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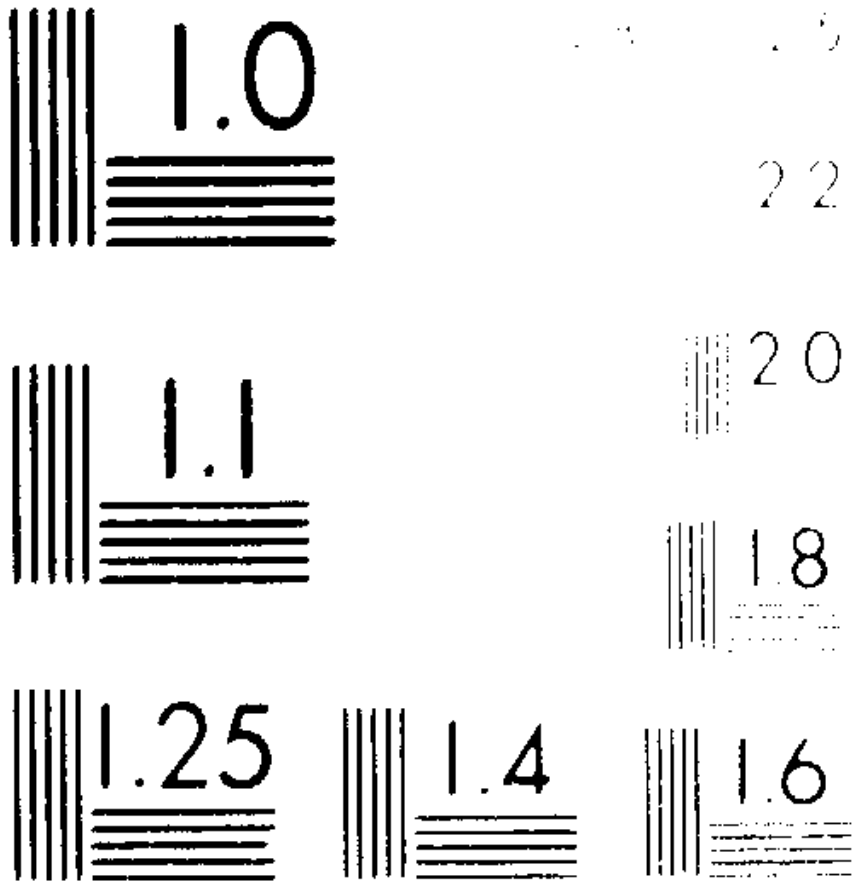
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ASSISTANCE TO

TANZANIA INDUSTRIAL RESEARCH AND DEVELOPMENT ORGANIZATION

(TIRDO)

Tanzania: REPORT ON

DEVELOPMENT OF TIRDO ACTIVITY

IN CHEMICAL AND ALLIED INDUSTRIES IMPORVEMENT

(DP/URT/78/019/11-51/31.3.J Rev.)

Prepared for

the Government of the United Republic of Tanzania

by

the United Nations Industrial Development Organization,

executing Agency for the United Nations Development Programme

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UNIDO-EXPERT IN CHEMICAL INDUSTRIES IMPROVEMENT

JULY 10, 1982

This report has not been cleared with the United Nations Industrial Development Organization which does not, therefore, necessarily share the views presented.

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ABBREVIATIONS

UNIDO	-	United Nations Industrial Development Organization
TIRDO	-	Tanzania Industrial Research and Development Organization
TISCO	-	Tanzania Industrial Studies and Consulting Organization
IPI	-	Institute of Production Innovation
STAMICO	-	State Mining Corporation
TSh.	-	Tanzanian Shilling (9.3 TSh = US $1.00)

1. SUMMARY

The expert carried out his assignment basically in line with his duties as described in the job description, supplemented during the briefing. During the mission, the expert has made efforts to identify some of the products and processes for small and medium scale production, as well as to identify some by-products that could be processed into semi-products required by small and medium-scale industry in Tanzania. Based on the visits to fourteen local factories and organizations, the findings and recommendations contained in this report, have been prepared.

As a result of his mission, the expert suggests the following projects be carried out by the Chemical and Food Department of TIRDO.

a) Near Term Projects:

- Small-Scale Essential Oils Manufacturing
- Non-Edible Oils Manufacturing
- Recovery of Mineral Salts from Bittern

b) Longer Term Projects:

- Small-Scale Sodium Hydroxide Production
- Recovery of Glycerine
- Organic Solvent Recovery
- Study on Utilization of Rice Husks for High Quality Sodium Silicate Manufacturing*
- Study on Local Production of Basic Resins*

The above list together with on-going projects can make a work plan for Chemical and Food Department of TIRDO. The relations between TIRDO and local chemical and allied industries ought to be developed based on the partnership of both sides. In order to achieve this target, local industries have to be convinced of the value of technical advice, technologies and equipment proposed to them by TIRDO personnel. Similarly, TIRDO's research officers themselves ought to be convinced about the usefulness of their work done for local chemical & allied industries. In the opinion of the expert, the projects listed above have the possibility of being entirely and satisfactory solved by TIRDO officers and to result in implementation and commercialization. The number of projects conducted

* previously proposed

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simultaneously should be very limited so that prompt and useful outputs result from the TIRDO efforts. By this "from identification to commercialization" method, confidence of local industry in work done by TIRDO can be achieved. Experience gained by TIRDO officers after implementation of near term projects could be utilized during conduct of longer term, more sophisticated industry-oriented research projects.

It is suggested that the Chemical Department of TIRDO should be assisted by a UNIDO Consultant during performance of the projects mentioned above either on a return-mission or on permanent basis.

2. INTRODUCTION

The expert arrived in Tanzania on the 18th June 1982 for a one month mission based on the Job Description DP/URT/78/019/11-51/31.3.J/ Rev. (Annex 1). The specific targets of the mission were:

- Review existing data on Tanzania chemical imports and on local materials and resources for chemical production or processing;
- Identify those products and processes with greatest potential for small to medium-scale manufacture;
- Identify existing industries which could be made more efficient either by -
  a) increasing the utilization of their capacity,
  b) diversification of their production programme, or
  c) improvement of quality and productivity;
- Assist in the outline of TIRDO activities and programmes to fulfill some or all of these research and study objectives.

Additionally, during the briefing in Vienna, Mr. F.J. Soede UNIDO Senior Industrial Development Officer, stressed the need of preliminary work plan preparation designed for the Chemical and Food Technology Department of TIRDO based upon the in-depth survey of the present and future requirements of some local small and medium-scale chemical industries.

The expert was obliged to prepare the final report of the mission with the findings and recommendations for the Government on further actions. It should be stressed that the duration of the mission was very short given that the period included also the briefing and debriefing in Vienna, travel to and from duty station and preparation of the report.

A proposed plan of visits in local factories and organizations was prepared by Mr. C.A. Stone, Project Chief Technical Adviser, which was supplemented and extended during the mission. The expert was accompanied during the visits by his TIRDO counterparts, Dr. P.K. Haule, Principal Research Officer and Mr. G. Njau, Research Officer. A UNIDO report[1] was reviewed to have insight into recent data on Tanzania chemical

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production, import and export, as well as on local natural resources and materials for chemical production and processing. Also proposed investment projects in local chemical & allied industries were studied[1,2, although the assumed time of their implementation will be surely postponed in the light of statements[4 made to the National Assembly on June 18, 1982 by the Minister of State for Planning and Economic Affairs Prof. K.A. Malima. According to this statement more than 200 proposed and on-going projects will be shelved or suspended in the 1982/83 financial year because of reduced development expenditure. The expert also studied reports of other UNIDO mission to TIRDO[5,6,7 for insight into suggestions about TIRDO's development.

3. FINDINGS

3.1. Background Information

The industrial plan targets in the Union Five Year Development Plan 1981/82 - 1985/86 have been accentuated by Hon. B.P. Mramba, M.P., Minister for Industries in the Budget Session of the National Assembly for the 1981/82 period, as quoted in Reference 1:

a) To increase efficiency and capacity of existing industries.

b) To establish a system which would promote and harmonize the development of small and big scale industries to make them inter-dependent.

c) To prepare the industries to start utilizing locally available raw materials, inputs and spares.

d) To improve industrial technological infrastructure so as to reduce problems affecting industries.

e) To strengthen and expand production capacity for export market.

Furthermore, in implementing the Five-Year Plan, first priority for industry is to be placed, it was noted in the budget speech, on the following areas considering the capability and requirements of the country:

a) Industries that cater for basic needs of the majority of the population,

b) Industries that sustain agricultural and rural development,

c) Industries that cater for construction, water and electricity sectors,

d) Industries that support transport and communication,

e) Industries that contribute to foreign exchange earning.

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Fulfilling the above directive lines, TIRDO in its scope of activity is to perform the following functions:[8]

- to carry out, and promote the carrying out of applied research designed to facilitate the evaluation, development and use of local materials in industrial processes;
- to provide to the Government, and to firms or organizations engaged in industrial production and technical and advisory services, advice and guidance on technical matters, necessary for the furtherance of, or relating to, industrial activity;
- to advise the Government and firms or organizations engaged in industrial production, on the adaptation of technology in industrial production;
- provide to industrial enterprises technical services connected with the design of prototype industrial plants, machinery and equipment for manufacture or use in Tanzania.

Current and potential projects for the Chemical and Engineering Departments of TIRDO have been outlined in a paper prepared by C.A. Stone, UNIDO Chief Technical Adviser.[9] They are as follows:

- Direct Reduction of Tanzanian Iron Ore;
- Pyrolysis of Agro-Industrial Wastes;
- Local Extraction of Dyestuff;

Potential industrial projects specified in the above document, are as follows:

- Technical assistance to the Ubungo Farm Implements, manufactures a variety of farm machinery and tools;
- Technical assistance to the Arusha Metal Industry Ltd., manufacturers brass water valve assemblies and water taps;
- Technical assistance to local factories regards energy conservation and reduction of furnace oil consumption;

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- Study on utilization of rice husks, (which is silica containing waste material) and local sodium carbonate deposits, for manufacturing of high quality sodium silicate.
- Study on local basic resins production based on local agricultural by-products i.e. cashewnut shell liquid (oil) and coffee husks (furfural);
- Others: redistillation of industrial solvents, recycling of used engine and industrial oils, design of shoe soles from sisal or coir fibres with rubber or resin binders, manufacture of cigarette filters from local fibres, anodizing of aluminium products and metal corrosion protection.

The task stressed in this paper is to develop TIRDO as an organization with close industrial links and a pragmatic view of industrial economic development.

3.2. VISITS

The main objective of visits in factories and organizations was to enable Mr. M. Nowak, UNIDO Expert, to obtain insight into chemical and allied industries activity in Tanzania and to enable him to make recommendations for the development of the Chemical Department of TIRDO. The expert and his counterparts visited altogether 14 factories and organizations in Dar es Salaam. The factories were selected on the basis of proposals prepared by Mr. C.A. Stone, UNIDO Chief Technical Adviser and C.L. Tarimu, Director General of TIRDO, to identify small-and medium-scale chemical technologies requiring technologies improvements, utilization of local raw-materials and by-products processing, which might be assisted by TIRDO Chemical Department personnel.

DAWA YA MBU, is producing mosquito coils based on the following raw-materials:

pyrethrum - locally obtained,
starch - at present imported under name "Uni-Gel" from W. Germany in quantity of 100 tonnes/year.

coconut powder - locally obtained

colouring agent - at present imported from U.K.
Imported starch which is soluble in cold water can be replaced by local cassava flour but the latter needs to be boiled before being used in the process. According to Mr. J. Mwakipesile, General Manager, some tests with local cassava flour were made last year with success, but because of the easier solubility of imported starch the latter is used. As relates to the colouring agent which is imported from UK, the General Manager stated that some tests were made last year with locally produced natural dye stuff but without success.

Annual capacity of the plant is about 43 million coils/year. The plant is working with full capacity which meets 40% of local demand. It is the intention of the General Manager to increase present production more than twice requiring new and more efficient machines. There is another competitive factory i.e., "East African Flower Industries"

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in Moshi, producing also mosquito coils which are scented giving a better smell when used.

Because of the above product competition, the UNIDO Expert was asked to advise on methods for adding scent to "Dawa Ya Mbu" mosquito coils. He advised the use of locally grown essential oil bearing raw materials e.g. lemongrass, orange (peels), cedar (wood saw-dust), eucalyptus (leaves), etc. Such essential oil bearing plants after solar drying and powdering can be added to the mixer which combines ingredients at the beginning of the process. Drying of mosquito coils is done at about 50 to 60°C and would not cause significant losses of essential oil. It is expected that, during mosquito coil burning, distillation of essential oil will take place releasing the scent. As an alternative to this, utilization of liquid essential oil based on the above local materials and a small-scale distillation set (see Annex 2) was suggested. Some tests are required to choose the best local, essential oil bearing raw material and the form of essential oil (dried powdered plant material or liquid essential oil) to be utilised.

BOBBY SOAP FACTORY LTD. is producing laundry bar soap at present. The following raw materials are used:

- animal fat imported from W. Germany, Holland and Singapore;
- coconut oil, imported as well as locally obtained;
- caustic soda, imported from W. Germany;
- sodium silicate, locally obtained (KIOO Ltd.);
- perfumes, imported from Holland (trade name "citronella perfume").
- colouring agents imported.

The factory has a soap capacity of 48 tonnes/day (3 shifts), i.e. about 15,000 tonnes of soap per annum. The factory works at present with 33% capacity (1 shift) because of lack of imported raw-materials. In spite of this, there is a plan to restart toilet soap production by December, 1982. According to the Production Manager Mr. M.F. Virani, imported animal fat can be replaced by vegetable oil, edible or non-edible. For example; castor oil, coconut oil, cashew nut shell oil etc, locally produced. The firm would be interested in the purchase of such oil rather than in producing it. The only condition is a price comparable to that of imported fat. At present,

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according to the Production Manager, the price including tax of local coconut oil is 55,000 TSh/ton while imported animal fat price is only 6,000/- TSh/ton which force them to use imported fat.

They spend 1.6 million TSh/year for importation of 3,200 Kg/year of perfumes. The price paid by the firm for perfumes is 500/- TSh/Kg (tax included). According to the Production Manager it is quite possible to replace imported essential oils by locally produced essential oils, for example: lemongrass oil, orange oil, or mixture of them. The only condition is that the price ought to be competitive to the import price above. Glycerine which is by-product during soap-production is not processed and apparently is not properly utilised by local soap factories.

H. STANLEY & SONS LTD., is producing common salt (sodium chloride) from sea water by solar evaporation. Present capacity and production is 10,000 tonnes/year. Mr. E.M. Stanley, Managing Director, informed the expert and his counterparts of intentions to establish salt production by the vacuum evaporation method with 30,000 tonnes/year capacity of high quality sodium chloride. Present solar evaporation methods depend upon precipitation of salts from sea water in the following order:

$CaSO_4$	19° - 20° Be'
NaCl	25° - 29° Be'
$MgSO_4$	30° Be'
KCl	above 30° Be'

where Be' is a measure of solution salt concentration. Precipitated $CaSO_4$ and solution of $MgSO_4$ and KCL are treated as a by-prodcts (bittern) at present.

The Managing Director expressed interest in the production of potassium chloride and magnesium sulphate from the bittern. The only problem is to estimate the demand of agriculture and industry for these products and the quality requirements as fertilizers and/or chemical compounds for further processing. According to the Managing Director there are not any technical problems in undertaking such production. Analysis of sea-water used by the firm as well as a sample of the bittern for analysis, was promised by the Managing Director but not yet submitted to TIRDO.

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TANZANIA CHEMICAL INDUSTRIES LTD., is a factory producing sodium hydroxide, chlorine and hydrogen by electrolysis of sodium chloride solution. Electrolysis is based on three mercury cells. Capacity of existing plant is 1 ton NaOH/day i.e., 350 tonnes NaOH/year. At present the factory is working at 40% capacity because of frequent breaks in the energy supply and lack of imported spare-parts. Some spare-parts are made by Mr. S. Cretella himself, who is the Owner & Director of the plant. Funds needed to purchase materials for spare parts were estimated as about 6,000 TSh/y. Final products manufactured from the above semi-products are shown in the following table:

Table 1.

Final products		1980 Production*
Chlorine	CL_2	204 tonnes
Sodium hydroxide	NaOH	101 tonnes
Sodium hypochlorite	NaOCL	595 tonnes
Hydrochloric acid	HCL	28 tonnes

*Production depends on demand and can be changed.

The firm is the only chlorine supplier in Tanzania. Sodium hypochlorite is used in local textile industry for bleaching of cotton as well as for disinfecting the water supply in certain regions of Tanzania. Basic raw material, sodium chloride, is received from H. Stanley & Sons Ltd. through STAMICO in the quantity of 500 tonnes/year and with quality which is satisfactory for the factory.

The owner stated that a supply of needed spares would allow him to increase production up to 80% of existing capacity and a more regular energy supply would avoid losses which are estimated as 20% of existing capacity. These conditions would permit the plant to work with full capacity and satisfy local demand for chlorine, sodium hypochlorite and hydrochloric acid as well as to increase the quantity of sodium hydroxide manufactured for the local market. According to the owner, the plant does not have technical problems which could be solved by TIRDO.

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SADOLIN PAINTS (Tanzania) Ltd., has a technical problem with recovery of used "Thinner Solvent" which is mixture of the following solvents:

toluene	240 parts
isobutanol	50 parts
butyl acetate	90 parts

Thinner solvent is used in the factory mainly for washing of equipment, tanks and returned paint containers. Annual consumption of this solvent in SADOLIN is at present 7,500 Kg. with the factory working at 20% capacity so with full capacity the need will be about 37 tonnes of "Thinner Solvent" per year. Present price of this solvent is 9,0 TSh/Kg, giving a cost of 67,500 TSh/year at present and a cost of 337,500 TSh/year if the factory would work with full capacity. All "Thinner Solvent" components are imported with difficulty (lack of import licences). Used "Thinner Solvent" contains different contaminants (paint residuals, mechanical particles, etc) which do not allow use of the solvent again. According to Mr. Lars Nilson, Production Manager, a recovery distillation unit could be bought, tested, adapted and a service offered to him by TIRDO. It was said by the Production Manager that a simple distillation set with capacity from 100 Kg/day to 500 Kg/day, (1 shift) with electric heater and water cooling system would be of interest to him, as well as other "Thinner Solvent" users. Such a distillation set could be bought (new or second hand) from firms such as Sussmeyer or Rio Beer of Switzerland. Alternatively, according to the Production Manager, manufacture of such a distillation unit could be performed in Tanzania, but detailed workshop design and part of construction materials would have to be supplied, through foreign channels. He would be ready to pay for leasing of the above set or to pay a fee in some agreed form.

BANCO PRODUCTS (Tanzania) Ltd., is producing paints based on alkyd resin which are imported at present. Because of difficulties with import licences, the firm has bought plant equipment for manufacturing alkyd resins locally with capacity of 1000 tonnes per annum. Vegetable oil which is the basic raw-material for alkyd resin production and is 60% of the total value of raw-materials needed, will be produced from local seeds and plants in the factory. To cover needs for alkyd resin production, about 300 tonnes of vegetable oils per annum have to be manufactured. The remaining raw-material input for alkyd resin production (i.e. 40% of total value of raw materials needed) will continue to be imported. According to Mr. Rajan Bhatt,

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Project Manager, most edible or non-edible oil bearing plant material or by-products can be used for the production of oil for resin manufacture which is of interest to TIRDO. According to information given by the Project Manager, screw-press and vacuum-filter have been bought and will be installed in 3 months time to process only coconut oil. By October, 1982 production of this local oil for alkyd resins production ought to start. It would be possible to sell a certain portion of the produced oil to local soap manufacturers.

At present the factory is working as a whole with 10% capacity because of lack of imported raw-materials (no-import licences). Other products manufactured by the firm are:

polyurethane foam,
artificial glue,
fibre glass reinforcing plastics,
expanded polystyrene,
car body surface filler.

The Project Manager stressed the need of TIRDO assistance also in improvements of technological processes in the factory to reduce present losses which amount to 10% of total production value. He also said that they were not interested in using furfural if locally produced, instead of imported aldehydes for the above resin production. No specific reason was given.

K.O.C. LTD., produces cosmetics with the following production programme:

- brillantines,
- cosmetic snow,
- talcum powder,
- castor hair oil
- perfumes,
- hand & body lotions

Raw materials used, are as follows: petroleum jelly, paraffin oil, stearic acid, colours, perfumes (all imported) and spirit, packing materials, bottles (locally produced). The quantity of perfumes imported is 1500 Kg/year with a cost of 750,000 TSh when the factory works at full capacity. The factory is not working at present because of lack of imported raw-materials.

According to Mr. A.C. Choksi, Factory Manager, the factory could use locally produced essential oils but only after their examination by KOC

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headquarters laboratory in Nairobi. The quality of such essential oils have to be satisfactory and provided in the form of a composition of essential oils equal to the standard essence used by the firm. According to Mr. B.J. Patel, Sales Manager, supply of local essential oils would allow them to produce perfumes since all materials would then be locally obtainable. Glycerin which is also imported by the firm in the quantity of 3000 Kg/year can be produced locally. At present glycerin which is a by-product during soap production, is thrown away by local soap factories according to Mr. Patel.

LEYLAND PAINTS (Tanzania) LTD., is producing water soluble paints. In June of this year the factory started production of "Thinner Solvent" for sale. All raw materials are imported at present and because of lack of import licences the factory is working with 20% capacity. According to Mr. Bashir Tejani, General Manager, the problem of "Thinner Solvent" recovery is touching users of his solvents i.e., workshops, dry-cleaners, etc, but is not of direct interest to him at present. However, users of "Thinner Solvent" ought to be interested in recovery therefore some distillation set is highly recommended by him. The only local raw-material which could replace an imported one is calcium carbonate used as a white filler for paint production in the factory. Calcium carbonate with quality adequate for Leyland Paints Ltd. is produced at present by firm ALFI in Arusha, but in too small a quantity to meet the need of Leyland Paints Ltd. A possible solution is to increase local production of $CaCO_3$ at ALFI perhaps with the assistance of TIRDO.

TROPICAL FOODS LTD. is a producer of fruit juices and related products. Talks were held with Mr. K.D. Tripathi, General Manager, on the possibility of using of orange and other citrus peels or residuals, by-products in the factory, for local essential oil and non-edible oil production from seeds. The factory can process from 5 to 7 tonnes of oranges per day during a season (4 months a year). In fact the factory process about 500 tonnes oranges per annum. Oranges are processed as follows: washed fruit are cut into four pieces and next peeled manually; peels are thrown away juice is squeezed from the fruit and the residuals from squeezing with contained seeds are separately thrown away. The General Manager showed interest in the processing of orange peels into essential oil and in processing of orange seeds into non-edible oil, if appropriate technology & equipment are presente to him by TIRDO. He was interested in such production in the factory rather than allow another company to use the factory's by-products.

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TANGOLD PRODUCTS CO. LTD. is a subsidiary company to the National Milling Corporation. The firm is the biggest orange juice producer in Tanzania. Talks were held with Mr. A. Luumba, General Manager, on the same subject as with Tropical Food Ltd. Installed capacity of orange processing is about 35 tonnes/day. In fact, operating only during the season (3 months a year) the factory processes about 500 tonnes/year of oranges. Orange processing is fully automatic with crushed peels and pulp transported together to a holding tank. It has been identified that essential oils could be recovered at this factory by two methods:

- from the peels and pulp by distillation method (the factory could use residual low-pressure technological steam, which is vented at present, for heating of the distiller).
- from orange juice which contains a relatively high percentage of orange oil by centrifugal method or by pressure-separation.

The General Manager expressed his interest in orange essential oil recovery and in the assistance of TIRDO in this project.

BERGER PAINTS (Tanzania) Ltd. where talks were held with Mr. D.W. Wright, General Manager, the factory produces common and industrial paints, based on almost all imported raw-materials. The only raw-material bought locally is kaolin supplied to the factory by STAMICO. Local chalk could also be used if of high quality. Samples of chalk from deposits near Dodoma contain some impurities which prevent the factory from using this chalk. Some research work would be required on purification methods for local chalk. Coconut and sunflower oils could be used by the factory for alkyd resin production, but at present there is no possibility to get local oils according to the General Manager. The factory is working at 60 to 80% capacity because of lack of imported raw-material (no import licences). The factory does not have any problem with used "Thinner Solvent" which is returned to the paint manufacturing process. According to the General Manager, the factory does not have any other technical problems to be solved by TIRDO.

TANZANIA INDUSTRIAL STUDIES AND CONSULTING ORGANIZATION. Talks were held with Mr. Manohar Singh, Senior Consulting Chemical Engineer. According to him, sodium hydroxide is planned for production in Tanzania in two ways:

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- Electrolysis of sodium chloride; an electrolysis plant with capacity of 8 tonnes/day of NaOH and CL_2 is under construction as a part of a new pulp and paper plant. All sodium hydroxide and chlorine produced will be utilised only by the pulp and paper factory.

- Chemical processing of natural soda ash from Lake Natron into caustic soda; this project requires establishment of local infrastructure which is lacking as well as investment in plant facilities. According to the Senior Consultant, a 3-year moratorium on new investment projects, recently announced by the Tanzanian Government, because of the country's economic difficulties. The above moratorium includes the Lake Natron caustic soda project.

As far as essential oils are concerned, there is no production on the Tanzania mainland at present. Clove oil is produced in Zanzibar in nominal quantity. TISCO is preparing some pre feasibility study on utilization of "Tanganyika Extract Co.," Arusha, equipment, for essential oils production. The plant is working with greatly underutilized capacity because of lack of enough quantities of pyrethrum plant materials, there. TISCO assumes the possibility of essential oil production there based mainly on lemongrass, cinammon leaves & barks, and other plants growing supposedly in quantity around Arusha. The Senior Consultant stressed his interest in collaboration with TIRDO on this problem.

STATE MINING CORPORATION. Talks were held with Mr. H.M. Kihwelo, Chief Chemical Engineer, on the possibility of using of natural soda deposit for local production of caustic soda.

The country's main soda ash deposit is Natron Soda Lake which is far from existing infrastructure. Composition of soda crush from this deposit is as follows:

$NaHCO_3.Na_2CO_3.2H_2O$	-	62.08%
$Na_2CO_3.H_2O$	-	28.08%
NaCL	-	0.51%
Na_2SO_4	-	3.05%
NaF	-	1.13%
mud	-	5.10%

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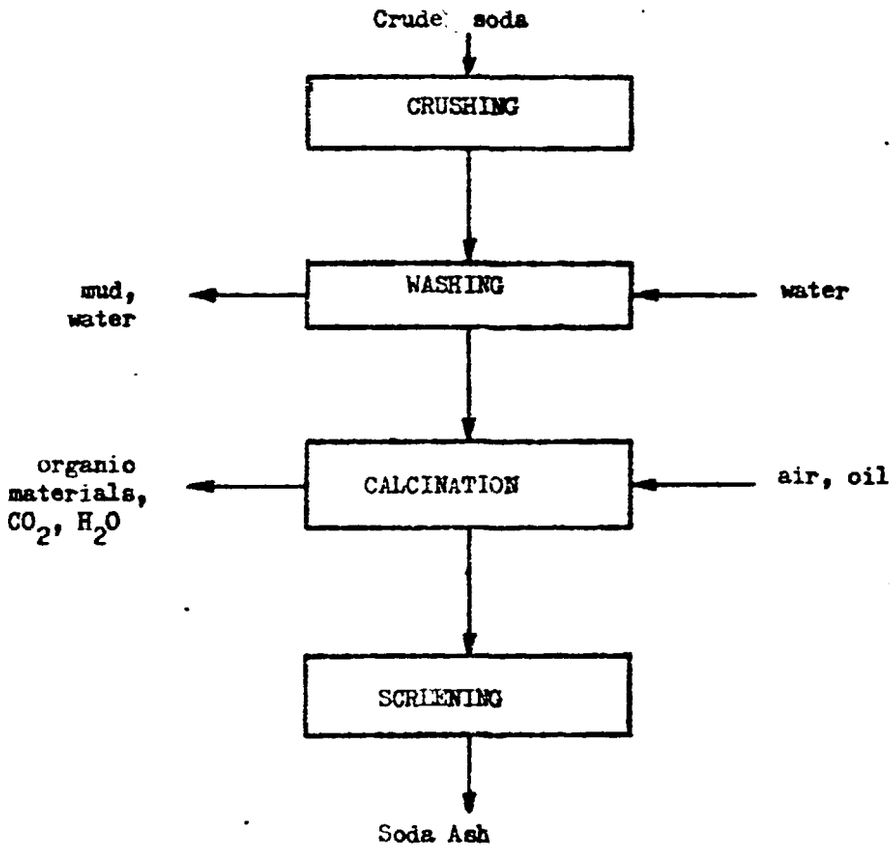
Another natural soda ash deposit has been recently discovered in Hanang District which is closer to existing infrastructure than Lake Natron. The chemical composition of natural soda crush from Hanang District was not known to Mr. H. M. Kihwelo.

Technology of crude soda crush processing is as follows:



At present plans are under development for a plant with capacity of 25,000 tonnes of soda ash per year to meet only local demand. The largest part of soda ash obtained, would be processed into caustic soda, based on the following chemical reaction:

$$Na_2CO_3 + Ca(OH)_2 \longrightarrow CaCO_3 + NaOH$$

(Calcium hydroxide is produced locally mainly for building industry.) Demand for sodium hydroxide in 1980 was estimated as 15,000 tonnes. Prices of imported soda ash and caustic soda are at present:

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Na_2CO_3	-	3,500 TSh/tonne
NaOH	-	4,500 TSh/tonne

According to Mr. H.M. Kihwelo the investment cost for the processing of natural soda crush with the above capacity would amount to 4.0 million TSh. in foreign exchange. (Investment cost of processing of soda ash into caustic soda would be about 36.0 million TSh for 15,000 tonnes NaOH per annum capacity).(10

Alternatively small-scale production of caustic soda can be considered to reduce investment funds needed. There are some firms and individuals interested in small-scale, local production of caustic soda. At present there is small production of soda ash from natural soda in Monduli town near Arusha. Ex-works price of soda ash manufactured there is about 800 TSh/tonne.

INSTITUTE OF PRODUCTION INNOVATION. Talks were held with Mr. Chungu, Research Officer, on small-scale soap production project led by IPI. The project is in an early stage with laboratory scale soap production based on local edible coconut oil and caustic soda made from Natron Lake soda crush and locally produced calcium oxide (lime). The project is not aimed at solution of the raw-materials problem which is facing local soap manufacturers, but rather to show the possibility of local small-scale soap production.

3.3. CONCLUSIONS OF THE FACTORY AND ORGANIZATION VISITS

a) All of the factories visited suffered from lack of imported raw-materials and spare parts, because of unavailability of import licences issued by Bank of Tanzania. As a consequence, the installed capacity of the majority of (9 cases) factories visited is utilized in range from 0 to 80 percent. Only two factories namely Dawa Ya Mbu and H. Stanley & Sons Ltd. are working close to full capacity at present.

b) Factories with underutilized capacities because of lack of imported raw materials and spares are using two different philosophies i.e.:

- to wait for import licences from Bank of Tanzania (6 cases).
- to try help production by utilization of local raw-materials or by recovery and reuse of used imported raw-materials (3 cases).

In one case (Dawa Ya Mbu) the firm, forced to use local starch (cassav flour) because of lack of imported starch, had done so with good effec When the factory received an import licence, they stopped using local starch and employed imports once again.

c) Prices of some locally manufactured raw-materials and semi-products are unrealistic. For example the price of locally produced coconut oil is 55,000 TSh/ton while the price of imported animal fat is 6,000 TSh/tonne (in foreign exchange). This is one of the basic reasons for the shortage of soap in Tanzania now. Establishment of proper prices of local vegetable oils ought to increase utilization of installed capacity in local soap factories and further the development of the local oil industry.

d) TIRDO assistance which is sought by factories visited can be divided into two groups:

- to identify local raw-materials and/or appropriate technology for local manufacturing of some semi-products which could replace imported ones (6 cases);

..../20

- to improve existing technologies in local factories to reduce losses of imported raw-materials and manufactured products. (1 case).

e) Lack of coordination between factories and knowledge about possibilities for processing of by-products. At present one factory throws away by-products which can be processed into raw-materials or semi-products lacking in another factory having underutilized capacity because of shortage of raw-materials, imported at present.

4. RECOMMENDATIONS

Relations between TIRDO and local chemical and allied industries are in their early stage. These relations ought to be established and developed based on partnership of both sides. In order to achieve this target, local chemical and allied industries have to be convinced of the value of technical advice, technologies and equipment proposed by TIRDO. In addition, TIRDO's research officers themselves ought to be convinced about the usefulness of their work for local industry.

At present TIRDO does not have any laboratory, workshop or pilot plant facilities and Tanzanian research officers in the Chemical and Food Technology and Engineering Departments of TIRDO have very little industrial experience. Thus subjects for research projects ought to be chosen very carefully and with realism. The expert believes that relatively simple, but industry-oriented research projects have the possibility of being entirely and satisfactory solved by TIRDO officers and to result in implementation and commercialization. By this, "from identification to commercialization" method, confidence of local industry in work done by TIRDO can be achieved and experience gained by TIRDO's officers could be utilized during implementation of the more difficult industry oriented research projects suggested for implementation in a few years. This "step-by-step" method seems to be more appropriate for TIRDO's Chemical Department than too ambitious research projects without a chance for implementation in the near future nor even a chance to be fully tested in lab or pilot plant scale.

4.1. Based on the above assumptions, the following small and medium scale industry-oriented research projects are recommended for the TIRDO Chemical Department, in the near term (0-3 years):

a) SMALL-SCALE ESSENTIAL OILS MANUFACTURING

Raw-materials needed for such production are:

- locally obtainable essential oils bearing plants such as lemongrass, vetivergrass, cinnamon roots, bark, leaves, cardamon seeds, cajeput leaves, eucalyptus leaves and flowers, copaiba tree resins, etc.

..../22

- essential oil bearing by-products like orange peels, lemon peels, lime peels, and other residuals from local citrus and fruit processing industry.

A small-scale technology and distillation set design is attached to this report in Annex 2. This distillation set was tested and implemented in 1979 by the expert in Ghana.(11 Because of its simplicity, fabrication can be performed in a mechanical workshop in Tanzania with construction materials obtainable locally. The estimated total investment cost for a single distillation set for essential oil production is 5,000/- TSh.

There is at present a market for essential oils in the country. The main users are soap manufacturers, cosmetic firms and maybe bakeries. Essential oils produced locally by the distillation metho could serve this market. Cosmetics producers would be interested in only compositions of few essential oils which could be achieved in the near term. In order to properly perform and implement the project, the following work ought to be done:

- essential oils local market review,
- essential oils local natural resources and by-products survey,
- build a distillation set for small-scale essential oil production with the possibility of using direct steam, water and steam or water distillations,
- to test selected plant raw-materials and by-products,
- to test samples of produced essential oils in local soap factories and bakeries,
- to prepare appropriate technologies adjusted to conditions and nature of raw-materials and by-products obtained,
- to prepare detailed design where required,
- to perform techno-economic evaluation of local essential oils production for each particular case,
- implementation and commercialization of technology and equipment for small-scale essential oils manufacturing; potential manufacturers of essential oils e.g. TANGOLD PRODUCTS CO. LTD, Dar es Salaam, TROPICAL FOODS LTD, Dar es Salaam with potential buyers of essential oils such as BOBBY SOAP FACTORY LTD, Dar es Salaam, K.C.C. Ltd, Dar es Salaam.

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b) NON-EDIBLE OILS MANUFACTURING

Raw materials which could be used for such production are:

- Castor seeds
- Cashew nut shells
- Cotton seeds
- Citrus fruit seeds
- Tea seeds
- Tobacco seeds

Appropriate technology with proper capacity for extraction of non-edible oils ought to be selected by TIRDO based for example on technologies tested and implemented in other developing countries. UNIDO experience and advice would be very helpful. The above technology ought to include processing of non-edible oils bearing local plants and by-products as well as purification of raw non-edible oils.

Procedures to be followed would be similar to those of Small-Scale Essential Oil Manufacturing Project above.

Non-edible oil is the raw-material sought by local soap manufacturers and paints producers to allow them utilize installed capacity and replace imported oils and fats. Potential users of non-edible vegetable oils include BOBBY SOAP FACTORY LTD, Dar es Salaam and BANCO PRODUCTS LTD. Dar es Salaam. BANCO plans to manufacture some non-edible oils.

c) RECOVERY OF MINERAL SALTS FROM BITTERN

The composition of sea water, in terms of its major mineral constituents, is, on average, as follows:

Sodium Chloride	-	2.806%
Potassium Chloride	-	0.080%
Magnesium Chloride	-	0.344%
Magnesium Sulphate	-	0.224%
Calcium Sulphate	-	0.137%
Bromine	-	0.007%

The bittern which is discharged from common salt crystallizing pans provides a valuable source of the more soluble constituents of sea water. The bittern in practice measure an average about 1000 litres per 1 ton of common solar salt harvested. The approximate amounts of salts contained in this quantity of bittern are:

..../24

magnesium sulphate	60Kg
magnesium chloride	100Kg
potassium chloride	20Kg
sodium chloride	160Kg
bromine	2Kg

Based on the above figures and results of talks with H. Stanley & Sons, the company could produce:

magnesium sulphate about 600 tonnes/year
magnesium chloride about 1000 tonnes/year
potassium chloride about 200 tonnes/year

Magnesium salts could be used in local industry as binding materials for refractory compounds production etc. Potassium chloride could be used in local agriculture as fertilizer on some crops (except tobacco).

A study ought to be prepared on the quantity and quality requirements for potassium and magnesium salts by local agriculture and industry. This study would allow H. Stanley & Sons Ltd to take further steps toward the processing of bittern, now a by-product at their plant. To perform this project, the following work ought to be done:

- potassium and magnesium salts local & external market demand review;
- quality requirements;
- analysis of sea water used by H. Stanley & Sons Ltd as well as analysis of bittern from their ponds;
- estimation of potential production of potassium and magnesium salts by H. Stanley & Sons Ltd.

Other near term projects have already been mentioned (9 and are as follows:

d) DIRECT REDUCTION OF TANZANIA IRON ORE.
e) PYROLYSIS OF AGRO-INDUSTRIAL WASTES.
f) LOCAL EXTRACTION OF DYE STUFF.

4.2. In the longer term (3-5 years) other more advanced projects could be performed by TIRDO. However, laboratory and pilot plant facilities are required first. The experience gained during performance of the projects mentioned above, would be the basis for future performance. These longer term projects could be as follows:

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a) SODIUM HYDROXIDE SMALL-SCALE PRODUCTION

Based on information received from STAMICO and TISCO, the expert suggests small-scale NaOH production by chemical processing. This could help the local soap manufacturers to increase utilization of the installed capacity. The technology is known and is based on reaction of dissolved soda ash with milk of lime. The principal reactions of this process are as follows:

$$Na_2CO_3 + CaO + H_2O \longrightarrow 2NaOH + CaCO_3$$

dissolved precipitate

$$CaCO_3 + \text{Heat} \longrightarrow CaO + CO_2$$

stone dry lime gas

Caustic soda is in 10-12% solution and is concentrated by multiple effect evaporation to 50% or 70% grades. The dry product can be made by direct heating methods and in such form could be sold to local soap manufacturers.

The precipitated $CaCO_3$ is usually high quality and can for example be used as paint filler by Berger Paints (T) Ltd., or Leyland Paint (T) Ltd. In this case $CaCO_3$ is not reburnt and limestone or lime needs to be supplied for the caustic soda production.

Raw-materials needed for caustic soda manufacturing are:

- local natural soda ash from Lake Natron or other deposits,
- dry lime produced locally.

Appropriate choice of processes and operations, equipment design and pilot-plant manufacturing are the basic objectives of the project.

b) RECOVERY OF GLYCERINE

The spent lye from soap production contains glycerine (glycerol), water, salt and excess caustic soda. The spent lye resulting from current soap-making processes generally contain 8 to 15% glycerol. The chemicals most commonly used to remove

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impurities from spent lye are hydrochloric acid, caustic soda, ferric chloride or sulphate, and alum. The hydrochloric acid and caustic soda are used as precipitants and neutralizers, and the others serve as coagulants and precipitants. The treatment of spent lye consists of a series of operations designed to remove impurities and to get dilute glycerol liquor which in next turn is concentrated to crude glycerol by evaporation. A combination of vacuum and steam distillation is usually used in which the vapours are passed from the still through a series of condensers. Pure glycerol is condensed at high temperature.

Raw-materials needed for glycerine (glycerol) manufacturing:

- spent lye received from local soap manufacturers as well as some of the chemicals mentioned above.

Glycerine could be used by:

- Local cosmetics producers (e.g. K.O.C. Ltd.) for creams & lotions
- Local toothpaste producers (e.g. ALFI, Arusha)
- Local pharmaceuticals producers.

Appropriate choice of processes and operations, equipment design and pilot-plant manufacturing are the basic objectives of the project.

c) ORGANIC SOLVENTS RECOVERY

The recovery of "Thinner Solvent" has been identified as a concern only for Sadolin Tanzania Ltd. i.e., one of the four paint producers in the country (see 3.2.). According to their report,[12] a small, semi-automatic distillation unit is necessary for the firm. The equipment can totally give a 70 to 90% recovery efficiency. The following distillation unit was recommended for the firm:

Producer:	RIO BEER, Niedernif, Switzerland,
Type :	HBE-50
Capacity:	50 litres/h (about 60.000 l/y)
Price :	24.300 SFr. (1978)

Purchase of this equipment by the firm would solve their problem and does not need TIRDO assistance.

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The problem of solvent recovery could be carried out by TIRDO based on a simple, universal distillation equipment designed for recovery of different solvents and organic chemicals used locally.

Detailed identification of the kinds and quantities of organic solvents requiring recovery ought to be done first. These data would be the basis for design and performance specifications of pilot-plant distillation equipment and its use. Assistance of a UNIDO Consultant would be helpful.

Other longer term projects which should be considered are:

d) STUDY ON UTILIZATION OF RICE HUSKS FOR HIGH QUALITY SODIUM SILICATE MANUFACTURING

e) STUDY ON LOCAL BASIC RESINS PRODUCTION

4.3. The basic conditions which should be fulfilled before satisfactory performance of the longer term projects is possible, are:

- well equipped laboratory and workshops with all necessary utilities,
- techno-economic capability with at least one experienced industrial economist who could support the above projects with cost/benefit analyses which are necessary to obtain industrial clients,
- short and medium-term training courses of TIRDO personnel in chemical factories in developed countries. Emphasis should be given to distillation, extraction, filtration and other basic chemical operations.

4.4. The Chemical Department of TIRDO could be assisted by a Consultant during performance of the projects mentioned in items 4.1 and 4.2 either on return-mission basis or on a permanent basis.

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UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

JOB DESCRIPTION

DP/URT/78/019/11-51 31.3.J Rev

Post title Expert in Chemical Industries Improvement

Duration One month

Date required As soon as possible

Duty station Dar es Salaam with possibility of travel within the country

Purpose of project To assist the Tanzania Industrial Research and Development Organization (TIRDO)

Duties The expert will work in co-operation with the TIRDO Principal Research Officer, Chemistry/Analysis and under the leadership of the Director General and the UNIDO Senior Technical Adviser, and will specifically be expected to:

1. Review existing data on Tanzanian chemical imports and on local materials and resources for chemical production or processing;
2. Identify those products and processes with greatest potential for small to medium scale manufacture;
3. Identify existing industries which could be made more efficient either by -
   a) increasing the utilization of their capacity,
   b) diversification of their production programme, or
   c) improvement of quality and productivity;
4. Assist in the outline of TIRDO activities and programmes to fulfill some or all of these research and study objectives.

..../2.

Qualifications	University degree in chemical engineering or chemistry with extensive experience in industrial chemistry and chemical production. Knowledge of small scale processes and developing country economics highly desirable.
Language	English

ACKGROUND NFORMATION

TIRDO, which was created in April 1979, will have the following functions:

a) to carry out and promote the carrying out of applied research designed to facilitate the evaluation, development and use of local materials in industrial processes;

b) to carry out research in various aspects of local and foreign industrial techniques and technologies and evaluate their suitability for adaptation and alternative use in local industrial production;

c) to promote or provide facilities for the training of local personnel for carrying out scientific and industrial research;

d) to monitor and co-ordinate applied research carried out within the country or elsewhere on behalf of or for the benefit of the Government and to evaluate the findings of that research;

e) to establish a system for the registration of the findings of applied research carried out within the country and to promote the practical application of those findings in industrial production;

f) to establish and operate a system of documentation and dissemination of information on any aspect of applied research carried out by or on behalf of the Organisation;

g) to provide the Government and firms or organisations engaged in industrial production, technical and advisory services, with advice and guidance on technical matters necessary for furthering industrial activity;

h) to advise the Government and firms or organisations engaged in industrial production on the adaptation of technology in industrial production;

i) to provide the Government and firms or organisations engaged in industrial production with advice and assistance related to the provision of technical facilities in industrial enterprises and the establishment of systems for the control and regulation of industrial processes in order to improve the performance and to avert or minimise the sources of industrial pollution;

j) to do whatever may be necessary to uphold and support the credit of the organisation, to obtain and justify public confidence, to avert or minimise any loss to the Organisation and to facilitate the proper and efficient performance of its functions.

.../...

In particular, the Organisation may carry out the following:

a) undertake, either alone or in association with any person or body of persons within or outside the country, the establishment, equipment and management, on a zonal or sectoral basis, of a centre or centres within the country for the performance of any of its functions;

b) carry out and promote the carrying out of applied research and investigation into the causes of and the ways of preventing industrial pollution;

c) in co-operation with the Government or any person or body of persons, evaluate and if necessary adapt, foreign technological processes for use in the country;

d) provide industrial enterprises with technical services connected with the design of prototype industrial plants, machinery and equipment for manufacture or use in the country;

e) provide industrial enterprises with technical services connected with the repair and maintenance of industrial plants, machinery and equipment,

In order that it may carry out its functions better, the Organisation will establish and maintain a system of consultation and co-operation with any person or body of persons established by or under any written law and having functions related to those already specified or which relate to technological research or to industrial development generally.

TIRDO's facilities and staff housing will be located at a 40 ha site; construction work has been started and it is expected that all buildings will be finalised by the end of 1982.

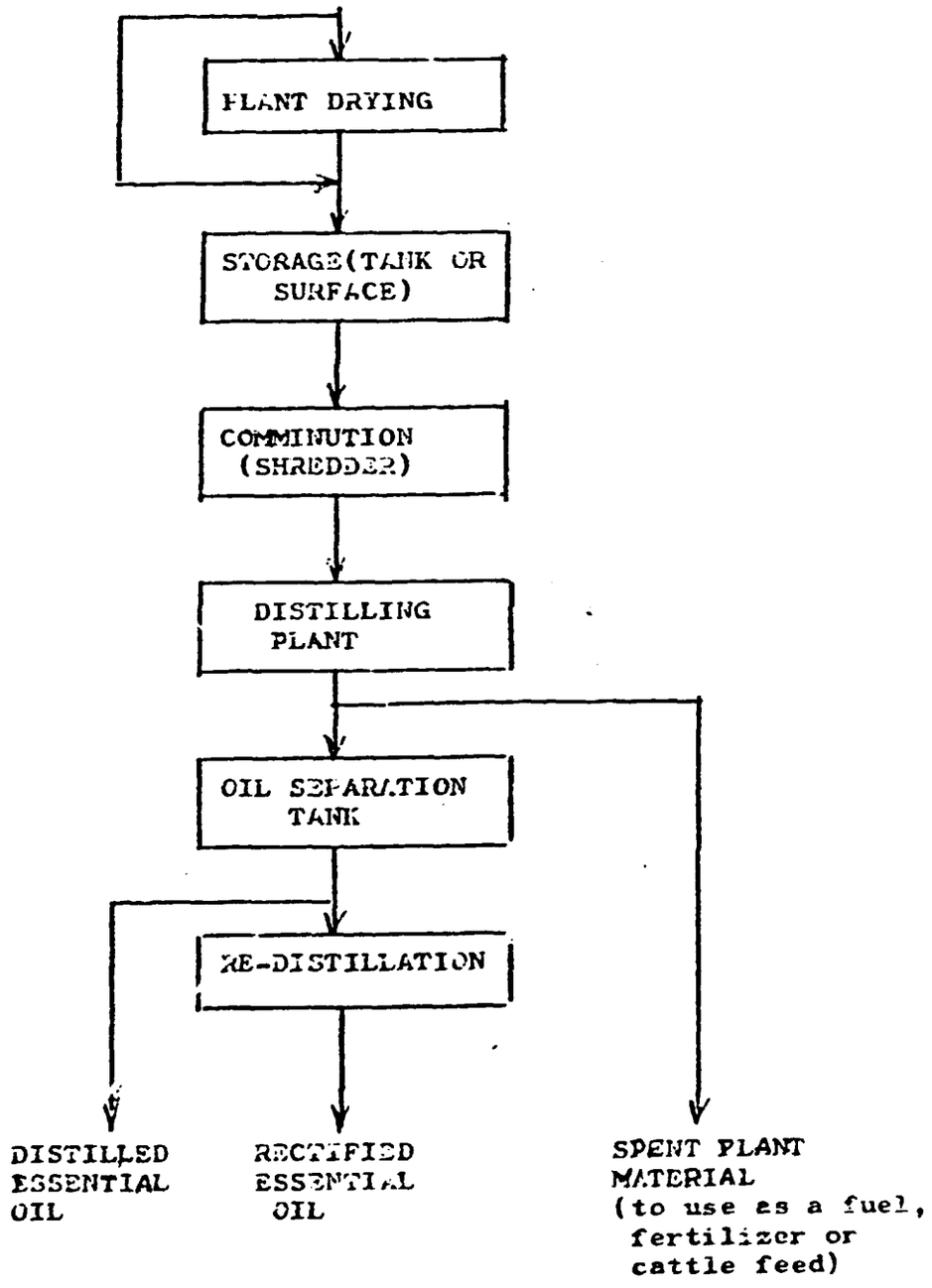
During the first phase of UNDP/UNIDO assistance, this project will provide six experts (Research and Development Management, Engineering, Analysis and Testing, Electronics Instruments, Repair and Maintenance, Information Retrieval and Information Extension) and eight fellowships for training of TIRDO staff abroad.

ANNEX 2

Technology and Distillation Set Design for the Small-Scale Manufacturing of Essential Oils

PROCESS FLOW SHEET

PLANT MATERIALS



Practical technological and operating problems connected with essential oils production are as follows:

1. PREPARATION OF RAW MATERIALS

1.1 PLANT DRYING

Essential oils are produced from fresh or dried aromatic plants. Plant drying before distillation, bring advantage like possibility of essential oil manufacturing through all year, independently from harvesting period. Other advantages are: more efficient utilization of production capacity, less consumption of heat, higher yield and essential oil quality. Though plant drying is generally recommended, utilization of either fresh or dried plants depends on the kind of raw materials and a manufacturer possibilities.

1.2. STORAGE OF PLANT MATERIAL

If the plant material is to be stored before the distillati it should be done in its natural conditions. The plant material ought to be stored in the uncomminuted form.

1.3. COMMINUTION OF PLANT MATERIAL

The disintegration process always reduces the thickness of material, greatly increasing the rate or speed of vaporization and distillation of the essential oils. This in turn shortens the production cycle, and increases the yield of essential oils. Comminution of plant material is therefore important in the technological process.
It is evident that once the plant material has been crushed or reduced in size, it must be distilled immediately.

2. DISTILLATION

There are three types of distillation in the essential oils manufacturing, i.e.

- water distillation;
- water and steam distillation,
- direct steam distillation.

2.1. COMPARISON OF THE THREE DISTILLATION METHODS

For small-scale installations, particularly in portable unit, water distillation or water and steam distillation offers the advantage of simplicity of equipment.

The latter method is rapidly superseding water distillation (except in a few special cases) because of the better quality and yield of oil, and higher rate of vaporization i.e. faster distillation. For larger and fixed installations, steam distillation unquestionably is most advantageous. It is however impracticable for the small producer in the field. Whenever conditions permit, the construction of a suitably located modern plant to process raw material from a large area, such distillery should be equipped to utilize direct steam distillation. However, as far as small-scale production of essential oils is concerned only water distillation or water and steam distillation can be applicable.

2.2. OPERATION OF ESSENTIAL OILS DISTILLATION PLANT

This problems is discussed base on distillation set designed by the author and shown on fig. 1.1;1.2; 1.3 attached to the study.

2.2.1. WATER DISTILLATION

The boiler 1 is charged with the well prepared plant material (see figure 1). Next the valve 11 is locked and the boiler is filled up with water to cover the charge entirely, leaving however, ample vapour space above the charge to avoid boiling over and carrying over of spray into the condenser. After securing the pipe connection 7 between boiler and condenser, two water seals 6 and 8 are filled up with water. The water height in these seals ought not exceed 10cm. (This water height allows to operate smoothly, attenuating immediately an effects of over and underheating i.e. over and underpressure, which are unavoidable especially when firewood is used.) Next the firewood is lit or alternatively steam/ electricity is switched on to heat the boiler.
Proper distillation begins from the moment of boiling of contents in the boiler. Condensation of essential oil and water, takes place in the condenser 9, and their separation in the receiver 10. The cohobation is not foreseen in case of operating of water distillation.
Cooling water can be supplied constantly in counter-current flowing or periodically by pouring in a new portion of cooling water, into the condenser.

When distillation is complete, the exhausted plant material is unloaded by turning down the boiler, which is set up on axles of the support 4.
The whole operation can be performed by two persons. The only skills required are that:

(a) 1st person - will be required to serve the boiler(s) heating and periodically collect distillate with essential oils obtained.

(b) 2nd person - will be required to prepare plant materials batch inputs (drying, cutting, eventually peeling of raw materials), as well as to prepare firewood.

Safety of an attendant in case of over and underpressure in the set is ensured, because the water seals are also operated as safety valves.

2.2.2. WATER AND STEAM DISTILLATION

The boiler 1 is filled by water but below the grid 2 level. Next the boiler is loaded up with a well prepared plant material. It is important when this method of distillation is employed, that the plant charge itself is kept out of contact with the boiling water. After fixing the pipe connection 7 between boiler and condenser, and after opening the valve 11 and connecting the cohobation system, two water seals 6 and 8 are filled up with water. The water height in these seals ought not exceed 10cm. (This water height allows to operate smoothly, attenuating immediately an effects of over and underheating i.e. over and underpressure, which are unavoidable especially when firewood is used).
Next the firewood can be set on fire, or alternatively steam/electricity can be switched on, to heat the boiler. Prover distillation begins from the moment of boiling of the water in the boiler. Condensation of essential oil and water takes place in condenser 9 and their separation in the receiver 10. The surplus aqueous condensate is cohobated i.e. made to constantly return to the boiler by the plastic pipe 13 and metal pipe 3.
The cooling system is the same as described at point 2.2.1.
The whole operation can be performed by two persons. The only skills required are that:

(a) 1st person - will be required to serve the boiler(S) heating, and finally collect essential oils obtained.

(b) 2nd person - will be required to prepare plant materials batch inputs (drying, cutting, eventually pecking of raw materials), as well as to prepare firewood.

The operation of the distillation set with cohobation system diminish man's care to a minimum, as the operation goes in close-circle, and man operating the set is engaged in practice only in boiler heating. Safety of an attendant in case of over and underpressure in the set is ensured, because the water seals are also operated as safety valves.

2.2.3. OTHER FACTORS CONNECTED WITH DISTILLATION

2.2.3.1 DURATION OF DISTILLATION

Experience with the distillation of any particular plant material will enable the operator to evaluate these factors properly. Collecting of small quantity of distillates in test-tube e.g. every half an hour and observing volume of essential oil in the sample can be simple but useful method to estimate duration of distillation.

2.2.3.2. TREATMENT OF THE DISTILLATION WATER

Distillation water (with dissolved oil) ought to be submitt to further treatment to prevent loss of essential oil. In the proposed technology where water and steam distillation is to be employed, this distillation water may be automatically returned(cohobated) into the boiler during distillation.

2.2.3.3. DISPOSAL OF THE EXHAUSTED PLANT MATERIAL

One very economical method of disposal consists in using it as fuel after air drying, either in the sun or near the hot boiler. The spent material has however a rather low fuel value per unit volume.
Alternatively, the spent material may be used effectively as fertilizer. Certain spent plants make good cattle feed; this is particularly true of seeds which contain a high percentage of protein and fatty oils. However spent material should be subjected to further analysis before being used as animal feed. This is most essential because of the excessive heat treatment of the material during the oil extraction process which may tend to have adverse effect on the protein content of the spent material.

2.2.3.4. INFLUENCE OF THE DISTILLATION METHOD ON THE QUALITY OF THE ESSENTIAL OIL

The quality, as well as the physicochemical properties, of an essential oil is greatly influenced by the conditions of the plant material (age, dried or fresh) and by the way distillation is carried out. It depends on the method of distillation (water distillation, water and steam distillation) the degree of comminution of the plant material, the duration of distillation, the pressure applied, the treatment of the distillation,water, whether the oil of cohobation is added to the main oil or not, etc. However with experience [illegible], in case of very simple apparatus, the quality of oil resulting from water distillation can be good. However, the yield of oil in field distillation is often far below that obtained by distillation on a large scale in more modern factories.

2.2.3.5. THE STORAGE OF ESSENTIAL OILS

As a general rule, any essential oil should first be treated to remove metallic impurities, freed from moisture and clarified, and then be stored in well-filled, tightly closed containers, at low temperature and protected from light.

3. THE DESIGN OF APPARATUS SET FOR LOCAL SMALL-SCALE ESSENTIAL OILS PRODUCTION

3.1. FIGURES

See figures: 1; 1.1; 1.2; 1.3;

Designations:

1 - Boiler (distiller);
2 - Grid;
3 - Metal Cohobation Pipe;
4 - Boiler Supports (with unloading mechanism);
5 - Cover;
6 - Water Seal ("big");
7 - Metal Pipe Connection;
8 - Water Seal ("Small");
9 - Condenser;
10 - Receiver;
11 - Valve;
12 - Furnace;
13 - Plastic Cohobation Pipe;
14 - Cooler Support;

3.2. DESCRIPTION OF THE ESSENTIAL OILS DISTILLATION EQUIPMENT

The apparatus set for water and steam distillation and water distillation of aromatic plants, has been designed and shown on the figures attached..

This set consists of:

- boiler,
- condenser,
- receiver,
- auxiliary equipment (i.e. cohobation system, supports with unloading mechanism, pipe connections).

The distillation set is adopted to use firewood as a fuel. Specification of materials needed for performance of this distillation set is shown in Table 1 by the author. The set was fabricated in 1979 for the Industrial Research Institute, CSIR, Accra, Ghana, from materials obtainable locally and by two local welders of Water Resources Research Unit Workshop, CSIR, Accra, Ghana. Operating the set is very simple and needs no skilled personnel to man it.

3.2.1. BOILER

The boiler is built of 200 litre (44 gallons) typical metal drum 1 and is equipped with grid 2 made of metal net. The grid is inserted sufficiently far above the real botton of the boiler, so that boiling water and plant material (the latter supported by the grid) do not come in contact during water and steam distillation.
The aqueous distillate is returned to the boiler for redistillation, through the cohobation system (pipes 3 and 13).
The boiler is set up on the furnace which is built in form of two supports 4 with the turning axles. Connection between boiler and cone-shape cover 5 is made through "big" water seal 6. The boiler usually is provided with some safety valve. In case of water or water and steam distillation, the water-seal additionally fulfil this function.
The cover is connected to the pipe connection 7 and next through "small" water-seal 8 to the condenser 9.

3.2.2. CONDENSER

The condenser is built of a brass coil inserted into 100 litres (22 gallons) metal drum, supplied with running cold

water, which enters from below and flows against the steam and essential oil vapours.

3.2.3. RECEIVER

Receiver 10 is built of 10 litres glass flask where final continous separation of oil from distillation water takes place. Receiver is connected to the boiler through cohobation system (pipes 13 and 3) (only in case of water and steam distillation).

TABLE 1

SPECIFICATION OF MATERIALS NEEDED FOR PERFORMANCE OF THE DISTILLATION SET FOR SMALL-SCALE ESSENTIAL OILS PRODUCTION

Items	Quantity	Size
- Metal Drum	1	Volume 44 gallons(200 litres)
- Metal Drum	1	Volume 22 gallons(100 litres)
- Wire Mesh	1	0.36m^2
- Steel Plate		4.0m^2
- Copper Pipe		6.0m (size 1½")
- Galvanised Pipe	1	1.0m (size ¾")
- Stop Brass Cock or Sto.	1	(size ¾") "
- Flat Iron		4.0m (size 1")
- Angle Iron		8m (size 1 x 1")
- Bolts	2	(size 4")
- Glass Bottle	1	Volume 10 litres
- Steel Pipe water		0.5m (size 1").

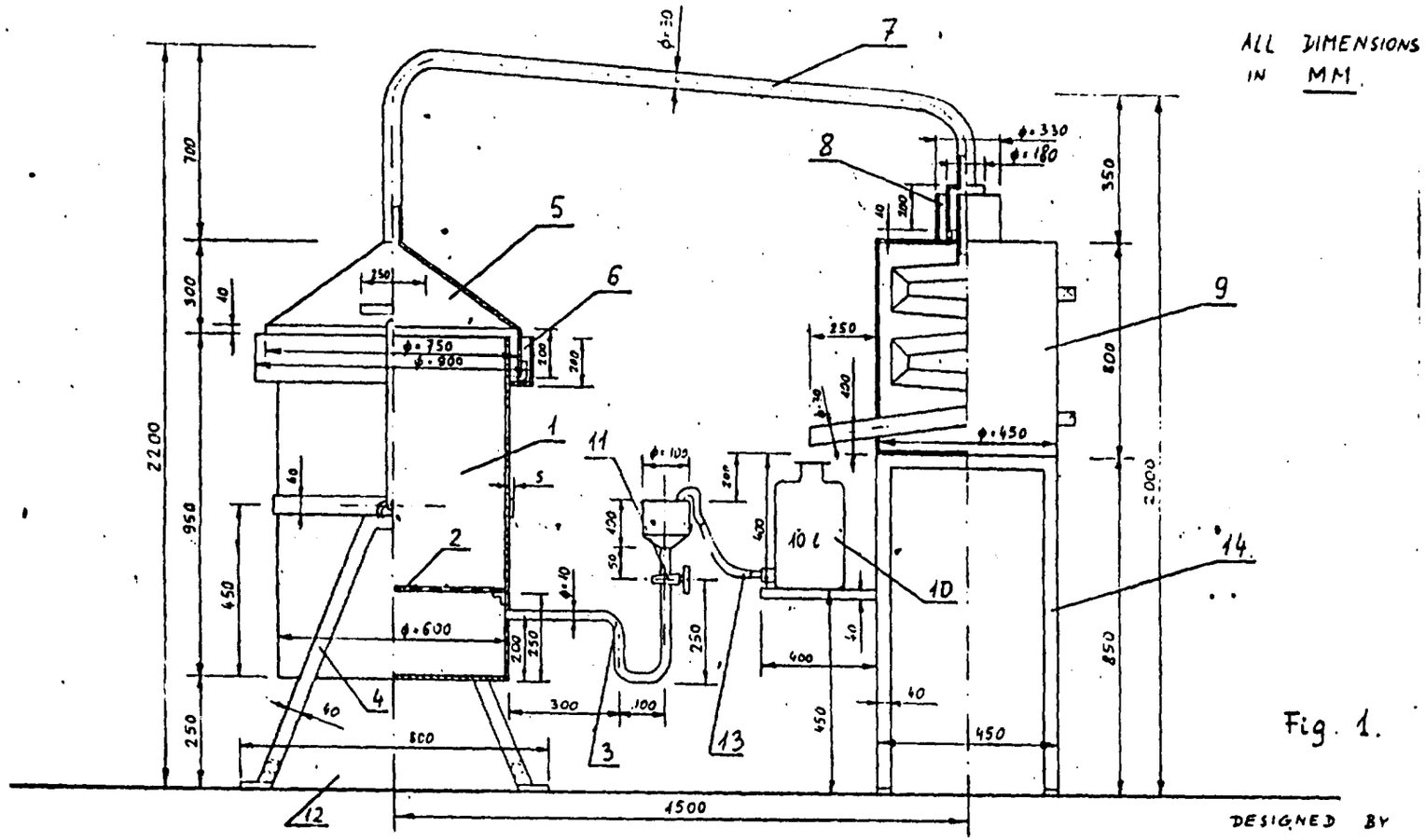
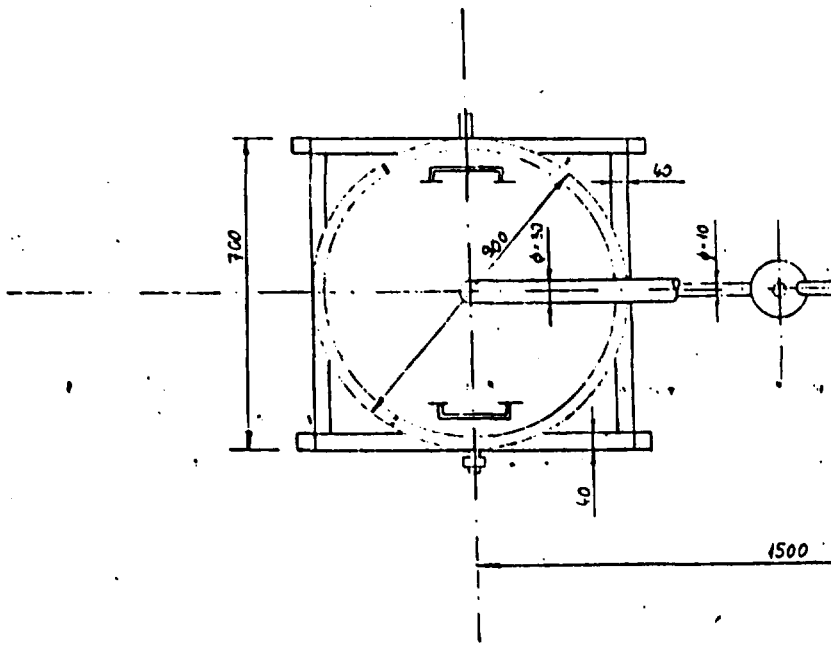

ALL DIMENSIONS IN MM.
7
8
5
6
9
1
11
2
4
3
13
10 l
10
14
12
APPARATUS SET FOR DISTILLATION OF ESSENTIAL OILS.
DESIGNED BY
M. NOWAK
on 4th Sept. '79

Fig. 1.



APPARATUS SET FOR DISTILLA

ALL DIMENSIONS
IN MM

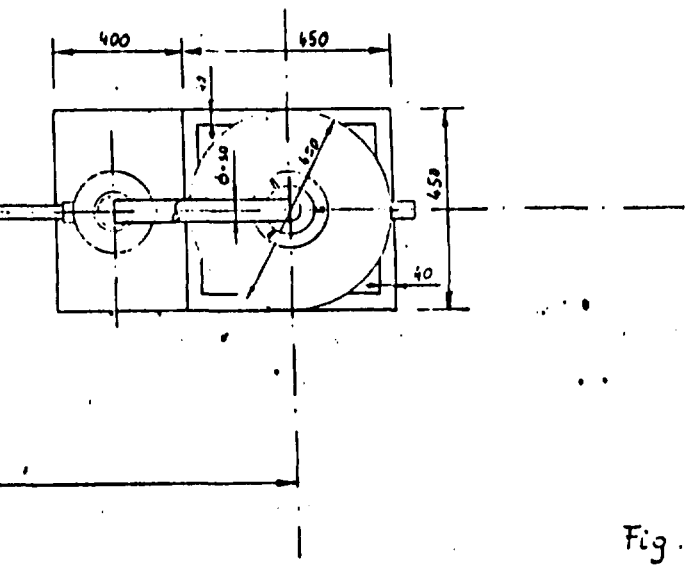


Fig. 1.1.

TION OF ESSENTIAL OILS.

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M NOWAK
on 4th Sept. '77

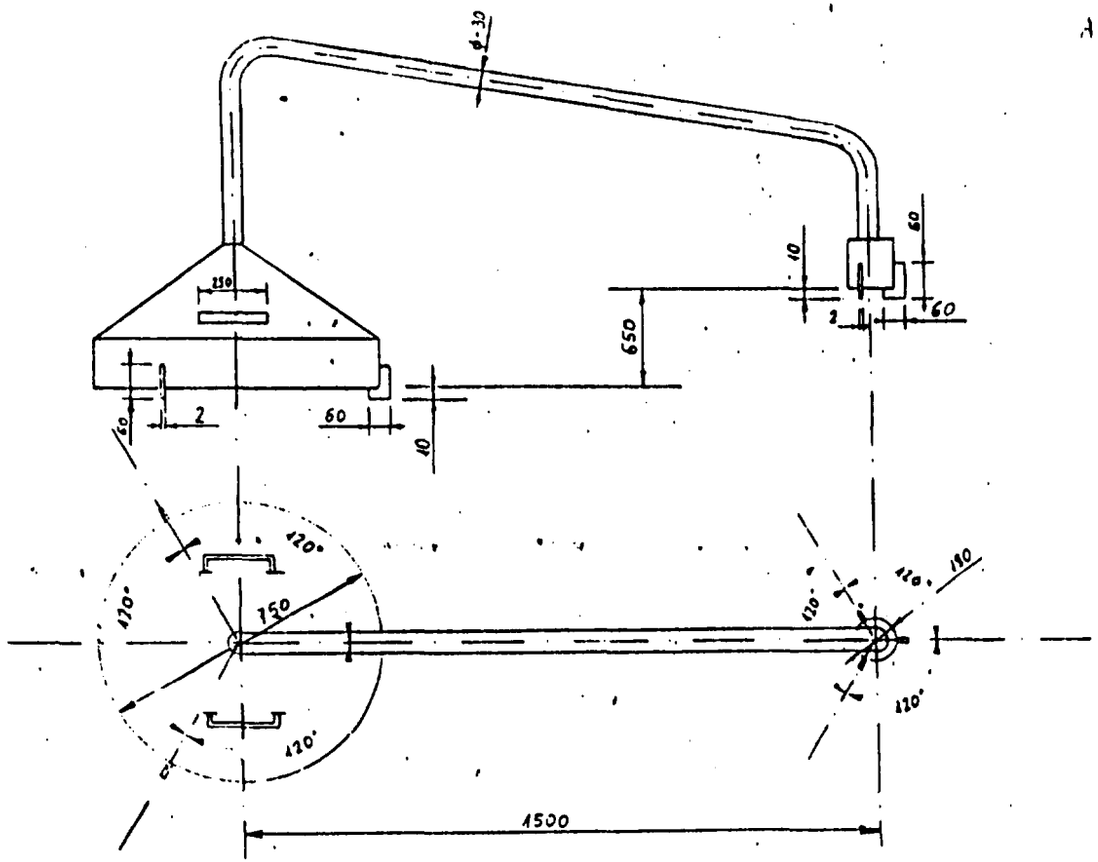

Fig. 1.2.

APPARATUS SET FOR DISTILLATION OF ESSENTIAL OILS.

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M. NOWAK
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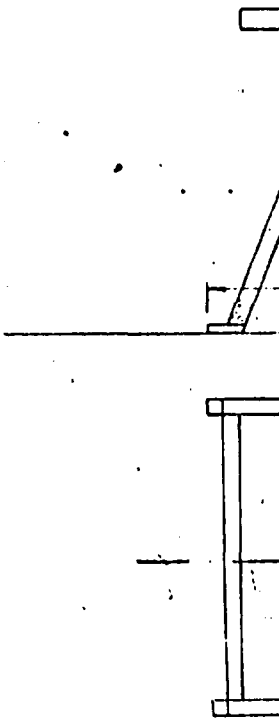

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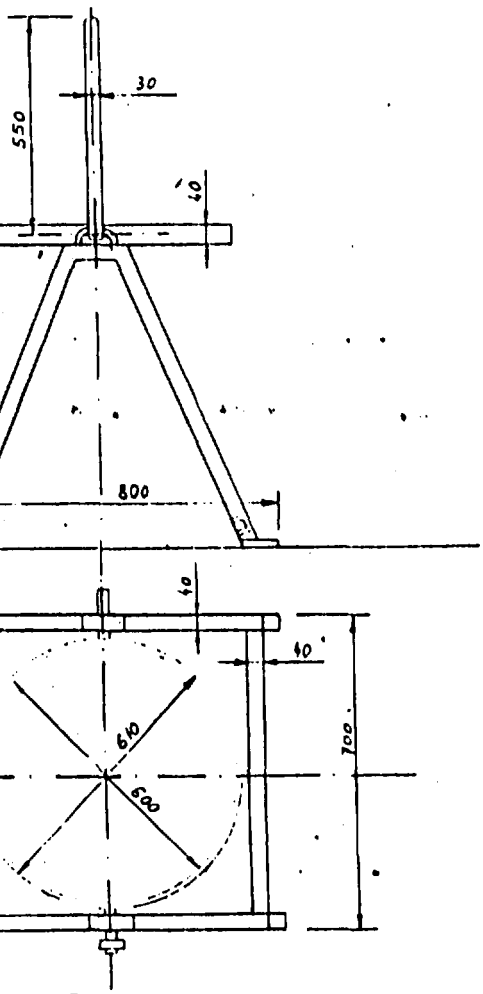

LLATION OF ESSENTIAL OILS.

ALL DIMENSIONS
IN MM

Fig. 1.3.

DESIGNED BY
M. NOLAN
on 4th Sept. '79