablet making section.

The sized detergent powder was homogenized with perfume and packed in cartons(k). The product is known as "ROL" detergent powder.

07.08.92

Some observations on Repi Soap Factory

1. Solid pellets in the nozzle chocking them-source coming from sodium tripolyphosphate or another source of raw material.

   What is happening to filters ?

2. Free alkali in slurry seems to be high.

3. Powder is too fine.

4. Why maximum of two nozzles at any time ?

   New diameteres of 2.0 mm. or 2.5 mm. nozzles

5. Why not increase nozzles dia. to 2.8 or 3.0 mm. ?

6. What happens if slurry temp. is maintained at min. 80 degree centigrade or above ?

7. Presently temp. and concn. of slurry are never constant.

8. Free alkali in the slurry seems to be on the high side.

9. Temp. of air and slurry should be maintained const. These are very important.

10. Thermometers dial type on

    - the air line 0-500 ^{o}C not working properly.
    - slurry line 0-100 ^{o}C .....Not fitted: Needed
    - paste line 0-100 ^{o}C .....Not fitted: Needed

11. Steam traps .....Not fitted: Needed

12. Glass wool .....A lot of glass wool is needed for insulation

13. Covering cloth over glass wool...Coarse/jute cloth
14. No person watches on spray nozzles fitted on the spray drier.
15. Plant area is polluted with det.dust - health hazard.
16. Tighten all the gas/powder leaking points.
17. Slurry overflows sometimes from preliminary filter of slurry tank 'B'.
18. Steam and water points leaking at some points.
19. There is too much of heat loss in the process and service lines.
20. No light points working on spray drier.
21. Record fuel consumption against production

    Boiler / Hot air furnace
22. Record production vs consumption of raw materials.
23. We have already changed nozzles with 2.8 dia. which resulted in : -Higher production rate
    -Less loss of powder
    -Less pollution
    -Standard granules

M.B. Narasimha

Copy to :- Factory Manager
- Head, Production & Technical Div.
- Head, Quality Control

Neutralisation of DDBSA with caustic soda solution is an exothermic reaction. the temperature of the reactants reaches about 75-80 degree centigrade in the neutraliser. No effort was made to conserve the heat.

A lot of heat energy was lost in the neutraliser, paste aging tank and slurry aging tanks as well as in the process piping and air heating furnace and its piping system.

No instruments are fitted on any one of theee tanks to measure temperatures, pressures and steam traps to prevent loss of steam, even though all these tanks are of volumes varying from 1 to 3 cubic metres and heated to about 60-80 ^{c}C.

In the absense of these instruments and lack of proper insulation, processing resulted in not only in the loss of heat and energy but also in the variations in slurry concentration and temperature, adding to these conditions, lack of proper insulatiobn on a good part of hot air (about 250 ^{c}C) line of about 450 mm. dia pipe and the hot air circulation blower and the hot air furnace was effecting not only the quantity but also the quality of the finished product.

Glass wool mats normally used in the insulation of process tanks and pipe and service lines was not available. the expert on mission accompanied by technical

staff of the factory, visited a few industrial units in the city, collected a couple of bags of this material from a discarded boiler lying in one of the factories, since required amount of glass wool was not available to insulate all the units needing insulation, only esential process piping and hot air piping was insulated. This was done to prevent heat losses in the process pipe lines, particularly pipe lines conducting the slurry from the slurry aging tank to the top of the spray drier, and some missing sections of the 450 mm. dia hot air line leading to the spray drier. By this measure alone, the temperature of the hot air from the furnace has risen from 250 °C to about 290 °C. [If the furnace, the remaining 450 dia pipe and the hot air blower is properly insulated, it is expected to result in the substantial saving of scarce fuel oil.]

The variation in the temperatures of the slurry and hot air delivered to the top and bottom of spray drier respectively were minimised and some savings in the consumption of fuel. Spray nozzles of 2.00 mm. dia were replaced with 2.8 mm. dia.

In a typical test run production after affecting modifications and conducted on 30 sept. 92 from 3 p.m. to 6 p.m. and by carefully controlling the slurry temp. at 80 °C and water content at 53 % and proper coordination of paste, slurry preparation sections and spraying

sections has yielded a product of about 2 tonnes in 3 hours and also in the considerable conservation of heat energy and consequent savings in the fuel oil savings.

The average production figures of August 92 (before refurbishing) and of September 92 (after refurbishing) bear testimony to the refurbishing operations conducted by the expert.

Average production in August 92 in 157.16 hours was 42.708 tonnrs;(i.e.) 6.522 tonnes/24 hours.

Average production in Sept. 92 in 171.25 hours was 68.091 tonnes (i.e.) 9.543 tonnes/24 hrs.

At the performance of the refurbished factory, the management of the factory expressed that " we highly appreciate the results achieved through the efforts of the expert and we would like to thank you for making his valuable services to the company."

" The expert identified the pre vailing production bottle necks and increased the production by significant amount and considerable energy saving."

The following operational procedures and proper insulations are recommended.

Sept. 29,1992

Please implement the following as early as possible:

1. Measure/weigh all inputs accurately and record both. in paste and in slurry preparation section.
2. Maintain slurry temp. between 80-90 °C (aver. 85 °C).
3. Maintain slurry water content between 50-55 %.
4. Insulate hot air furnace with glass wool
   - Body
   - Hot air lines and all steam lines
5. Insulate with glass wool
   (a) Paste preparation tank
   (b) Paste aging tank
   (c) Slurry making tank
   (d) Slurry aging tanks
6. Maintain slurry concentration constant.
7. Maintain nozzle diameter at 2.8 mm.
8. Run not less than two nozzles of spray drier at any time.
9. Keep an operator at the top of the spray drier to watch and see the nozzles are in operation.
10. Recycling of slurry from high [illegible] pump should be avoided.

(signed)

M.B. Narasimha

If these procedures are properly followed as demonstrated by the expert, a target of average daily production of 12 to 14 tonnes/24 hrs is attainable (even after making provision for shut down periods for repair and maintenance).

To maintain this production rate all sections of production and maintenance should be well coordinated and suitable incentative schemes could be introduced for motivation of production staff at all levels.

Suggestions for future implementations

To procure and fit on the reactors/vessels/tanks of paste preparation section numbered (enclosed flow diagram) 6 and 7, slurry preparation section numbered 9,10,12,13 and 14 with:

-Digital indicating or dial type thermometers 0-150 oc

-Pressure gauges on the jackets, except on (9)0-2 kg/sq.cm

-Steam traps except on (9)

To procure glass wool/glass fibre and insulate:

-All these tanks with minimum of 50 mm. thick

-All the process pipe line 6 to 7., 8 to 9 to 10 to 11 to 12, 13 and 14 and give thin aluminium sheet protective coating

-To insulate the outer body of the entire hot air furnace (h). interconnecting pipe 450 mm. dia between

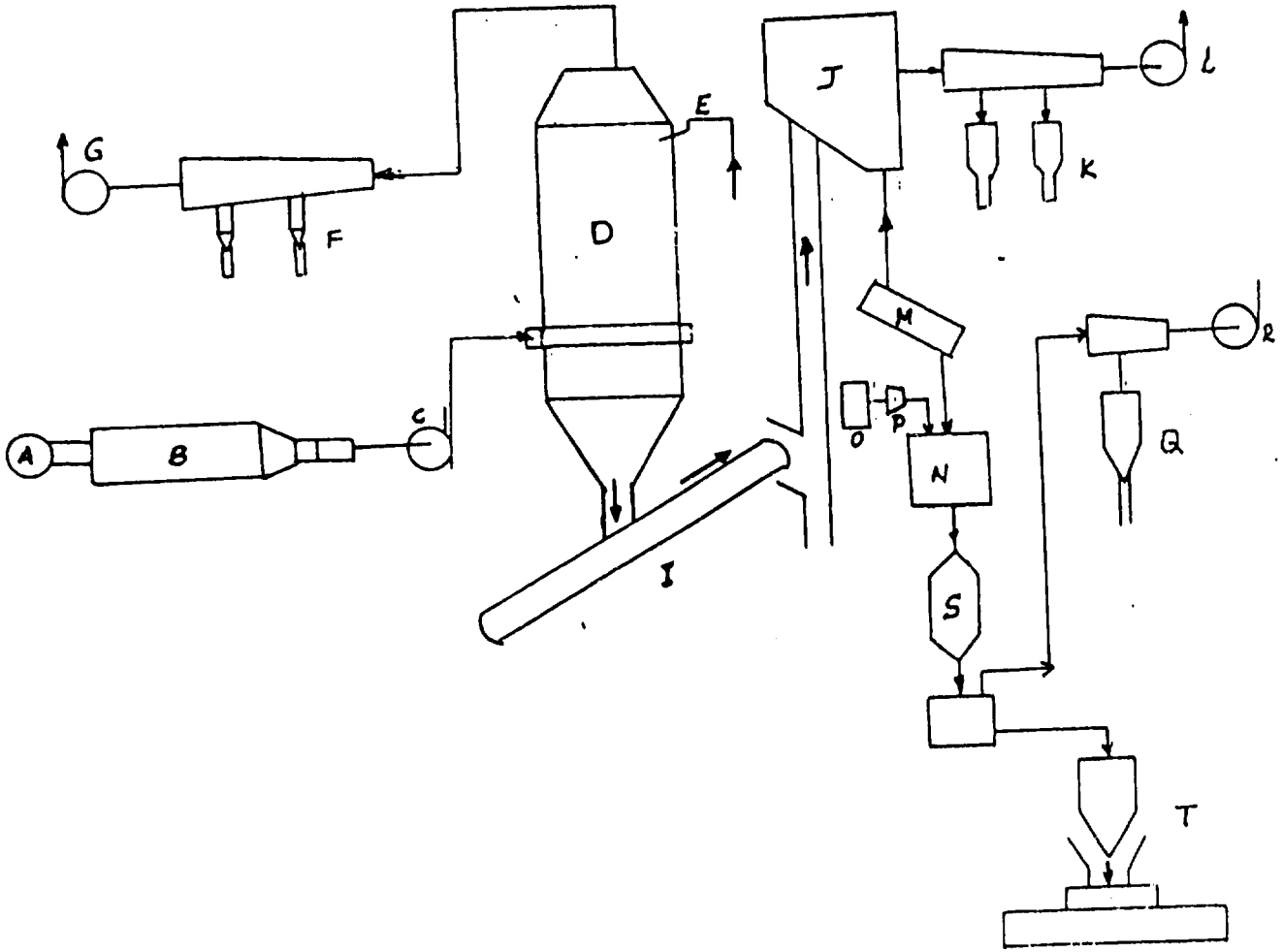
(b) and (c) and between c and d, including hot air blower (c) with 100 mm. thick glass wool/glass fibre and cover it with thin aluminium sheet

-To replace with 50 mm. thick glass wool the present insufficient covering on all the steam lines and give thin aluminium sheet protective covering.

-To repair/replace dia type thermometers on the hot air line (0-500 C). The existing one is not functioning well.

Main Bottle Necks noticed

-Mechanical problems in the carton folding and packing section & in the hot air furnace.



LEGEND

A. FUEL BURNER
B. FURNACE
C. BLOWER
D. SPRAY DRYER
E. NOZZLE CIRCUIT
F. CYCLONES
G. EXHAUST BLOWER
I. BELT CONVEYOR
J. POWDER SETTLING VESSEL
K. CYCLONES
L. EXHAUST BLOWER
M. VIBRATORY SIEVE
N. PERFUME HOMOGENIZER
O. PERFUME TANK
P. PERFUME DOSING PUMP
Q. CYCLONE
R. EXHAUST BLOWER
S. POWDER SILO
T. PACKING MACHINE

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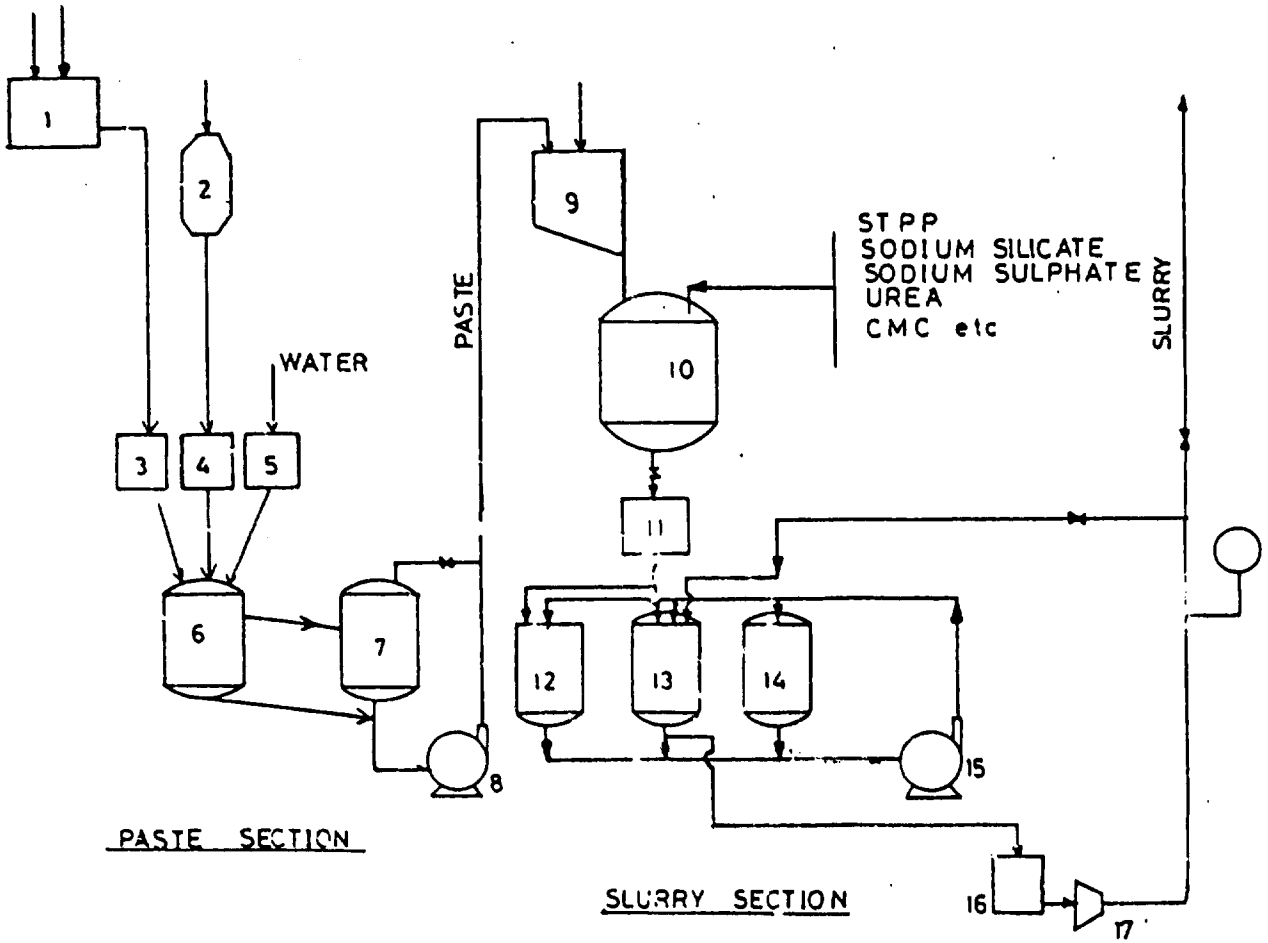
FLOW-DIAGRAM DET POWDER MAKING SECTION

REPI SOAP FACTORY (ETHIOPIA) Drg No 1 of 2



LEGEND

1. NaoH OVER HEAD TANK
2. DDBSA OVER HEAD TANK
3. NaoH MEASURING TANK
4. DDBSA MEASURING TANK
5. WATER MEASURING TANK
6. PASTE PREPARATION TANK
7. PASTE AGEING TANK
8. PASTE PUMP
9. PASTE WEIGHING TANK
10. SLURRY PREPARATION TANK
11. FILTER
12. SLURRY TANK
13. " "
14. " "
15. SLURRY PUMP
16. FILTER
17. HIGH PRESSURE PUMP

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FLOW DIAGRAM SLURRY PREPARATION SECTION

REPI SOAP FACTORY (ETHIOPIA) Drg No 2 of 2

M.A.V.U

FACTORY PROFILE

Supervising Ministry : Ministry of Inudstry

Supervising Corporation: National Chemicals Corporation

1. Present name of the Factory : REPI SOAP FACTORY
2. Name of the Factory before Natinalization : BIANIL ETHIOPIA S.C.
3. Date of nationalization : FEBRUARY, 1975
4. Legal notice or letter of Nationalization : PROCLAMATION NO. 26, 1975
5. Capital
   - 5.1 Authorized
     - 5.1.1 At date of establishment 400,000
     - 5.1.2 At date of Nationalization 620,000
     - 5.1.3 At present 1,525,394.81
6. Status of the factory at date of Nationalisation : Share Company
   - 6.1 Shareholders of the Factory
     - 6.1.1 Total number of shares : 6,200
     - 6.1.2 Par value of Shares : 100
7. Location of the Factory
   - 7.1 Adminstrative Region : Addis Ababa Metropolitan
   - 7.2 City/Town : Addis Ababa
   - 7.3 Awraja : Lideta
   - 7.4 Kebele : Repi
   - 7.5 House No. : -
8. Address of the Factory
   - 8.1 P.O.Box 5557
   - 8.2 Telephone No. 20-18-14
9. Land area occupied by the Factory : 28,247 sq.m.
10. No. of employees
    - 10.1 At date of establishment : Unknown
    - 10.2 At date of Nationalization

10.2.1 Permanent:

10.2.1.1. Total 63 Male 54 Female 9

10.2.1.1.1 Administrative staff Unknown

10.2.1.1.1 Production " Unknown

10.2.2 Temporary : Total - Male - Female -

10.3 At present

10.3.1 Permanent

10.3.1.1.1 Total 253 Male 191 Female 62

10.3.1.1.1 Administrative staff : 110

10.3.1.1.2 Production " : 143

10.3.2 Temporary : Total 9 Male 4 Female 5

11. Type of products : Detergent (Powder, Bar)

12. Grand names of products : ROL, DETERGENT BAR

13. Production since date of Nationalization

YEAR (G.C)	QUANTITY (TON)	VALUE (BIRR)
75-76	451	1,406,569
76-77	476	1,524,794
77-78	475	1,485,092
78-99	1,145	3,501,628
79-80	1,194	3,622,776
80-81	787	2,030,447
81-82	1,119	3,067,558
82-83	1,092	3,421,110
83-84	1,157	5,298,076
84-85	993	4,105,460
85-86	1,433	5,118,289
86-87	1,846	6,158,530
87-88	2,104	8,255,413
88-89	1,211	4,239,358
89-90	1,899	6,240,091

14. Sales since date of Nationalisation:

YEAR (G.C)	QUANTITY (TON)	VALUE (BIRR)
75-76	-	2,214,240
76-77	465.41	2,292,770
77-78	466.63	2,276,553
78-79	1,012.18	4,809,597
79-80	994.33	4,703,347

YEAR (C.C)	QUANTITY (TON)	VALUE (... BIRR)
80-81	981.50	4,128,388
81-82	836.01	3,534,765
82-83	965,86	4,232,518
83-84	1,340.58	5,871,477
84-85	1,121.89	4,686,654
85-86	1,531.65	5,869,736
86-87	1,936.34	7,143,156
87-88	1,926.79	8,088,992
88-89	1,371.61	5,397,540
89-90	1,745.21	6,819,728

15. Full Capacity of production (establishment)

15.1 Designed : Unknown

15.2 Attainable : "

16. Full capacity of production (Nationalisation)

16.1 Designed : Unknown

16.2 Attainable : "

17. Full capacity of production (Current)

17.1 Designed : Unknown

17.2 Attainbale : "

17.2.1	Detergent Powder	Detergent Bar
per shift	2.025 ton	3.2 ton
" 24 hrs	6.075 "	9.6 "

18. Shift Operation

18.1 No. of shifts at date of establishment 1½

18.2 " of shifts at date of nationalisation 1½

18.3 " " " the factory is now working Three

19. Type of process : Batch

20. Machinery makeup : Semi-automatic

20.1 Major groups of machines:

20.1-1 by activity and No. of machines in each group:

Mixers	8
Pumps	16
Fans	4
Paper folding machine	1
Detergent powder packing machine	1
Boiler	1
Roll mill	1

ANNEX XI

Panel discussion on

" TRANSFER OF TECHNOLOGY "

At the invitation of the Chemical Society of Ethiopia, the Expert on mission participated in a " Panel discussion " on the Transfer of Technology on Aug 8, 1992, at the premises of the Addis Ababa University. The following are his observations on the occasion:

Addis Ababa
8 Aug. 92.

Mr. Chairman, Fellow panelists, Ladies and Gentlemen !

At the outset I would like to express my thanks to the President and members of the Chemical Society of Ethiopia for invitng me to participate in the discussion on Technology Transfer.

I have jotted down some stray ideas on the topic, which I am going to share with you.

-Industrialization is an important parameter in the economic growth of any developing country.

-There has been considerable growth in some of these countries, but due to population explosion, the per capita income remained very low, compared with that of Industrialised countries.

-R & D is an important prerequisit for industrial growth.

-Developed countries spend annually about 2 to 3 % of their GNP on R & D. This amount is considered necessary to keep the economy competitive internationally.

-To accelerate economic progress at an early stage of Industrial development in the developing countries, it is considered appropriate to transfer technologies from the industrialised countries rather than indigenously develop them, since development of commercially viable technologies is both time and capital consuming. However, it may also happen that by the time indigenous technology is developed, the countries in

possession of technologies may have advanced further, thus there is every possibility of indigenously developed technology becoming obsolete.

-It is better to explore international technology transfers among the developing countries with similar organisational and institutional levels, but some-what different degrees of technological development.

-Greater labour absorption potential, can be exploited more easily with the use of cheaper and more labour intensive equipment.

-Priority should be given to R & D activity that speed-up the introduction of products and processes already well tried else where and that may be modified if necessary, to suit the local needs. While doing so, care should be excercised to prevent transfer of obsolete know-how and out-dated equipment.

-Transfer of technology can not only be achieved by joint ventures, but also employment of individual experts, arrangement for the supply of machinery, license agreement and technical assistance in various stages of project implementation.

-Care should be taken to establish enterprises for promoting import substitution and export promotion.

-for developing countries the transfer of technology is not only a question of commercial profitability but development of economic structure using local resources and creating skilled manpower.

-Developing countries need massive inflow of capital in the form of foreign exchange, technical, and marketing skills, export outlets and training.

-It is suggested to initiate simultaneous time bound indigenous R & D programmes to develop and transfer technologies of long range needs.

-Here I would like to share my observations in Addis Ababa. thanks to the management of the National Chemical Corporation who conducted my visit to some of the industries in and around Addis Ababa. I am glad to say that I am quite impressed with the available engineering infrastructure at Akaki Spare Parts Factory. But unfortunately its installed capacity utilization seems to be around "15-20 %". It has all the facilities to undertake fabrication of any chemical plant and equipment. It may not possess the plant design capability, if this is so, I would suggest the agreements for the transfer of technologies, should include the design drawings of equipment and have them fabricated here in this city itself. However, importation of some critical equipment can be considered.

This proposal if followed would result in:

-The saving of foreign exchange not with-standing importation of requisite stainless steels and other materials necessary for fabrication.

-Training of engineers and technicians, most importantly moral booster to the country's technical staff, who can develop design and engineering skills and confidence to meet future needs of plant and equipment of the country.

-Self reliance in design and engineering

-Potential for extra jobs at all levels

-This when done may also cut-down the project implementation time and enhance employment of local manpower.

This arrangement I strongly recommend.

Thank you.

Backstopping Officer's Technical Comments
based on the work of M.B. Narashima
SI/ETH/90/802/11-01

The report contains a comprehensive account of the work carried out by the expert, designs and bills of quantities for equipment to be fabricated and recommendations for the development of the essential oils industry in Ethiopia. During the mission, he has also assisted in improving the production methods of a detergent factory, including energy saving. A proposal for the establishment of a national institute for medicinal and aromatic plants has been recommended with a view to conducting R&D on all aspects of industrial utilization of medicinal and aromatic plants. A glass fractionation column has been fabricated under the supervision of the expert, who also has trained counterpart staff in designing some equipment necessary for essential oil production. Secondary processing of essential oils has been assessed and appropriate recommendations have been made.

The expert has discharged the duties expected of him to the satisfaction of the counterparts and has even done more work than given in the job description. BSO agrees with most of his recommendations and hopes that the Government and the NCC will implement the recommendations without much delay. UNIDO experience could be shared in developing the essential oils industry in Ethiopia.