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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
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21775

Distr.
RESTRICTED

ISED/R.81
26 February 1997

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ORIGINAL: ENGLISH

TECHNO-ECONOMIC DEVELOPMENT OF MEDICINAL AND AROMATIC PLANTS FOR INDUSTRIAL UTILISATION

DG/NIR/92/015/11-51

NIGERIA

Technical report: Work performed and recommendations*

Prepared for the Government of Nigeria
by the United Nations Industrial Development Organisation

Based on the work of Narasimha B. Marla, Chemical Technologist

Project Manager: T. De Silva
Chemical Industries Branch

* This document has not been edited.

V.97-21367

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ABSTRACT

The UNIDO Consultant on mission to the Project DG/NIR/92/015, was briefed by Mr. De Silva, Project Manager, at Vienna on 20 and 21st May 1996 and Mr. Anton Sarbu UNIDO Country Director, at Lagos on 23 and 24th May, 1996, who gave him the benefit of advise and general guidelines in the implementation of the project.

The consultant carried out the duties as given in the job description (Annex 1) from 18 May 1996 to 22nd December, 1996. Upon arrival at the project site, he held discussions with National Project Director(NPD) and project coordinator and visited the pilot plant building, with a built-up area of about 758 sq. metres. He noticed a number of short-comings in the construction and services provided and got them rectified (See text).

The consultant also designed the water distribution piping network, helped the management of the Institute in the procurement of materials needed and got them fitted in one of the bays of the pilot plant building. The 25mm diameter G.I. pipe laid underground and outside the building could have been a source of a lot of operational problems.

He also designed the steam distribution piping network for all the pilot plant bays starting from the adjoining boiler shed and assisted in the procurement of pipes and fittings and got them fitted. He also worked out the power distribution and control system to all the entire pilot plant bays and the boiler house. In addition he worked out a scheme for an independent supply of water to the pilot plants and the adjoining "medicinal plants garden" for tapping sub-soil water by boring "bore holes".

UNIDO consultant assisted the NPD in the creation of a nucleus for technology development and transfer by the recruitment and training of some of the staff required. This nucleus has the potential to develop into a full fledged department of chemical technology within the Institute.

He designed the following equipment:

- an essential oil distillation unit and prepared bill of materials.
- an essential oil fractionation unit of 100 l (working capacity of about 65 l per batch). and prepared bill of materials. The unit has been designed to work under high vacuum.
- boiler accessories:(chimney, fuel oil bulk storage tank, fuel oil "day service" storage tank, feed water tank and I-beam,with support-structure).

The consultant also installed a "climbing/falling" film evaporator of 20-25 litres per hour capacity, including a watering vacuum pump and support structure and an I-Beam as desired by M/S Tournaire, France, to facilitate them in the installation of the multi-purpose pilot plant.

Furthermore he interacted with the consultants, architects and engineers to NIPRD to construct a boiler house, alter the drainage system in and outside the pilot plant building, install the power distribution and control to the pilot plant building, and provide for a built-in process control laboratory (with in pilot plant complex), a built-in design and engineering cell, a built-in maintenance workshop and a built-in herbarium.

The consultant trained the counterpart staff in the bench scale production of essential oils and oleoresins and prepared a number of reports as requested by the NPD.

It may, however be mentioned that due to severe financial stringency, the Institute was passing through, several work items could not be completed.

I. INTRODUCTION

Nigeria is endowed with distinct geoclimatic regions in which a large variety of medicinal and aromatic plants grow and can be cultivated. This potential could be exploited to industrially produce not only essential oils, and isolates but aroma chemicals and pharmaceutical intermediates from aromatic and 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 plants is at least ten times the value of crude extracts and subsequently, the high value 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.

The National Institute for Pharmaceutical Research and Development (NIPRD) established in 1987, is the only one of its kind in the country which has short and long range programmes to harness this abundant national wealth. In pursuance of this objective NIPRD has carried out research on a number of indigenous medicinal and aromatic plants. Some of which have yielded new drugs viz. NIPRISAN, NIPRIFAN, NIPRIDAN, and NIPRIPAN, which are undergoing clinical trials for sickle cell anaemia, fungal infections, diabetes and peptic ulcer respectively.

NIPRD has long term programmes for the establishment of phytochemical industries, which could utilise rural sector participation. It has plans to conduct a survey of the availability of naturally growing medicinal and aromatic plants and to grow selected plants at different agro-climatic zones. Towards meeting these goals the NIPRD has:

- a moderately equipped laboratory and well qualified scientific manpower at Abuja.
- plans to modernise the Institute (construction of 5 storey building is at its final stages of completion)
- a large farm around the Institute.
- a newly set up pilot plant building
- plans to set-up field distillation stills
- plans to se-up a mobile distillation still
- plans to set-up a workshop and acquire capability in the maintenance of various pilot plants.
- plans to develop design and engineering capabilities.
- plans to develop capabilities to fabricate chemical plants and equipment.

The last two capabilities when developed could:

- provide indigenous components to the implementation of new projects.
- reduce the project implementation time
- save considerable foreign exchange
- instill confidence and moral booster to the engineers and technologists.

II. ACTIVITIES

On his arrival at NIPRD Abuja, the consultant held discussions with NPD and the Project Coordinator and visited the Pilot Plant building (under construction) and all the departments of the Institute. The persons contacted by the consultant during his mission are listed in Annex 2.

After careful evaluation it was apparent that the building with a built-up area of about 758 sq metres to house the Pilot Plants was almost complete. He, however, noticed the following short-comings and got them rectified:

(i) Openings of 1.5m x 2m have been made on the outside wall of each bay, to accommodate a shutter. This was considered too inadequate to haul in packages containing pilot plant equipment. As per his advise, these were increased to 3m x 2.4m in all the bays and three of the six bays have been fitted with rolling shutters.

(ii) 25mm diameter G.I. pipes to supply water to the pilot plants in all the bays including the boiler, have been laid underground, outside the buildings (earlier to the arrival of the consultant). The supply of water through 25mm diameter pipe, would have been too inadequate to meet the requirements of the pilot plants and boiler. Besides, the pipes laid underground and outside the building could have been a source of a lot of operational problems. With the consent of NPD and the project coordinator, the consultant helped in the procurement of 50mm diameter G.I. pipes and fittings and fitted them as water header in one of the bays on the walls, one metre above the ground and connected to the main supply line (50mm diameter) located at about 90 metres away.

(iii) Designed steam distribution piping network for all the pilot plant bays, starting from the adjoining boiler shed. Assisted in the procurement of pipes and fittings and got them fitted.

(iv) With the assistance of a technician the power distribution and control system to all the pilot plant bays and the boiler house was worked out.

(v) Drainage system provided in all the bays of the building was just one or two points of 50mm diameter PVC fittings (similar to fittings provided in the bathrooms) which were positioned at the surface of each bay, and connected to the main drainage system of 100mm diameter PVC pipes. This was replaced by running gutters of 150mm x 225 mm on two/three sides of each bay, and these in turn were connected to the main drainage system of 450mm diameter cement pipe, replacing the earlier mains of 100mm diameter PVC pipe.

NIPRD has a built-in infrastructure and qualified scientists who are conducting scientific research, leading to the development of processes for the extraction of active principles and essential oils from medicinal and aromatic plants. However, no such base exists for the technology development and transfer. UNIDO consultant assisted NPD in the creation of a nucleus with a potential to develop into a full fledged department of chemical technology within NIPRD by the recruitment of chemical engineers, mechanical engineer and technicians. They were trained by the consultant in

a. design of chemical plant and equipment
b. piping systems
c. laboratory techniques in the distillation of essential oils, and solvent extraction.

The consultant also interacted with the consultant architects and engineers of the Institute:

- to build a boiler house
- to alter the drainage system in and outside the pilot plant building
- to fit in power distribution and control to the entire pilot plant building including the boiler house.
- to provide for a built-in process control laboratory (with in pilot plant complex).
- to provide for a built-in design and engineering cell.
- to provide for a built-in maintenance workshop
- to provide for a built-in herbarium.

It may however be mentioned that due to severe financial constraints the Institute was passing through, the following work remained incomplete:

- installation of a step-down transformer (additional)
- electrical power distribution and controls
- external drainage
- fitting of rolling shutters in the remaining three bays.
- design and engineering cell
- process control laboratory
- workshop for maintenance and fabrication of plant and equipment.

The consultant worked out a scheme (Annex 3) for an independent supply of water to the pilot plants and the adjoining "medicinal plants garden" by tapping sub-soil water by boring "bore holes", building an overhead tank of 10,000 litres capacity and fixing "submersible" and surface pumps to replace the inadequate Federal Capital Development Authority supplied potable water.

Plant Design

The following equipment were designed by the consultant (Annexes 4 & 5):

- an essential oil distillation unit of 500 l, with a shell and tube condenser (3.6m^2 surface area) and a separator and prepared bill of materials

- an essential oil fractionation unit, consisting of a reboiler of 100l, packed column of 100 mm diameter, 4000mm height, to be packed with either "Knit-mesh" or "Montz", high efficiency packings, shell and tube condenser of 3.8 m^2 surface area, receivers, interconnecting pipes and fittings. The unit has been designed to work under high vacuum. Working capacity is about 65 litres per batch and prepared bill of materials

- boiler accessories:

    a. chimney (designed and got it locally fabricated)

    b. fuel oil bulk storage tank

    c. fuel oil "day service" tank

    d. feed water tank

    e. I-beam, with support structure of 2.4m x 6.2m x 5.75m

Item 'e' was designed and locally fabricated and installed in PPI, as desired by M/S Tournaire, France, to facilitate in the installation of multi-purpose pilot plant.

Installation:

- Installed a "climbing/falling" film evaporator, of the capacity of 20-25 litres per hour, including a water ring vacuum pump, and support structure.

- I- Beam with support structure of 2.4m x 6.2m x 5.75m.

Developmental work:

The following were demonstrated at a bench scale(Annex 6) to train the counterpart staff:

(a) Distillation of the following essential oils :

- Lemon grass
- Ginger
- Eucalyptus citriodora

(b) Extraction of oleoresins from:

- Ginger officianale
- Red Peppers.

Specifications of the Essential oil association of USA for Giger oil, and oleoresins of ginger, capsicum and red peper are in Annexes 11-14.

Reports prepared:

Following reports were prepared by the consultant during the mission:

a) A proposal to augment water supply to the laboratory, pilot plants and medicinal plants garden (Annex-3)

b) A proposal to set-up additional facilities at the pilot plants of NIPRD, Abuja (Annex-5)

c) "Prospects for the development of essential oil industries in Nigeria" (Annex 7)

d) "NIPRD - Some perspectives and constraints" and submitted it to the National consultative workshop on equipment maintenance rehabilitation, manufacture, and technology and development in Nigeria, Abuja 18 - 19 Sept. 96, (Annex-8).

e) A note on NIPRD-Industry linkages(please refer Annex-9).

f) A note on safety aspects of solvent extraction plants (Annex-10).

The Institute (NIPRD) was passing through severe financial constraints during the mission time which considerably effected the progress of the project.

III. CONCLUSIONS

1. As a large variety of medicinal and aromatic plants grow in Nigeria under distinct geo-climatic regions, it possible to introduce exotic plants of economic importance into the country.

2. At present no industry exists in the country to process aromatic and medicinal plants to produce crude extracts, essential oils, let alone value added pure isolates and aroma chemicals.

3. The National Institute for Pharmaceutical Research and Development (NIPRD) has short and long range programmes to harness this abundant national wealth. It has already developed some

new drugs, viz., Niprisan, Niprifan, Nipridan and Nipripan, which are undergoing clinical trials for sickle cell anaemia, fungal infections, diabetes, and peptic ulcers respectively.

4. It is feasible to develop appropriate technologies for industrial production of these indigenously developed drugs during the period the clinical trials are being conducted.

5. It is possible to establish an essential oil industry in the country(Annex 7). Initially a single mobile distillation unit could move from site to site (natural flora and plantations) to produce crude essential oils. It is feasible to transport the crude essential oils to NIPRD for secondary processing to produce refined essential oils, pure isolates and aroma chemicals.

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

7. A very good quality engineering infrastructure for the fabrication of industrial size chemical plant and equipment exist in the country, (African Regional Centre for Engineering Design and Manufacture-ARCEDAM Ibadan, and Federal Institute for Industrial Research - FIIRO, Lagos) but its design capability to undertake fabrication of such plants needs re-enforcement. This capability could be acquired through international training.

8. To develop self reliance in the industrial development of Nigeria, including phytochemical industry, its existing engineering infrastructure should be fully exploited even if the country has to import necessary steels and stainless steel for fabrication.

IV. RECOMMENDATIONS

1. It is recommended that agronomic and process research on selected essential oil bearing plants be conducted at different geo-climatic zones, by the use of mobile distillation units. These stations could develop into a national network of aromatic plantations and distillation centres.

2. The development of essential oil industry in Nigeria could be done in stages;

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

3. Steam distillation plants are provided to meet the future plantations. Designs for 0.5t, 2t, 3t and 5 tonnes per batch (of green herb) stills were prepared (Drawings in Annex 4).

4. Medicinal and aromatic plants selected for industrial use should be based on world wide demand and whose products command best international prices. These, may be cultivated in selected areas to the extent possible, since the yield and quality of the product from the given plant material depends on the local conditions viz., soil, climate, altitude etc. It is further suggested that the following aromatic plants may be planned to be cultivated in Nigeria:

   - Mentha arvensis
   - Mentha piperita
   - Geranium
   - Basil (Oscimum basilicum)

5. It is recommended to explore the possibility of introduction cultivation of Cymbopogan martini (Palmarosa) on a pilot scale and then extend it to a commercial scale, since there is a good demand for geraniol in the manufacture of high quality perfumes. Palmarosa oil obtained from Cymbopogan martini is one of the best natural sources of geraniol. It contains about 58% geraniol and 14% geranyl acetate. The later can be hydrolysed to geraniol.

6. Some of processes developed in the Institute that have potential for industrial exploitation, be subjected to in-depth evaluation for technical feasibility and economic viability on pilot plant. Intense investigations on pilot plant expected to generate:

   - technologies to produce active principles, essential oils, and aroma chemicals, from medicinal and aromatic plants.
   - assess technical feasibility and economical viability of the processes developed.
   - technical data necessary to scale-up the pilot plant operations to industrial operations.

7. In-depth studies on pilot plant scale may be undertaken to develop appropriate technologies on the new drugs developed by the Institute (on "bench-scale" viz., Niprisan, Niprifan, Nipridan, and Nipripan, which are undergoing clinical trials for sickle cell anaemia, fungal infections, diabetes and peptic ulcer respectively).

   These studies may be undertaken simultaneously with the clinical trials of these new drugs. This when done, the Institute would be ready with the technologies to produce the drugs on a commercial scale by the time the clinical trials, are successfully concluded, and, consequently would reduce the gestation period in the industrialisation of life saving indigenously developed drugs.

8. 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. Setting-up secondary processing of essential oils to produce value added products given below is recommended:

   a. deterpinated essential oils
   b. pure isolates
   c. aroma chemicals

9. NIPRD has a scientific base and is conducting basic research on indigenous medicinal and aromatic plants to complement this base, it is recommended that a full fledged department of Chemical Technology with a design and engineering cell be created within NIPRD. A newly created nucleus already exists with UNIDO/UNDP sponsored pilot plants, newly recruited chemical and mechanical engineers, pharmacists, with a mandate to:

   - scale-up laboratory processes
   - develop appropriate technologies
   - transfer of technologies on turn-key basis
   - design and fabricate chemical plant and equipment.
   - maintain pilot plants and utility equipment.

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

10. Collaboration with national and international institutes should be established for quicker development of aromatic and medicinal plants based industries in Nigeria.

11. It is further recommended that the existing library should be upgraded to include chemical engineering, mechanical engineering and technology books and journals.

12. The water supply to pilot plant has to be augmented. A proposal (Annex 3) has been submitted by the consultant to the NPD to have an adequate and independent source of supply by:

- digging a borehole in the pilot plant enclosure
- constructing an overhead tank of $10m^3$ and surface tank of $20m^3$
- fitting-up the bore hole with a submersible pump, to pump-up water from bore hole to the surface tank.
- a surface pump, to pump-up water from surface tank to overhead tank.

A similar set-up should be there for the expanded laboratory (under construction).

13. 400 KVA step-down transformer should be installed to meet the present and the future electric power demands of the pilot plant, workshop and auxiliary services. A 30 KVA step down transformer, presently supplying power to the laboratory, cannot meet the power needs of the pilot plants, in addition to the Institute's laboratories.
The 500KVA step-down transformer, approved by NEPA (Nigeria Electric Power Authority), would be adequate to meet the power needs of the new laboratories only.

14. It is further suggested that the "gas" needs of the new laboratory may be foreseen, and adequate steps be taken to set-up gas generators, gas holders and a distribution network from gas holders to the entire laboratory (parallel to water distribution).

ACKNOWLEDGEMENTS

The UNIDO consultant acknowledges with thanks, the advise and generous help extended to him during briefing on 20 and 21 May, 1996 by Mr. Tuley De Silva, Special Technical Adviser, Chemical Industries Branch, UNIDO, Vienna, Mr. Anton Sarbu, UCD, Lagos, for briefing, active interest and advise during his mission, and debriefing, Mr. A. Ajani, Programme Officer, with UCD, Prof. C. O. N. Wambebe, NPD and Director/Chief Executive, NIPRD, Mrs. N. Enwerem of (NIPRD) Project Coordinator for their active interest and advise during his mission, Dr. Gamaniel K. Shingu, DD(R&D) NIPRD, for his help, Mr. Nasidi Kabiru Asst. Res. Rep., UNDP Office in Abuja for help and assistance, Mr. Elias Nda Amlabu, Mr. Yakubu Gang, young counterpart engineers for their assistance,and Mr. Tunde Olorode for typing the report.

Annex-1

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Project of the Government of
Nigeria

JOB DESCRIPTION
DG/NIR/92/015/11-51/073000

Post title	Chemical Technologist
Duration	6 m/m
Date required	15 May 1996
Duty station	Abuja, Nigeria
Purpose of project	The project intends to provide institutional facilities which will strengthen the capacity and technical capability of the National Institute for Pharmaceutical Research and Development (NIPRD), to enable it operate a multi-disciplinary research on the medicinal and essential oil containing plants which are locally available vis-a-vis isolation, identification, production and pharmacological evaluation of such products.

Duties

The consultant working in collaboration with NIPRD/UNDP and under the general supervision of the National Project Director will be specifically expected to carry out the following duties:

1. Assist in the installation and commissioning of the for the pilot plant equipment.

2. Assist in documenting the procedures for the pilot plant operation in respect to isolation of essential oils, drug substances, etc. from plants.

3. Assist in training NIPRD staff in the use of the pilot plant and the proper operation as well as routine maintenance of the equipment.

4. Assist in setting up the maintenance workshop which would enable spare parts and other components of the pilot plant to be fabricated locally for either industrial use or in-house purposes.

5. Assist in the preparation of standard operational procedures and in validation of equipment and processes.

6. Develop process parameters for the products being developed.

7. Design and supervise fabrication of accessory equipment such as percolators and field distillation units.

8. Prepare a final report on the output of the mission together with the recommendations for further action by NIPRD and the Government.

Qualifications University degree in chemical or mechanical engineering and extensive experience (at least 10 years) in process technology involving the bulk extraction of essential oils and drug substances from plants.

Language English

Annex -2

Persons Contacted

1. Prof. C.O.N. Wambebe	- Director, NIPRD, Abuja
	- NPD., DG/NIG/92/015 Lagos
2. Mr. Anton Saibu	- U. C. D., Lagos
3. Mr. Kabiru A. Nasidi	- Asst. Res. Rep. UNDP Office Abuja
4. Mrs N. M. Enwerem	- Project Coordinator, NIPRD
5. Prof. J. I. Okogun	- H.O.D. Medicinal Plant Research and Traditional Medicine Department.
6. Dr. K. S. Gamaniel	- Deputy Director, (R&D) NIPRD
7. Mr. V. Oyaigbevwen	- Deputy Director, (P&MS) NIPRD
8. Mr. R. G. Jigah	- Chief Accountant, NIPRD
9. Prof. Z. O. Gbile	- National Consultant to the Project
10. Prof. Sam Okonkwo	- National Consultant to the project
11. Mr. Adegboyega Ajani	- Programme Officer, UNDP, Lagos
12. Ms. Joke van der Ven	- Programme Officer, UNDP, Lagos.
13. Mr. John Mark Audam	- Technologist NIPRD
14. Dr. Abdullahi Aliyu	- Chief Executive, RMRDC, Abuja.
15. Alh. Wakeeli	- Contractor Pilot Plant Building, c/o NIPRD, Abuja.
16. Mr. O. Akale	- Store Keeper, NIPRD, Abuja.
17. Mr. Robert Alli	- Principal Personnel Officer, NIPRD, Abuja.
18. Ms. Mercy Iyortyer	- Consultant (Civil Engr.) to NIPRD
19. Mr. Steven Adebayo	- Consultant Architect to NIPRD.
20. Mr. S. A. Adewuni	- Administrative Associate, UNDP Office, Abuja.

Annex-3.

A PROPOSAL TO AUGMENT THE WATER SUPPLY TO THE LABORATORY, PILOT PLANTS, AND MEDICINAL PLANTS GARDEN

TO: Director, NIPRD

FROM: Narasimha B.Marla, UNIDO Consultant
DATE: 18th November, 1996

Please refer Prof. Gbile's Note of 12/11/96 marked to me

Prof. Gbile and I visited the medicinal plant garden. We noted that:

- there are a few *Calliandra portoriscensis* plants scattered widely amidst weeds and bean plants.
- these plants are almost dying
- the field is slopy
- the shortest distance from the location of these plants from the nearest place in the Pilot-plant-building, where water is available is about 200m.

Suggest the following measures:

Short Term:

Water is available in 1" pipe already laid, near the proposed work shop in pilot plant building.

- this can be used for irrigation of the surviving plants.
- this arrangement may work till the time pilot plants and boiler become operational.

For this arrangement, we need

a. 200m of 25mm PVC hose
b. 25mm G.M. valve - (1)
c. 25mm nipples - (2)

However water supply through the presently laid 2" G.I. pipe lines may not be sufficient to feed both pilot plant (boiler included) and the medicinal plants garden, even after the commissioning of a small water cooling unit, supplied by UNDP/UNIDO Project.

Long Term:

Viewing from the comprehensive long-term needs of water for expanding pilot plants and growing medicinal plants garden, it is not advisable to depend on the supply of government water and that too potable drinking water which is already under short supply.

Added to this, will be the water requirements of the new five storeyed laboratory, when it becomes operational. Hence the Government supply simply would not be sufficient.

I am therefore of the opinion that it is advisable to:

- dig a bore hole within pilot plant campus, to tap copious supply of ground water.
- build an overhead tank of about $10m^3$ (10,000 litres capacity), near the borehole.

- install submersible pump (capacity) depending on the depth and capacity of the hole or surface bore well pump (jet pump), to pump up water from the bore hole to the ground tank.

- install surface pumps (centrifugal pumps) to pump up water from the surface tank to the overhead tank. Capacity 4-5m^3 per hour (against total head depending on the height of the overhead tank).

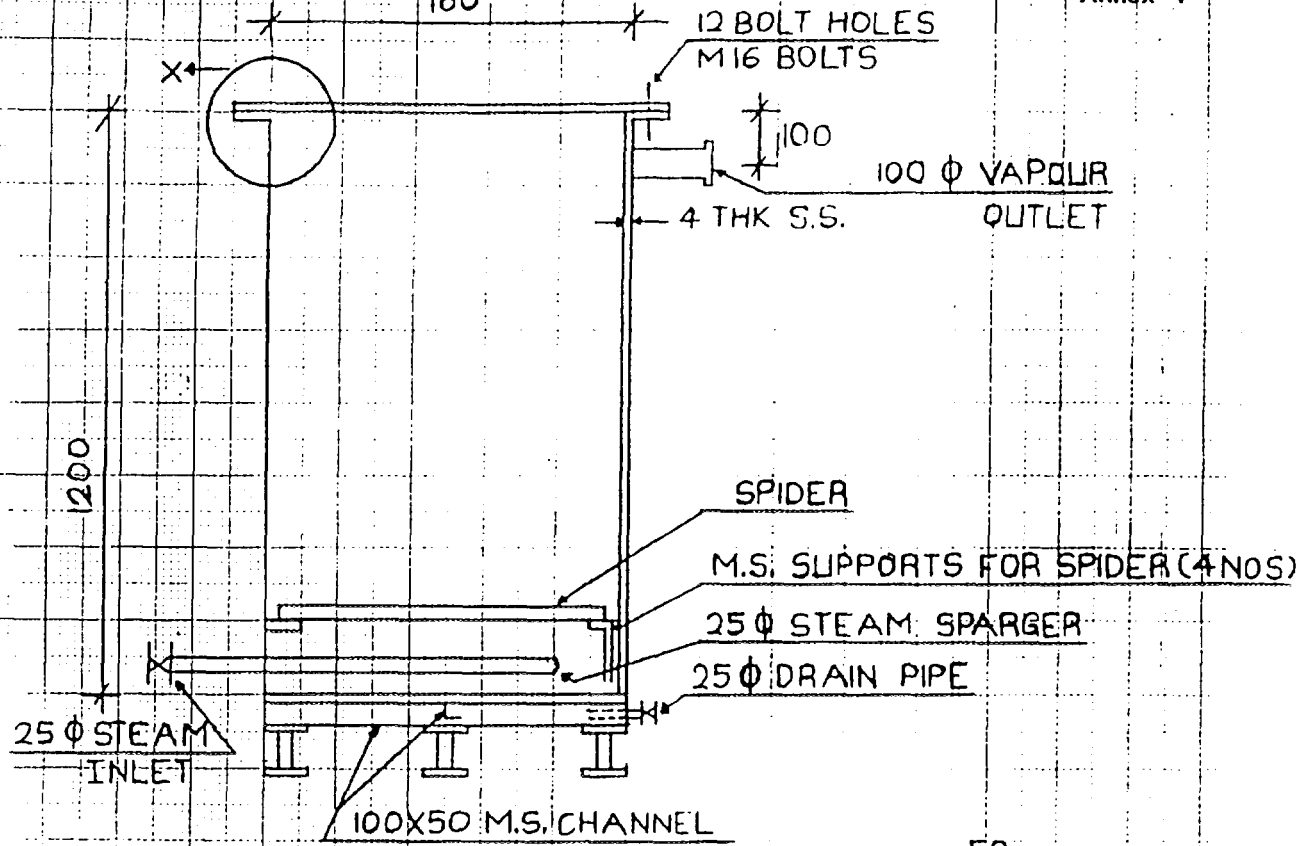
- install feeder pipe lines (G.1.). Two sets of pipelines for feeding to:

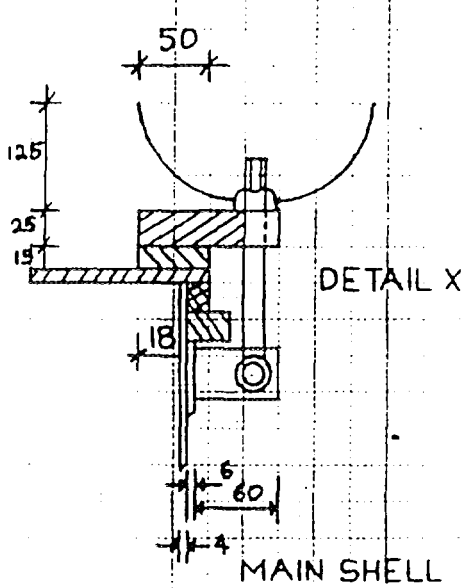
    a. pilot plants
    b. for irrigation of medicinal plants garden through a system of sprinkler/open ground channels.

Similar set-up may be planned to meet the water supply of the new laboratory building under construction.

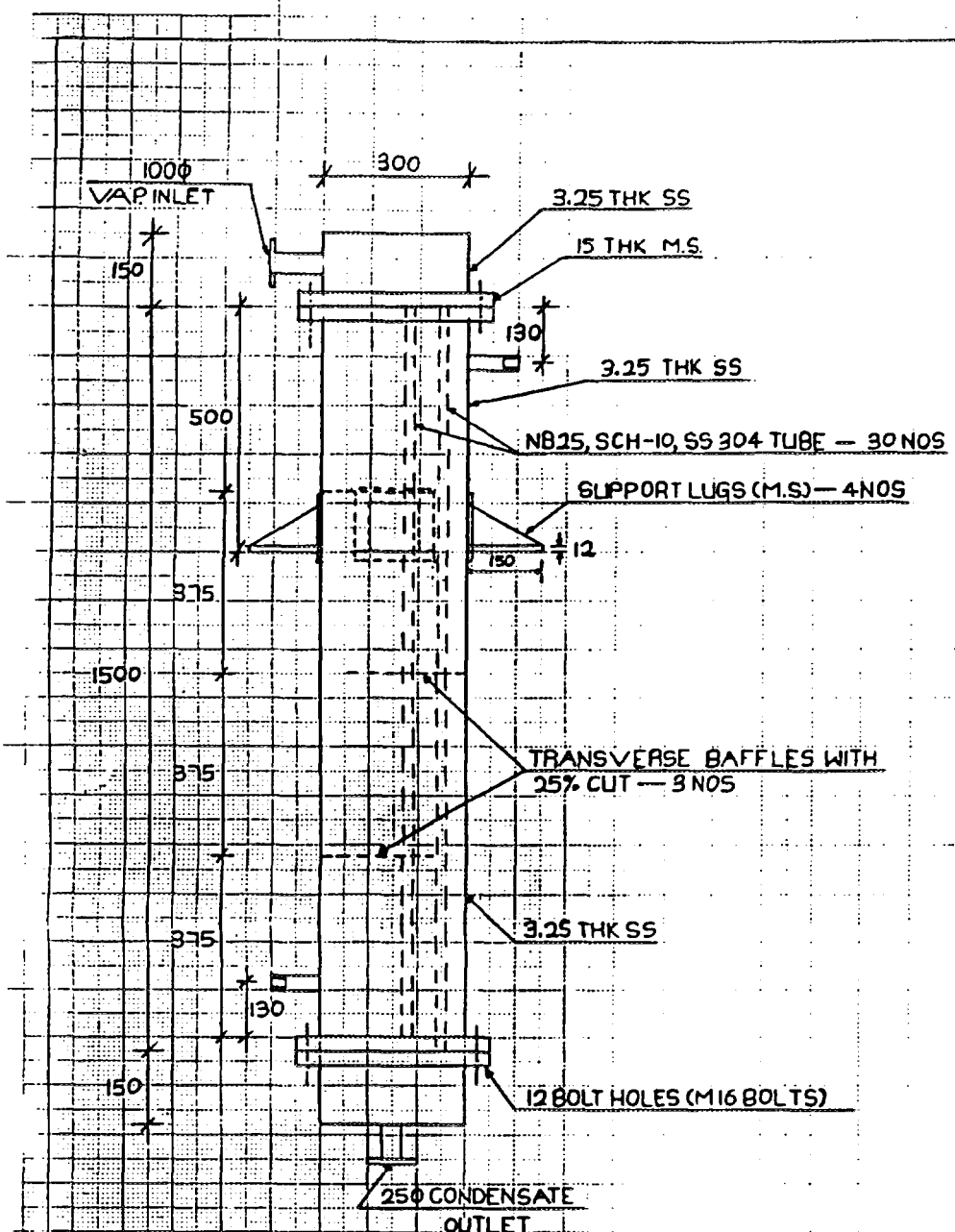
- dig a bore hole at a place near the new laboratory building
- install a submersible pump in it.
- construct an overhead tank and a surface tank near the site of the bore.
- install surface pumps to pump up the water from surface tank to the overhead tank.
- lay water distribution pipe net work from overhead tank to the entire laboratory building.

Annex- 4

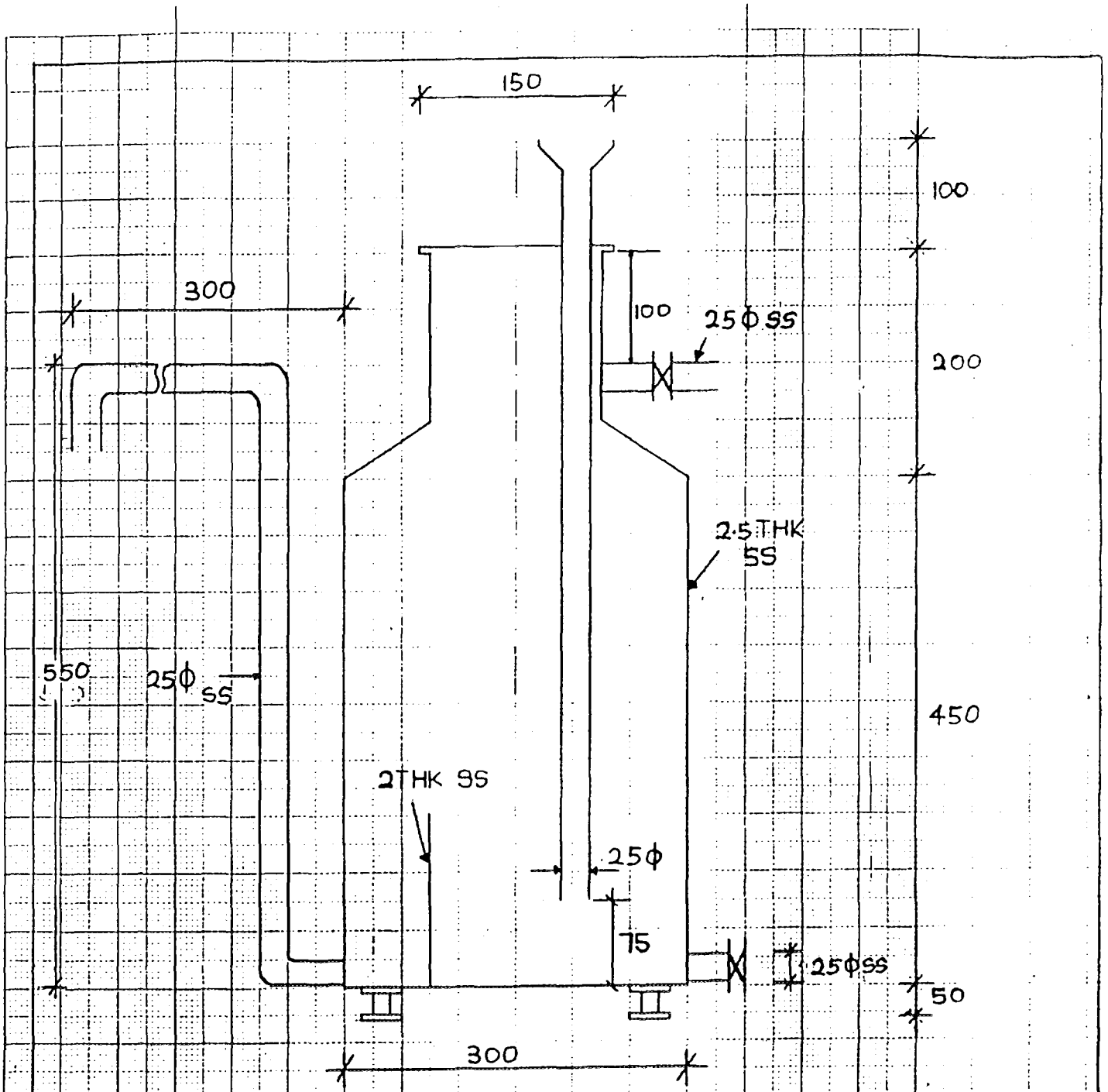




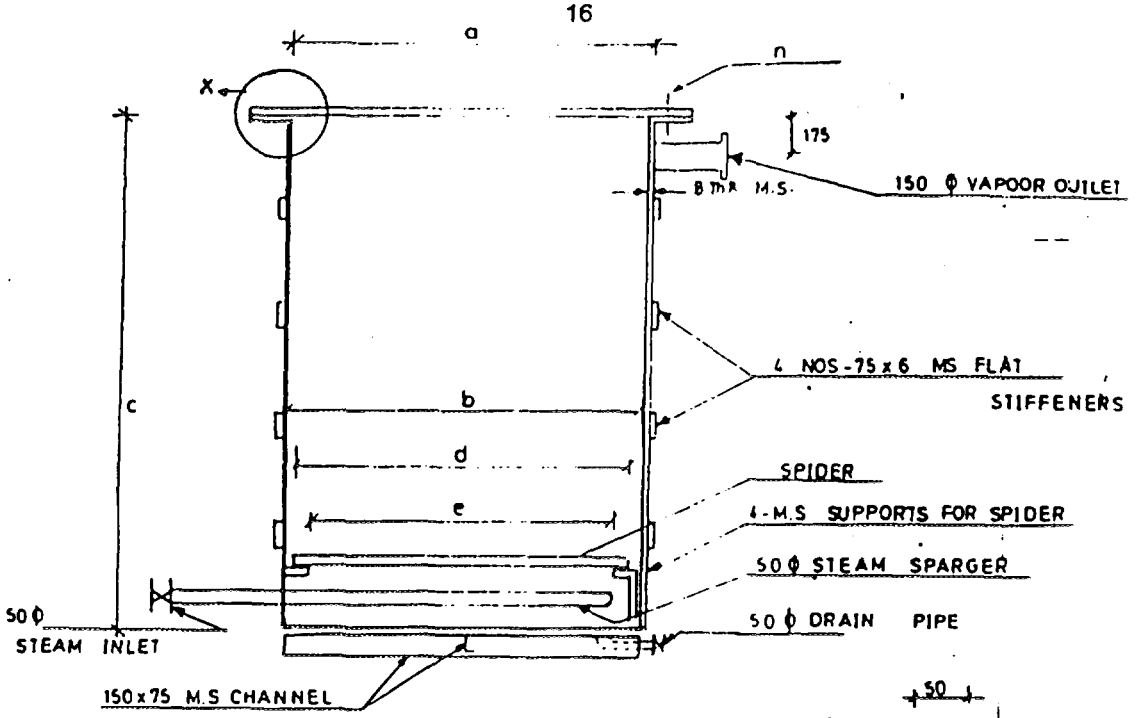
N·I·P·R·D — ABUJA	
ESSENTIAL OIL DISTILLATION STILL	
DESIGNED	NARASIMHA B. MARLA (UNIDO)
DIRECTOR	PROF. C.O.N. WAMBEBE
DRAWN	ELIAS N. AMLABU
DATE	NOV. '96
DRG No.	1 OF 3

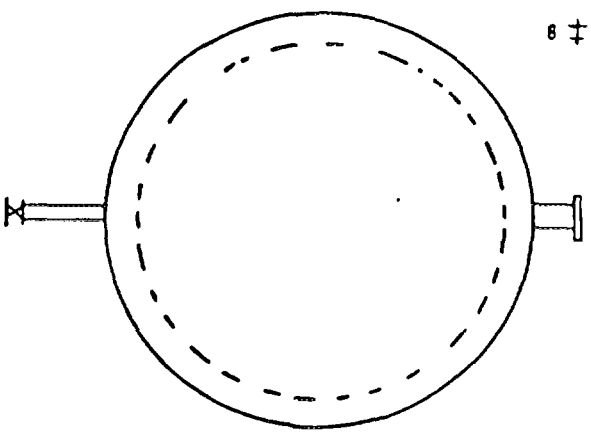


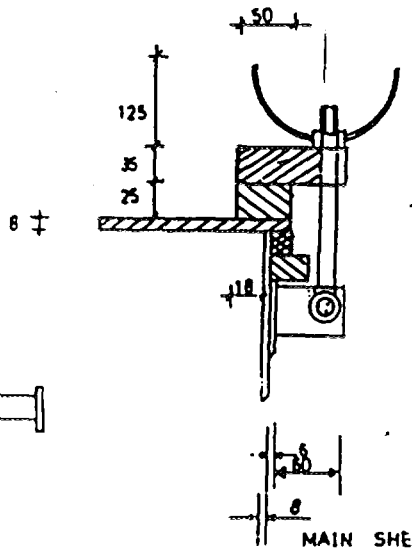
NIPRD — ABUJA	
ESSENTIAL OIL CONDENSER	
DESIGN	NARASIMHA B. MARLA (UNIDO)
DIRECTOR	PROF. C.O.N. WAMBEBE
DRAWN	ELIAS N. AMLABU (NIPRD)
DATE	NOV. '96
DRG. No.	2 OF 9



N.I.P.R.D — ABUJA	
ESSENTIAL OIL SEPERATOR	
DESIGN	NARASIMHA B. MARLA/UNIDO/
DIRECTOR	PROF. C.O.N. WAMBEBE
DRAWN	ELIAS N. AMLABU/NIPRD/
DATE	NOV. '96





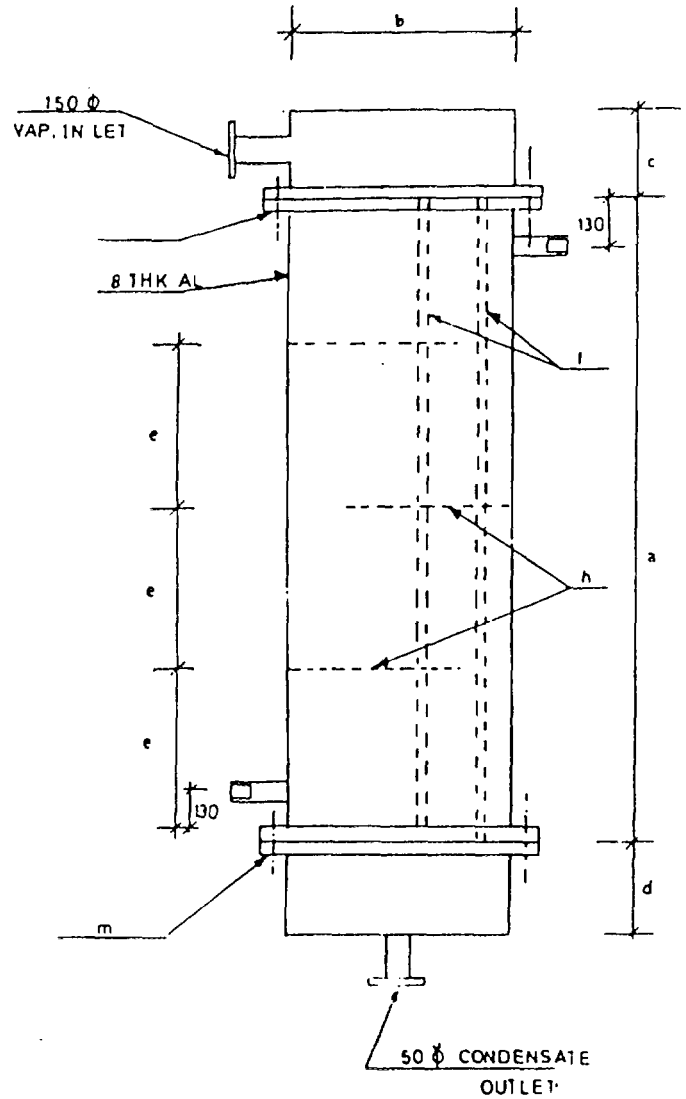


NOTE: SUITABLE ON MONORAIL & ELECTRIC 4-WAY HOIST NECESSARY

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

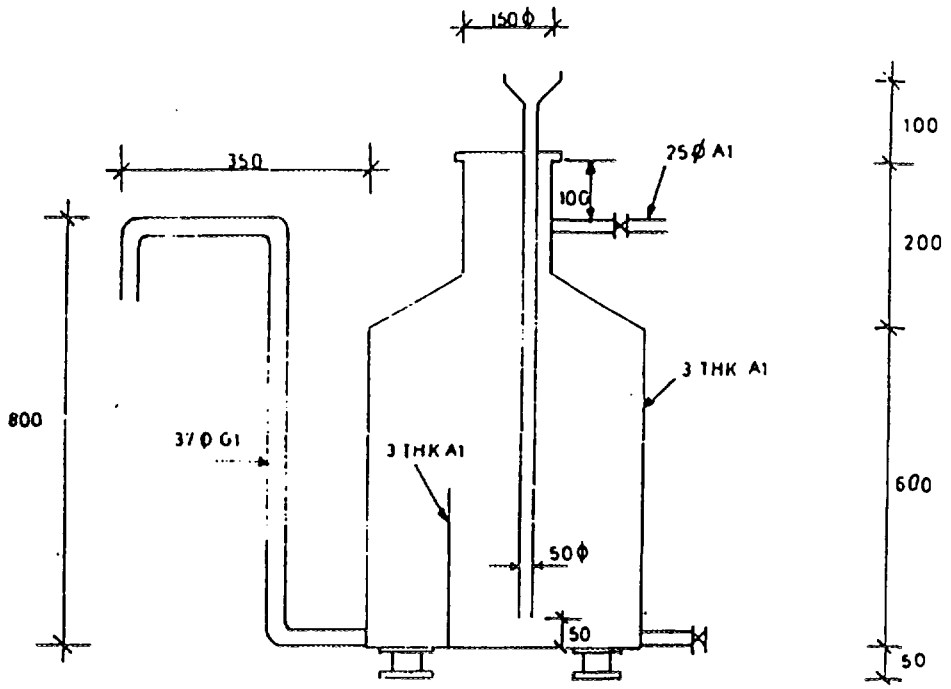
n-19 ϕ SWIVEL BOLTS

NIPRD—ABUJA	
ESSENTIAL OIL DISTILLATION STILL	
DESIGN.	NARASIMHA B. MARLA
DIRECTOR	PROF. C.O.N. WAMBEBE
DRAWN	ELIAS N. AMLABU
DATE	NOV. '96
DRG. No.	1 OF 3



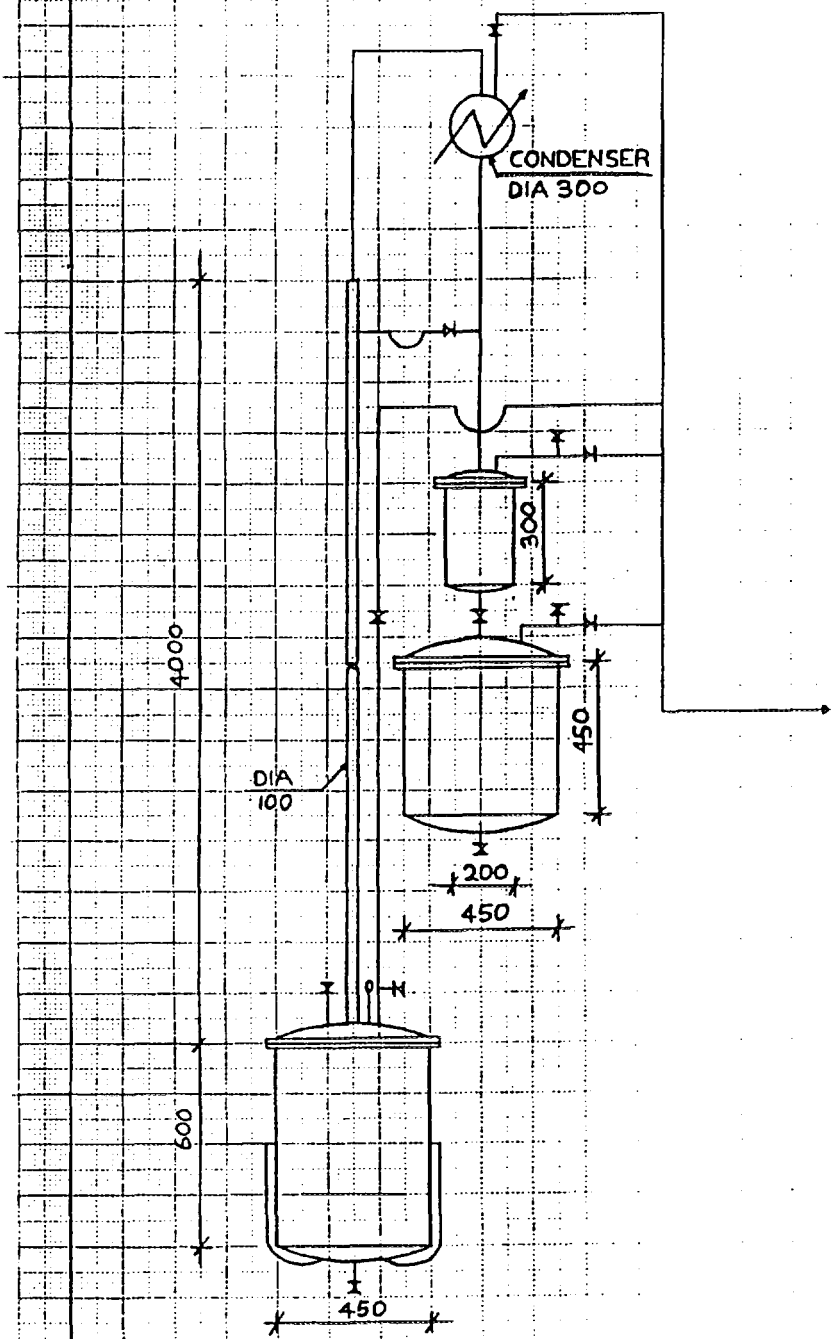
m	20 NOS BOLTS M16 BOLTS HOLES on 500 536 586ϕ PCD		
	520ϕ 20Th	576ϕ 20Th	626ϕ 20Th
f	Al Tube Plate	Al Tube Plate	Al Tube Plate
h	TRANSVERSE BAFFLES WITH 25% CUT -3 NOS.		
	250Dx 12 GAl 80 Tubes on 37Δ pitch	250D x 12G 104 Al Tubes on 37Δ pitch	250D x 12G 136 Al Tubes on 37Δ pitch
e	400	450	500
d	150	150	150
c	250	250	250
b	420ϕ	470ϕ	520ϕ
a	1600	1800	2000
	2 ton	3 ton	5 ton

NIPRD—ABUJA	
ESSENTIAL OIL CONDENSER	
DESIGN	NARASIMHA B. MARLA
DIRECTOR	PROF. C.O.N. WAMBEBE
DRAWN	ELIAS N. AMLABU
DATE	NOV. '96
DRG No.	2 OF 3

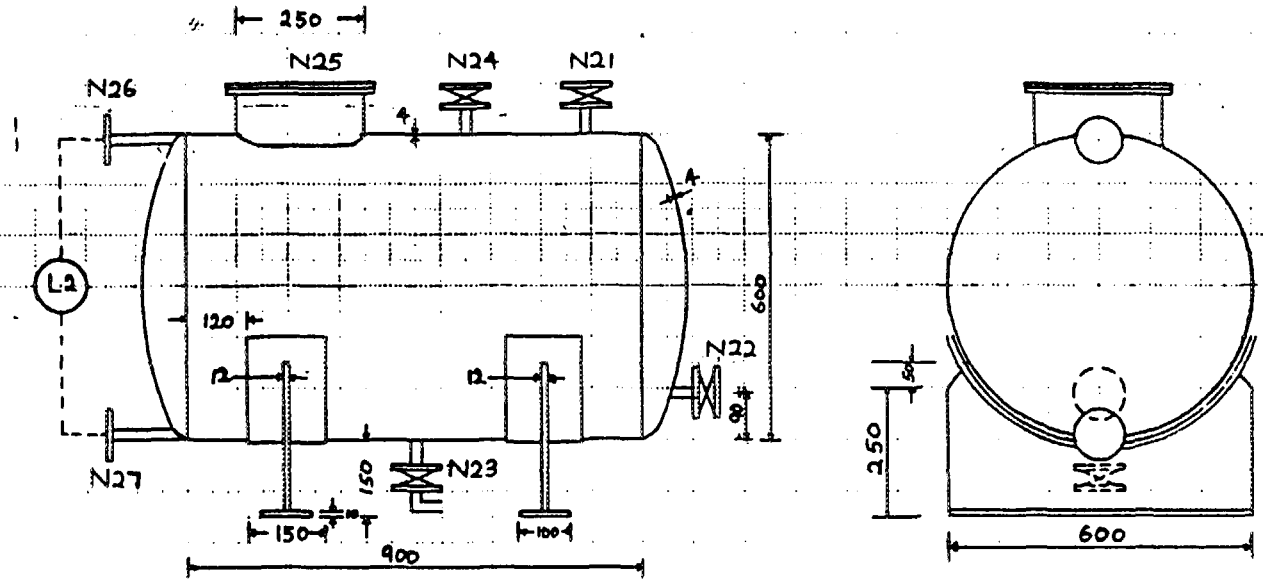


NOTE ALL DIMENSIONS ARE IN mm.

NIPRD—ABUJA	
ESSENTIAL OIL SEPERATOR	
DESIGN	NARASIMHA B. MARLA
DIRECTOR	PROF C.O.N. WAMBEBE
DRAWN	ELIAS N AMLABU
DATE	NOV. '96
DRG No.	3 OF 3



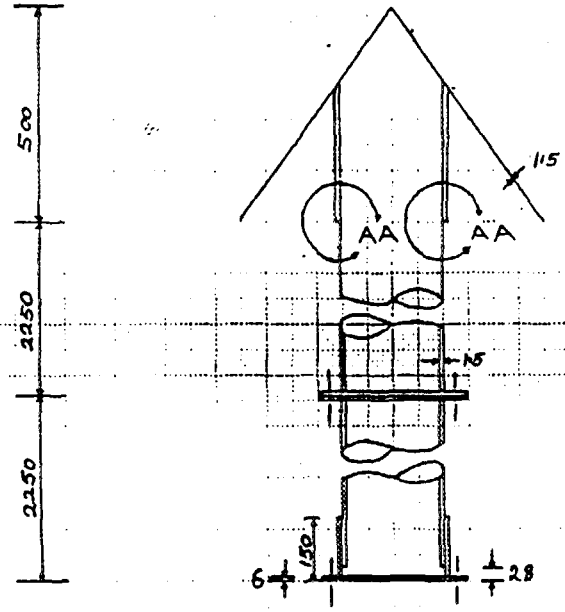
NIPRD — ABUJA	
FRACTIONATING COLUMN	
DESIGN	NARASIMHA B. MARLA
DIRECTOR	PROF. C.O.N. WAMBEBE
DRAWN	ELIAS N. AMLABU
DATE	DEC. '96
DRG No	1 OF 4

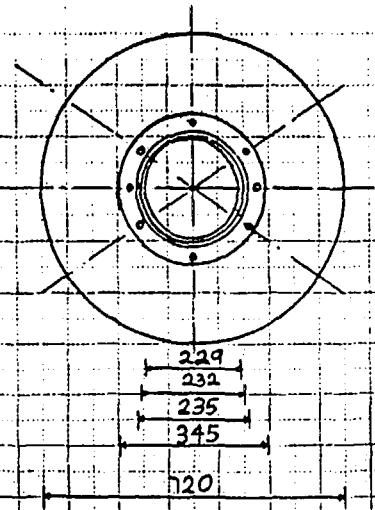


LEVEL INDICATOR SHOULD BE FITTED WITH BRASS CORKS, GLASS TUBE AND TUBE GUARD

FLANGE	DIA(MM)	THICKNESS	APPLICATION
N21	25	10	WATER INLET
N22	25	10	WATER OUTLET
N23	25	10	DRAIN
N24	25	10	VENT
N25	250	10	MANHOLE
N26	13	10	LEVEL GAUGE
N27	13	10	LEVEL GAUGE
L2			LEVEL INDICATOR

NIPRD—ABUJA	
DRAWING No	DGINRI 921015-B.02
BOILER—FUEL OIL TANK	
DESIGN	NARASIMHA B. MARLA
DRAWN	ELIAS N. AMLABU
DIRECTOR	PROF. C.O.N. WAMBEBE
SCALE	1:10
DATE	OCT. '96

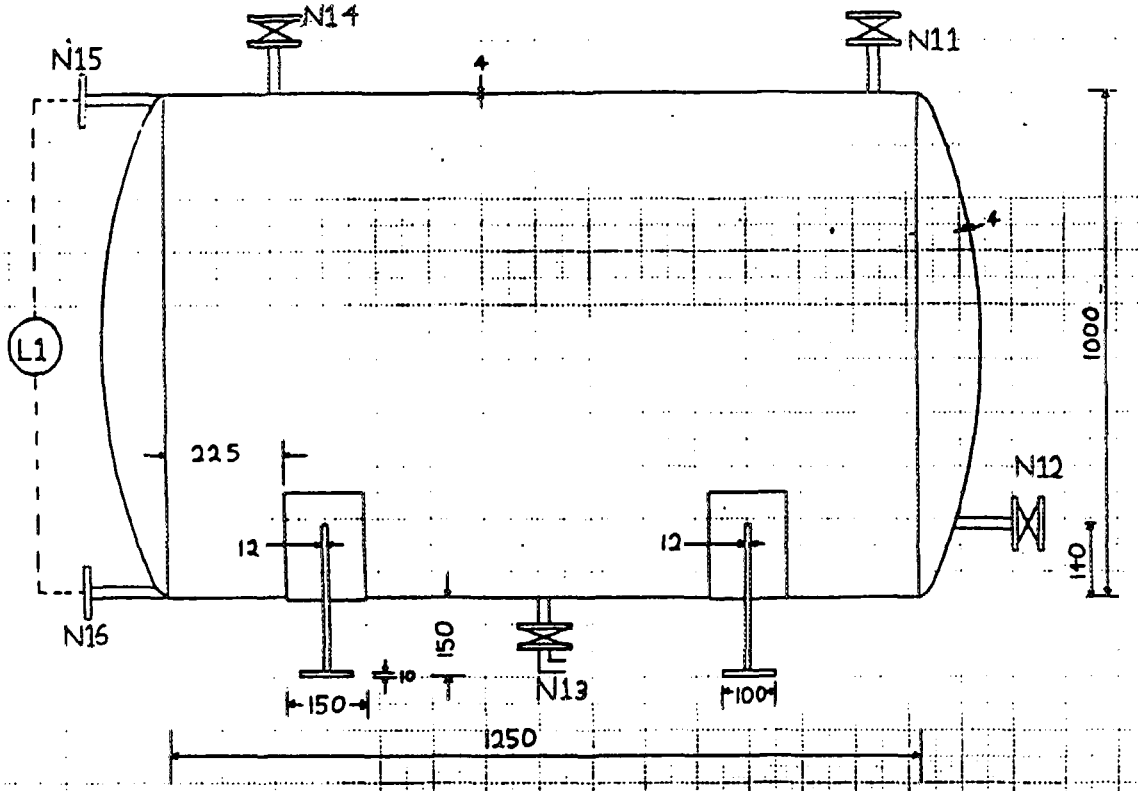


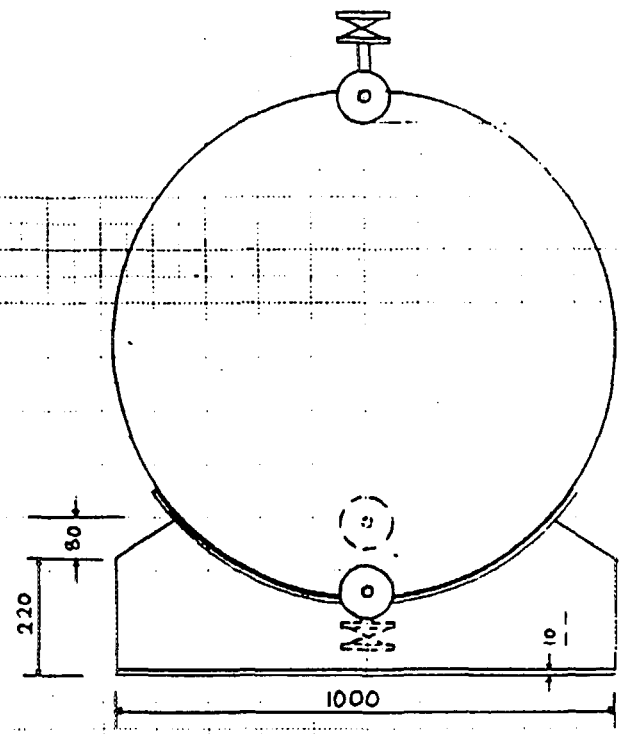


MATERIAL OF CONSTRUCTION: M.S

ALL DIMENSIONS IN MM

DRAWING No. DG/NIR/92/015-8.03	NIPRD—ABUJA
BOILER—CHIMNEY	
DESIGN	NARASIMHA B. MARLA
DRAWN	ELIAS N. AMLABU
DIRECTOR	PROF C.O.N WAMBEBE
SCALE	1:12
DATE	OCT. 96





MATERIAL OF CONSTRUCTION: CYLINDRICAL BODY, DISHED ENDS, NOZZLES } FRP

LEVEL INDICATOR SHOULD BE FITTED WITH BRASS CORKS, GLASS TUBE AND TUBE GUARD

VALVES : GM

ALL DIMENSIONS IN MM

FLANGE	DIA (MM)	THICKNESS	APPLICATION
N11	25	10	WATER INLET
N12	25	10	WATER OUTLET
N13	25	10	DRAIN
N14	25	10	VENT
N15	13	10	LEVEL GAUGE
N16	13	10	LEVEL GAUGE
L1			LEVEL INDICATOR

DRAWING No.	NIPRD—ABUJA
DGNR/92/015-B01	
BOILER-WATER TANK	
DESIGN	NARASIMHA B. MARLA
DRAWN	ELIAS N. AMLABU
DIRECTOR	PROF. C.O.N. WAMBEBE
SCALE	1:10
DATE	OCT. '96

Annex-5

PROPOSAL TO SET-UP THE FOLLOWING ADDITIONAL FACILITIES AT THE PILOT-PLANT SECTION OF NIPRD in ABUJA

PHASE 1: DISTILLATION OF ESSENTIAL OILS

The following items are needed for the design and fabrication of an essential oil distillation still (volume 500 litre):

(a). Design uni

Needed instruments	Quantity
- Draughting board	1
- Drawing tools/insturments	1 set
- Ammonia printer	1

(b) The following items of stainless steel and mild steel are required for the fabrication of an essential oil distillation still (volume 500 litre), a condenser oil/water separator and support structure:

AISI 304/18-8 stainless steel sheets	Quantity
1.2m x 2.4m (4mm thick)	3
1.2m x 2.4m (2.5mm thick)	1
1.2m x 1.2m (12mm thick	1
25NB, 6m long tubes	12
80 NB, 6m long tube	1
300 NB, 3m long tube	1
25 NB, ball valve	1
2 litre blue paint and brush	1 each
Insulating glass wool 50mm thick	
1m wide, 10m length	1 roll
Coarse cotton cloth	1 roll
1m width x 5m length	1 roll

(c). Approximate expenditure under phase 1 is One Million Naira

PHASE II (For the production of Aroma Chemicals)

Design of fractionation Column

A. Fractional distillation column. All contact parts in AISI 316.
- Reboiler ... 100 l
- Fractionation column 100 mm diameter, 4m height
- Condenser (Shell and tube)
- Receivers
- Reflux distributor - To be imported
- Internal packings - To be imported
- Inter connecting piping
- Valves - To be imported
- Vacuum pump - To be imported
- Carbon steel support structure

B. Vacuum flash evaporator unit, all contact parts in AISI 316

- Feed tank 20-30 l/hr (evaporation)
- Shell and tube preheater
- Flash unit
- Cyclone separator
- Vapour - liquid mixer
- Shell and tube condenser
- Condenser receiver
- Water connecting pipes and fittings (vacuum)
- Carbon steel support structure.

C. Stirred reactor 100 l capacity
Maximum temperature 125 - 150°C. All contact parts AISI 316
Shell and tube condenser(s)
Reflux distributor
Condensate/product receivers
Inter connecting piping, valves
Vacuum pump

D. The approximate expenditure under phase II is Nine Million Naira.

Note:

1.Design of all the above units is possible. If approved in principle design of these units can be taken -up and appropriate cost of each units can be worked out. Adequate workshop facilities are available at FIIRO, Lagos and ARCEDEM Ibadan. We may use these facilities to fabricate the above items. (including their technicians and necessary welding and cutting tools, gases and fitting tools).

2.The above items if imported in finished form may cost 4 to 5 times to what it would cost if designed and fabricated within the country. Additionally this activity would expose the engineers and technicians to the design and fabrication of chemical plant and equipment. When fully trained they can handle these jobs on their own.

NARASIMHA B. MARLA
UNIDO Consultant

Based on the proposals, designs and the bill of materials of the UNIDO Consultant to the project to set-up additional facilities of the pilot plant section of NIPRD, Abuja, the NIPRD authorities have submitted the proposals and the designs to the Raw Materials Research and Development Council (RMRDC) Abuja for the grant of necessary funds under phase I (please refer Annex-6).

Annex-6

Bench - Scale Results

Hydro-distillation

	EUCALYPTUS CITRIODORA						
Expt. No.	1	2	3	4	5	6	7
Weight of fresh leaves/Shrub (g)	150	100	200	150	200	200	250
Volume of water added (ml)	500	500	300	150	200	200	200
Leave to water ratio	1:3.33	1:5	1:1.5	1:1	1:1	1:1	1:0.8
Time of distillation (Hrs).	3	3	3	2	3	2	3
Volume of oil collected (ml)	4	2.6	5.8	4.8	5.2	5.5	7.5
Volume of water left (ml)	430	450	230	80	135	140	100
Weight of leaves/Crushed rhizome after drying (g)	58.6	38.0	85.0	73.0	76.0	80.0	109.0
Percentage oil content (vol./wt) (%).	6.83	6.84	6.82	6.85	6.84	6.88	6.88
Moisture content (%).	61.0	62.1	55.8	60.9	62.0	60.0	56.4
Solid content (%).	39.0	38.0	42.5	48.67	38.0	40.0	43.6

GINGER (ZINGIBER OFFICIANALE)			CYMBOPOGON CITRATUS (LEMON GRASS)		
1	2	3	1	2	3
100	100	100	100	100	100
800	600	600	100	100	100
1:8	1:6	1:6	1:1	1:1	1:1
3	4	3	3	3	3
0.3	0.4	0.4	0.6	0.8	0.7
400	260	235	60	65	55
84.5	87.0	86.2	25.2	33.33	29.05
0.36	0.46	0.46	2.38	2.40	2.41
15.8	13.2	14.1	74.8	66.67	70.95
84.2	86.8	85.9	25.2	33.33	29.05

Solvent Extraction

	GINGER (ZINGIBER OFFICIANALE)					
Expt. No.	1	2	3	4	5	6
Weight of Crushed Shrub or rhizomes (g).	30	40	50	30	30	30
Volume of Solvents (ml).	300 hexane	300 acetone	300 acetone	250 hexane	300 hexane	250 acetone
Mass of extract (g)	1.2	2.29	2.9	1.01	1.03	1.70
Weight of shrub or rhozome after extraction	25.98	34.7	43.7	26.1	26.1	25.8
Percentage Oleoresin content (wt/wt) %.	4.00	6.60	6.64	3.86	3.95	6.59
Moisture content (%)	13.4	13.2	12.6	13	13.21	14
Solid Content (%)	86.6	86.8	87.4	87.0	86.79	86.0

RED PEPPER (Piper nigrum)			
1	2	3	4
30	30	30	30
300 hexane	300 hexane	300 hexane	250 hexane
1.5	1.8	1.81	1.79
29.15	27.26	27.23	27.09
5.00	6.62	6.66	6.60
9.51	9.13	9.24	9.7
90.49	90.87	90.79	90.3

Annex 7

PROSPECTS FOR THE DEVELOPMENT OF ESSENTIAL OIL INDUSTRY IN NIGERIA

Nigeria is endowed with distinct geo-climatic regions, in which a large variety of essential oil bearing plants are grown. Variations in altitude and climatic make it possible to introduce exotic plants to the country.

Number of plants indigenous to Africa are collected and shipped to manufacturing facilities in developed countries. The value added to obtain pure active principles from plant is at least ten times the value of crude extracts and consequently, 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 reserves of developing countries.

At present no industry exists in the country to process aromatic and medicinal plants on an industrial scale to produce crude essential oils, let alone value added pure isolates and aroma chemicals. The entire needs of these chemicals in the country are met by imports. Some of these are:

Item	Demand MT	Local Supplies	
Essential oils	109	N.A.	insufficient local production
Eucalyptus oil	12.5	1.69	Insufficient local production
Citronella oil	1.5	Nil	No local production
Menthol	16	Nil	" "
Peppermint oil	49.6	Nil	" "
Aniseed oil	2	Nil	" "
Terpeneol	11,200 litres	Nil	" "
Thymol	2	Nil	" "
Lemon oil1	10	Nil	" "
Orange oil	0.24	Nil	" "
Capsicum oleoresin	0.40	Nil	" "
Caffeine	1.56	Nil	" "
Furfural	50	Nil	" "

Source:
Raw Materials revolution and impact on industrialisation in Nigeria.
by Dr (Mrs.) O. A. Aribisala, 1992[EX D. G. of RMRDC].

A large variety of medicinal and aromatic plants, including spices and cheap labour are abundantly available in the developing countries. Essential oil production is an agro-based industry and utilizes rural sector participation , in the collection, cultivation, harvesting of raw materials and exports in many of these countries. In some countries the income of a large number of peasants/farmers is by growing these plants as secondary crops and by participation in field distillation activities.

The National Institute for Pharmaceutical Research and Development (NIPRD), established in the year 1987, is the only one of its kind in the country, is endeavouring to harness this abundant national wealth.

Towards this goal, NIPRD has short and long range programmes to:

- 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 specimen
- introduction and adaptation of select plant materials, genetic manipulation /hybridisation/tissue culture, for higher, crop yield, oil content and quality of oils.

Medicinal and aromatic plants to be selected for industrial use would be based on world wide demand and whose oils command best international prices, would be cultivated and processed.

The following aromatic plants have potential for large scale cultivation for industrial exploitation:

1. Mentha arvensis (Japanese mint) for isolation of menthol, used in Pharmaceuticals, toothpaste, shaving creams, etc.
2. Mentha piperita for peppermint
3. Palmarosa (Cymbopogan martini). The oil is a source of high-grade geraniol. There is a good demand for geraniol in the manufacture of high-quality perfumes.
4. Lemon grass (Cymbopogan flexuosus). Oil is used in soap perfumes, as a source of citral, a chemical used in perfumery, flavour industry and as a raw material in the synthesis of vit.A.
5. Java citronella (Cymbopogan winterianus) Oil is used in perfumery and cosmetic industries, also, a source of aroma chemicals such as citronella, hydroxy citronellol, geraniol.
6. Eucalyptus citriodora. The oil is used for isolation of citronellol, an important perfumery chemical.
7. Basil (Oscimum basilicum)Oil is used in perfumery industry.
8. Geranium (Pelargonium graveolens)Oil is used in high grade perfumes and as a source of rhodinol.
9 Coriander sativum (Bulgarian coriander) Oil is used in the food flavouring industry

Production of some essential oils in the developing countries:

Essential Oil	Country	Annual Production (1990) Tonnes
Lemon grass oil	India	800
	Sri Lanka	5
Palmarosa oil	India	60
Eucalyptus citriodora oil	India	25
Eucalyptus globulus oil	India	50
Geranium oil	Egypt	50
	India	10
Patchouli oil	Indonesia	500
Vetiver Oil	Indonesia	85
	India	10

NIPRD with UNIDO sponsored pilot plants is striving towards development of simple technologies for the distillation of aromatic plants, and has plans 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, harvesting and in distillation.

Establishment of field distillation stills near natural habitat/plantations, 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 stations could thus develop into a national network of aromatic plantation and distillation units in the suitable agro-ecological zones of the country, and lead to large scale production of essential oil.

The existing, centrally created pilot plant facilities at the premises of NIPRD, Abuja to be appropriately re-enforced with fractionation columns, reactors, storage tanks etc for secondary processing of essential oils for the development of appropriate technologies to produce value added products like terpeneless essential oils, pure isolates or enriched components, aroma chemicals, to stringent internationally marketed quality standards.

The workshop on Essential oil Industry (organised jointly by UNIDO, Government of India, ESCAP, November - December 1981, Lucknow, India, Page 38 recommended among others, "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, cosmetic and flavour chemicals, utilizing citronella oil, lemongrass oil, palmarosa 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".

NIPRD with its extensive existing scientific infrastructure and UNDP/UNIDO sponsored pilot plants with qualified and experienced scientific manpower has been carrying out research on a number of indigenous medicinal and aromatic plants. Some of which have yielded new drugs, viz: NIPRISAN, NIPRIFAN, NIPRIDAN and NIPRIPAN, are the drugs which are undergoing clinical trials for sickle cell anaemia, fungal infections, diabetes and peptic cell ulcer respectively. The Institute has arrived at the threshold of a very challenging field of technology development and transfer on turn-key basis. Towards this goal, it intends to set up chemical engineering and design section, this when established would conduct in-depth evaluation of processes/operations developed in the Institute at the bench scale level, assist in the scaling-up of selected processes at the pilot plant level.

Extend the capability to fabricate the chemical plant and equipment using the installed facilities at ARCEDAM, Ibadan, FIIRO, Lagos. Intense process investigations at the pilot plant level is expected to generate:

- Technology to produce the product to reproducible quality and quantity.
- Technical feasibility and economical viability of the process know-how.
- Assess to user industries acceptability of the product in their production lines.
- Technical data necessary to scale-up the pilot plant operations (technology transfer).
- Train engineers and scientists,who could man industrial operations in the future.

NIPRD with built-in scientific and technological infrastructure, would be able to undertake applied research and successfully develop, demonstrate and transfer technologies in the industrial utilisation of aromatic plants for the production of essential oils, and value added aroma chemicals, to a number of entrepreneurs, and is expected:

- to generate technically feasible and economically viable technology.
- to provide R & D facilities for use by the industry to offer analytical instruments by testing quality control by industry.

Annex-8

Paper submitted to the 'National consultative workshop on equipment maintenance rehabilitation manufacture and technology development in Nigeria, Abuja 18-19 September, 1996. Under heading demands and problems encountered by the institution/agency including resources constraints, engineering constraints, technology capability constraints, in equipment maintenance/rehabilitation and in technology innovation/services.

NIPRD - SOME PERSPECTIVES AND CONSTRAINTS

ABSTRACT

Nigeria is a habitat for a large variety of medicinal and aromatic plants. No industry exists in the country to extract crude drugs/essential oils from these. NIPRD established in 1987, the only Institute of its kind in the country, is pursuing to harness this national wealth. It has to its credit the discovery of some new drugs, notably NIPRISAN to combat "sickle cell", NIFRIFAN an antifungal cream, NIPRIDAN anaemia for control of diabetes. Its existing scientific infrastructure is being augmented and an UNDP/UNIDO sponsored modern pilot plant is being set up. NIPRD is poised to enter a challenging area of technology development and transfer on turn-key basis, including design and fabrication of process plant and equipment, diagnostic studies and rehabilitation of sick chemical industries, repair and maintenance of sophisticated quality control instruments, pilot plants and other laboratory equipment.It has the potential to develop into a centre of excellence in the areas enumerated above. The main constraint in achieving these goals is the financial inputs.It is a known fact that in some of the developing countries investment in R & D is as much as 1% to 5% of GDP, in the sound belief that investment today in R & D is for a better tomorrow (for the nation and its people). NIPRD has the necessary built - in infrastructure, competence, and international contacts to shoulder the responsibility in its successful implementation.

Nigeria is endowed with distinct geoclimatic regions in which a large variety of medicinal and aromatic plants are grown and can be cultivated. The National Institute for Pharmaceutical Research and Development(NIPRD) established in 1987 is endeavouring to harness this abundant national wealth.

This Institute being the only one of its kind in the country, has well equipped laboratories which are manned by qualified and experienced scientists. Research is being conducted on medicinal/aromatic plants, traditional medicines, medicinal chemistry, pharmacology/toxicology, Pharmaceutical technology and drug production, micro-biology, biotechnology and keeping an animal house. It also undertake an extensive agronomical survey, research on tissue culture and maintains plant nursery. The Institute has in place an ultra modern quality control instrument section.

NIPRD has carried out research on a number of indigenous medicinal and aromatic plants, some of which have yielded new drugs, viz., NIPRISAN , NIPRIFAN, NIPRIDAN, AND NIPRIPAN are drugs, already undergoing clinical trials for sickle cell anaemia, fungal infections diabetes, and peptic ulcer respectively.

Presently, available infra-structures are being augmented with the expanded five storey new laboratory, expected to be completed by the end of this year, and UNDP/UNIDO sponsored, modern multi-purpose pilot plant for the extraction of medicinal plants and distillation of essential oils.

In Nigeria today, no industry exists to process plant materials to produce crude drugs/crude essential oils, let alone value added products like, pure isolates and aroma chemicals. This then necessitate the importation of these chemicals into the country. It has been stated that a "number of plants indigenous to Africa are collected and shipped to the manufacturing facilities in the developed 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 of scarce foreign exchange resources of developing countries".

The workshop on essential oils (organised jointly by UNIDO, ESCAP and the Government of India at Lucknow, India, November/December, 1981) recommended among others:

"There is no reason why every producer country (medicinal and aromatic plants) should not strive to export natural perfumes, 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 satisfy the most stringent quality requirements. There is now justification for many of the developing countries in terms of research and development for production of perfumes, cosmetics and flavouring compounds from natural sources".

A number of developing countries viz., India, China, and Sri Lanka have created strong industrial bases in their respective countries to produce and export these chemicals.

There is a need in the country for the establishment of a chain of field distillation units near the plantations/natural habitat (Zones), this will go a long way in reducing the cost of transportation of a large bulk of green herbs, wilting, fermentation and consequent deterioration in the quality of distilled oils. These zones could form a network of aromatic plantations and distillation units in the country. The crude essential oils and drugs when produced at these zones can be refined at the Institute to produce value added products like terpeneless essential oils, aroma chemicals, and drugs of international quality and export or create internal market. If fully utilized, this could serve as the nucleus for the development of indigenous industries for the production of drugs, spice extracts, essential oils and aroma chemicals.

The cost of essential oil distillation plants vary widely, depending on the capacity, material of construction and the country of its origin. For instance, a distillation plant of the capacity of one tonne of green herb per batch, made of stainless steel, an appropriate boiler added to it, costs about $100,000 to $150,000 in France. Also stills as large as $5m^3$ to $10m^3$ are used for the distillation of mentha-arvensis, lemongrass, eucalyptus citriodora, java citronella, etc.

There is an urgent need for a country like Nigeria to build the infrastructure to design simple but appropriate plant and equipment based on optimisation studies in the laboratory/pilot plant. Design and fabrication of such units indigenously would save not only time and money but also valuable scarce foreign exchange . It is worthwhile to note that first grade engineering infrastructure is available at ARCEDAM Ibadan and FIIRO, Lagos, for the fabrication of chemical plant and equipment.

NIPRD with its extensive existing scientific infrastructure and UNDP/UNIDO sponsored pilot plants, with qualified and experienced scientific manpower, has arrived at the threshold of a very challenging field of technology development and transfer on turn-key basis. Toward this goal, it intent to set-up, design and engineering section, within the Institute, this section when established would conduct in-depth evaluation of processes/operations developed at the laboratory level, assist in the scaling-up of select processes in the pilot plant vis-a-vis, the product samples for market acceptance and reaction and the collection of technical data necessary for the design and fabrication of proving and or commercial plants.

The main constraint facing NIPRD is the financial inputs. The monetary requirements are needed to augment laboratory research facilities, create engineering infra-structure for maintenance of sophisticated quality control instruments, design of chemical plant equipment and fabrication, technology development and transfer, to undertake diagnostic studies of sick chemical industries and rehabilitation.

Problems/Constraints.

NIPRD presently lacks the following services:

i) A glass-blowing section to repair glass apparatus and to undertake, the fabrication of simple laboratory apparatus.
ii) Repair and maintenance of process/quality control instruments.
iii) Engineering workshop for the repair/maintenance of pilot plant and other services of the Institute.
iv) Design and engineering section for technology development and transfer on turn-key basis. Diagnostic studies of sick industries (chemical) and rehabilitation.
v) A library exists but needs urgent augmentation of books and journals.

There is an urgent need to build basic infrastructure needed to overcome the above constraints, given necessary financial supports, NIPRD is confident and competent to build the needed engineering infra-structure by:

- the recruitment of national engineers, scientists, technicians and selectively train them abroad.
- invite foreign experts to train the institute's scientists and engineers in specific areas.
- seek UNDP/UNIDO assistance (where necessary)
- set up an engineering workshop
- a glass blowing workshop
- an instrument maintenance section
- a design and engineering section
- acquisition of raw materials for fabrication of plant and equipment, such as, stainless steel (sheets ,pipes, valves, gauges, welding electrodes, industrial gases etc). Mild steel (sheets & pipe), steam traps, glass wool etc.)

Collaboration/linkage with the following organisations is envisaged.

a) Raw Material Research and Development Council (RMRDC0
b) Petroleum Trust Fund (PTF)
c) Federal Institute for Industrial Research (FIIRO)
d) African Regional Centre for Engineering Design and Manufacture (ARCEDAM)

Annex -9

A NOTE ON NIPRD - INDUSTRIES LINKAGES

NIPRD can generate internal resources by undertaking consultancy services:

- technology development and transfer (technically feasible and economically viable technologies in the utilization of aromatic and medicinal plants).
- to provide R & D facilities for use by the industry
- to offer analytical instruments for testing, quality control by the industry.
- to provide consultancy and advisory services
- to act as centre for training and development of scientific and technical manpower
- by undertaking diagnostic studies of "sick" industries
- by rehabilitation of "sick" (technical sickness only) industry.

After establishing credibility and competence of the Institute, industrial entrepreneurs are expected to come forward to sponsor, co-sponsor the R&D efforts to generate know-how, diversify the production line, or production of new generation products.

The terms and conditions of sponsoring differs from entrepreneur to entrepreneur and the nature of developmental work. The sponsor usually meets the cost of developing the know-how, diversification, new product and training of scientific and technical personnel, under stipulated condition that, the sponsor has exclusive rights for the industrial exploitation of the results and data for a specified period of time and pay a mutually agreed percentage of royalty on the turnover for the duration of the period, and or lump-sum payment. Thereafter, the research organisation is free to offer to other entrepreneurs and collect the premium and royalty.

The pilot plant and other infrastructure facilities existing within the laboratory are made use of for the purpose.

In case the know-how is also released to the third party within the stipulated period with the approval of sponsor, a lump-sum premium based on financial inputs for generating know-how and 2-3% royalty on the annual turnover is charged. The sum total thus collected from the third party is shared (proportionally) by the research organisation and the sponsoring authority.

Annex-10

A NOTE ON SAFETY ASPECTS OF SOLVENT EXTRACTION PLANTS

Normal hexane is generally used in the extraction operations at all the stages of process/product development viz., bench scale, pilot plant and commercial plant, since it has properties most suitable for extraction purposes. However, the high inflammability of n-hexane makes it necessary that the design and operation of solvent extraction plants should aim at elimination of fire hazard.

Inflammability indicates the rate at which a material undergoes combustion. Combustion is a chemical reaction by which the oxygen combines with the elements of the combustible materials forming mostly carbon-dioxide. The reaction is highly exothermic and in the case of highly inflammable materials the heat of combustion is very high, so much so, that once the reaction is set in by application of external heat, the heat of combustion itself will provide enough heat for further ignition and the heat of reaction is released as fire. The heat of combustion of n-hexane is 21,000 Btu/lb., and the reaction start at an ignition temperature of 260°C.

Hence for a solvent to catch fire, two conditions are to be simultaneously fulfilled. These are:

- there should be a correct amount of air.
- there should be enough heat to bring the temperature to 260°C to start the combustion reaction.

Absence of any one of these conditions renders the solvent extraction safe. The design of extraction plants should aim at the elimination of both of these conditions required for starting the combustion of the solvent to ensure perfect safety.

The mixture of air and hexane may not always be flammable unless proportionate amount of oxygen and hexane vapour is present in the mixture. The flammable limits for n-hexane is 1.2% by volume minimum and 6.9% by volume maximum in air, in other words any mixture containing less than 1.2% and more than 6.9% hexane is considered safe.

The sources of ignition in an extraction plant can be of two types.

- mechanical.
- electrical.

In the extraction plant area metal to metal impact should be avoided.

All the electrical equipment such as starters, cables, light fittings, motors, etc., required in the extraction plant are necessarily to be flame proof type equipment, where any spark occurring is confined inside a perfectly air tight casing, so that it is impossible for the spark to come into contact with the outside atmosphere.

An electrical spark can be set off, due to static electricity generated in the equipment, due to friction between various parts of the extraction plant. To avoid such a contingency it is necessary to ensure the electrical continuity between any two points in an extraction plant and earth the entire plant, so that statically generated electricity is transferred to the earth as and when produced. The lightning arresters grounded to the earth are also installed at suitable points so that in case of lightning in the solvent extraction area, it is immediately grounded.

All heating operations in the extraction plant are carried out by steam heating only to ensure that the temperature in the plant at any point does not reach the ignition temperature of 260°C. Temperature of steam a pressure of 150 p.s.i.g is only 185°C.

Under abnormal conditions, solvent can find its way out of the equipment and is likely to create a hazardous situation. To avoid such abnormal conditions the following general safety design features are to be incorporated.

Solvent vapours from distillation as well as desolventisation sections are led to a system of condensers and then the uncondensed gases are led through a "breather" or an oil absorber or through a chilled condenser, a cold trap and then vented into the atmosphere. Under normal operation conditions the gases vented out contains traces of solvent vapours much below the flammable limits. But in the case of failure or inadequacy of cooling water in the condensing system the gas will consist mainly of solvent vapours, hexane vapour being three times heavier than air would settle in the extraction area creating a very hazardous atmosphere. It therefore becomes necessary that the person in charge of the plant must be alerted in advance of such a situation occurring so that he can take immediate preventive action. For this purpose a vent thermostat is installed in the vent line. The function of this thermostat is to actuate an electrical contact as soon as the temperature of the vent reaches $45^{0}C$, an alarm is set off thus warning of the impending danger. For further precaution, this electrical contact is installed in sequence with an electrically operated steam value installed in the main steamline. As soon as this contact is activated the main steam valve is automatically closed, thus cutting off the supply of steam, so that no further evaporation of solvent occurs in the extraction plant.

In case of power failure, the main steam valve is automatically shut off thus cutting off the steam supply.

Live steam is used for final stripping of the oil and this is condensed along with the solvent vapours and is separated from the solvent in a separator.

The vent of exhaust gases of the extraction plant must be located at a minimum height of 7 meters, so that traces of solvent vapour present in the gas gets diluted with atmospheric air below the flammable limits and does not settle down near the floor.

Solvent extraction plant area should be well ventilated so that concentration of vapours due to any leaks in the equipment does not take place.

Annex-11

Oleoresin Ginger is the product obtained by solvent extraction of the dried rhizomes of Zingiber officinalis L. Roscoe (Family Zingiberaceae), with the subsequent removal of the solvent.

The ginger extractives are the sum of the non-volatile ether extract and the volatile oil content.

SPECIFICATIONS

Other General Names	Oleoresin Ginger Jamaica. Oleoresin Ginger African. Oleoresin Ginger Cochin.
Botanical Nomenclature	Zingiber officinalis L. Roscoe (Family Zingiberaceae).
Preparation	Obtained by solvent extraction of the dried rhizomes of ginger with the subsequent removal of the solvent.
Physical and Chemical Constants	**Appearance and Odor:** A dark brown viscous to highly viscous liquid with the characteristic odor and flavor of ginger. **Volatile Oil Content:** 18-35 ml/100 gms. **Method:** Proceed as directed for the determination of Volatile Oil (See E.O.A. Determinations No. 1WG using 25 gm. sample accurately weighed and report as ml per 100 gms. of oleoresin. **Optical Rotation of Oil:** −30° to −60°. **Refractive Index of Oil at 20°C:** 1.4880 to 1.[illegible]70. **Residual Solvent in Oleoresin:** Meets with Federal Food, Drug and Cosmetic Act regulations. Method: Proceed as directed for determination of residual solvent in oleoresins. (See EOA determination No. 1-1D-3-1).
Descriptive Characteristics	**Solubility:** Alcohol: Soluble with sediment. Benzyl Benzoate: Soluble in all proportions. Fixed Oils: Slightly soluble in most fixed oils. Glycerine: Insoluble. Mineral Oil: Insoluble. Proplyene Glycol: Insoluble.
Containers	Ship in glass or suitably lined containers.
Storage	Store preferably in tight full containers in a cool place protected from light.

Oil Ginger is a volatile oil with the aromatic and persistent odor of ginger, but lacking the pungency or "bite" usually associated with ginger. It is widely used as a flavor in soft drinks, bakers' products and in candies. The dried rhizoms, from which the oil is made, derives its name from the country or locality of its origin, e.g. Jamaica, from the West Indies; Africa, from the west coast of Africa, and both Cochin and Calicut from southern India. The African and Cochin are the types most frequently used for distillation.

SPECIFICATIONS

Botanical Nomenclature

Zingiber officianale, Roscoe.

Family Zingiberaceæ.

Preparation

By direct steam distillation of the dried course ground rhizome.

Physical and Chemical Constants

Color and appearance—Light yellow to yellow.

Specific Gravity at 25° / 25°C.: 0.871 to 0.882

Temp. Correction factor from n° / n°C.: 0.00058 per °C.

Optical Rotation — 28° to — 45°

Refractive Index @ 20°C 1.4880 to 1.4940

Saponification Number—Not more than 20.

Proceed as directed for the determination of esters (see Determinations E.O.A. No. 1A), using 5 grams of Oil of Ginger, accurately weighed. Calculate as follows: $\frac{A \times 28.05}{B}$ = Saponification No.

A is the result obtained by subtracting the number of cc of half normal hydrochloric acid required in the titration from the number of cc of half normal alcoholic potassium hydroxide originally taken.

B is the weight in grams of the oil taken.

Descriptive Characteristics

Stability:

Alkali:	Relatively stable to weak alkali. Unstable in the presence of strong alkali.
Acids:	Unstable in the presence of strong acids.

Solubility:

Alcohol:	Soluble, usually with turbidity.
Benzyl Benzoate:	Soluble in all proportions.
Diethyl Phthalate:	Soluble in all proportions.
Fixed Oils:	Soluble in most fixed oils.
Glycerin:	Practically insoluble.
Mineral Oil:	Usually soluble in all proportions.
Propylene Glycol:	Practically insoluble.

Containers

Should be shipped in glass, tin-lined or aluminum containers.

Storage

Store preferably in tight, full containers in a cool place protected from light.

Annex-13

Oleoresin Capsicum (African Chillies) is the product obtained by solvent extraction of the dried ripe fruit of Capsicum frutesens L., or Capsicum annum L. var conoides Irish., with the subsequent removal of the solvent.

SPECIFICATIONS

Botanical Nomenclature	Capsicum frutescens, or Capsicum annum L. var conoides Irish.
Physical and Chemical Constants . .	**Appearance and Odor:** A clear red, light amber or dark red somewhat viscid liquid with characteristic odor and very high bite. **Scoville Heat Uits:** 480,000 minimum **Method for Determination of Scoville Heat Uits.** I. 0.2 gm of the oleoresin is weighed into a 50 ml volumetric flask. 95% alcohol is addel to volume, the material shaken and allowed to settle. II. **N.F. Solution** A solution of 22 ml sugar syrup is diluted to 140 ml with water and 0.15 ml of alcoholic solution I is added. After thorough shaking, 5 ml of this solution is swallowed. A bite or stinging sensation in the throat which is just perceptible at this dilution is equal to 240,000 Scoville Units. **Note:** If bite is very strong, a further dilution is necessary as follows: III. A sugar solution is prepared as follows: 22 ml sugar syrup diluted to 140 ml with water. The following dilutions are equal to the corresponding Scoville Heat Units when 5 ml swallowed cause a perceptible pungent sensation. a) 15 ml of sugar solution 30 ml N. F. Solution II = 360,000 b) 20 ml of sugar solution 20 ml N. F. Solution II = 480,000 c) 30 ml of sugar solution 15 ml N. F. Solution II = 720,000 A panel of five members is used, three out of five must find the solution to be pungent. **Color Value:** 4,000 maximum **Method:** See Determination of Color Value as outlined under OLEORESIN PAPRIKA. **Residual Solvents in Oleoresin:** Meets with Federal Food, Drug and Cosmetic Act regulations. **Method:** Proceed as directed for determination of residual solvent in oleoresins. (See EOA determination No. 1-1D-3-1).
Descriptive Characteristics	**Solubility:** Alcohol: Partly soluble with oily separtion and or sediment. Benzyl Benzoate: Soluble in all proportions. Fixed Oils: Soluble in all proportions in most fixed oils. Glycerine: Insoluble. Mineral Oil: Insoluble. Propylene Glycol: Insoluble.
Storage	Ship in glass or suitably lined containers.
Containers	Store prfeerably in tight full containers in a cool place protected from light.

Annex-14

Oleoresin Red Pepper is the product obtained by solvent extraction of the dried fruit of Capsicum annum L. var longum Sendt. or the hybrid pepper known as the Louisiana Sport, with the subsequent removal of the solvent.

SPECIFICATIONS

Botanical Nomenclature	Capsicum annum L. var longum Sendt or Louisiana Sport.
Physical and Chemical Constants . .	**Appearance and Odor:** A deep red liquid with characteristic odor and high bite.
	Scoville Heat Units: 240,000 minimum.
	Method: See Method of Determination of Scoville Heat Units under OLEORESIN CAPSICUM.
	Color Value: 20,000 maximum.
	Method: See Determination of Color Value as outlined under OLEORESIN PAPRIKA.
	Residual Solvents in Oleoresin: Meet with Federal Food, Drug and Cosmetic Act regulations:
	Method: Proceed as directed for determination of residual solvent in oleoresins. (See EOA determination No. 1-1D-3-11).
Descriptive Characteristics	**Solubility:** Alcohol: Partly soluble with oily separation and or sediment. Benzyl Benzoate: Soluble in all proportions. Fixed Oils: Soluble in all proportions in most fixed oils. Glycerine: Insoluble. Mineral Oil: Insoluble. Propylene Glycol: Insoluble.
Containers	Ship in glass or suitably lined containers.
Storage	Store preferably in tight full containers in a cool place protected from light.