# STATUS OF NON-ELECTRIC USE OF GEOTHERMAL ENERGY IN THE SOUTHERN NEGROS GEOTHERMAL FIELD IN THE PHILIPPINES

S.E. CHUA AND G.F. ABITO

PNOC, Energy Research and Development Center, Commonwealth Avenue, Diliman, Quezon City, Philippines

ABSTRACT

A 1 MWth multi-crop drying facility using low enthalpy waste geothermal heat is being installed within the vicinity of the Southern Negros Geothermal Project. The plant is envisioned to demonstrate the direct use of geothermal resources for agro-industrial purposes and at the same time provide major benefits by raising the quality of the agro-industrial products to meet higher standards.

The development and design of the heat exchangers that will supply the heat and the dryer to be used in the facility is presented. The process flow and the drying parameters to be initially considered in the drying of coconut meat and other crops have been determined. The initial design of the dryers will target the dehydration of coconut meat and other crops using boxes and trays.

## INTRODUCTION

The Philippines ranks second to the United States in terms of geothermal 'power generation with the present total generating capacity of 894 $MW_e$. On the other hand, the potential for the direct heat applications of geothermal energy has largely remained untapped. Realizing the potential significant impact of direct utilization of geothermal heat, particularly in the agro-industrial sector, PNOC-Energy Development Corporation (EDC) undertook a series of UNDP-assisted feasibility studies on the development of non-power applications of geothermal energy in 1986. One of the recommendations of these studies was the setting up of an agro-industrial demonstration plant which would demonstrate the technical and commercial viability of using geothermal heat for the drying of crops and aquatic products. Of the many sites studied under this project, Palinpinon, Valencia, in the province of Negros Oriental, was identified as the most promising site for an agro-industrial demonstration plant.

In response to this recommendation to set up an agro-industrial demonstration plant, the PNOC-Energy Research and Development Center (ERDC) in cooperation with PNOC-EDC conducted a pre-project study in 1990 to ascertain the appropriate size and capacity of the demonstration plant that would be commercially viable. Surveys were conducted and information on the types of crops dried, types of dryers currently in use (including capital, operating and maintenance costs), estimated volume of raw materials available for drying, and clients who would be receptive to the idea of using the geothermal drying plant, were obtained. These data indicated the commercial potential of a 1 $MW_{th}$ dryer utilizing geothermal heat in the drying of coconut meat among other agricultural crops.

As a consequence of the above recommendation and studies, the United Nations Development Programme (UNDP) is funding the establishment of such an agro-industrial demonstration plant in Palinpinon, where PNOC is operating one of its geothermal fields which supplies steam to a power plant of the National Power Corporation, the state-owned utility company. The project, which was approved by the UNDP in early 1992, is being implemented by the PNOC-Energy Research and Development Center. The project's developmental objective is to develop the capability in the Philippines to be self-sufficient in the design, installation and operation of geothermal direct-use applications. More specifically, the project will install and operate a 1 $MW_{th}$ pilot crop drying facility using low-enthalpy geothermal heat, evaluate the techno-economic viability of this pilot plant, and continue with its commercial operation through a private local cooperative in Valencia if proven economically and technically viable.

## PROCESS FLOW, MAJOR EQUIPMENT AND BUILDING

### PROCESS FLOW

#### GEOTHERMAL BRINE SIDE

The drying plant will use as its primary source of heat the separated geothermal brine from the Palinpinon I steam gathering system. The plant is located at one of the reinjection pads, N3, of the Southern Negros Geothermal Field where the separated geothermal brine is reinjected back into the geological formation though wells N3, TC1RD, TC2RD, and TC3RD. Currently, because of its low capacity for acceptance, TC1RD is not being used and the geothermal brine to be used in the plant will be tapped from the main line leading to this well.

The geothermal brine with a temperature of 160°C will pass through a primary shell and tube heat exchanger (EA-100), where heat will be extracted. Two schemes of reinjection of the geothermal brine are being considered. One scheme is for the geothermal brine from the primary heat exchanger to be released to a cold reinjection sump, subsequently to be reinjected back to N1, a cold reinjection well located northwest of the N3-pad. Another scheme is to reinject the geothermal brine back to TC2RD well at a minimum temperature of 154°C through the existing top valve.

The outlet temperature of the primary heat exchanger (EA-100) will be controlled to a minimum of 154°C to avoid silica deposition in the reinjection well by controlling the flow rate of the clean water through the temperature control valve TV-100. The inlet and outlet temperatures and pressures at, as well as the flow rate to, the primary heat exchanger will be continuously monitored at the control room through the various sensors and transmitters that will be installed at the geothermal brine line.

The required flowrate of the geothermal brine will be fixed at 60 kg/s for the reinjection scheme to N1, and a minimum of 80 kg/s for the reinjection scheme to TC2RD. Calculated corresponding temperature drops are estimated at 7°C and 3°C, respectively.

## CLEAN WATER SIDE

A closed loop system is designed for the clean water side. Clean water at 80°C will be pumped from the atmospheric hot water tank (TK-100) to the primary heat exchanger (EA-100). From the primary heat exchanger, the heated water at 98°C will pass through seven identical air heaters (EC-100 A/B/C/D/E/F/G ), cool down to 80°C and then return to the hot water tank.

As shown in Figure 1 which is the piping and instrumentation diagram, seven modular air heaters will be used to provide flexibility in the operation of the drying plant. To compensate for the increase in the line pressure if one or more heaters were partially or totally closed, an automatic by-pass pressure control valve (PV-100) is provided. This will ensure the operation at constant heat rate of the other heaters.

## HEAT EXCHANGERS

### PRIMARY HEAT EXCHANGER (EA-100)

The primary heat exchanger shown in Figure 2 will transfer heat from the geothermal brine to the closed loop water system. It is a TEMA type 'AES' shell and tube heat exchanger with a heat duty of 1 $MW_{th}$ and will consist of 123 1524-mm long, 25.4-mm od tubes. The calculated pressure drop across the heat exchanger in the brine side is 24 kPa.

An advantage of a shell and tube heat exchanger over a plate type heat exchanger, which is more commonly used in the industry, is that the former is more flexible in terms of massive flow rate fluctuations typical of the chosen reinjection lines. Furthermore, plate type heat exchangers are limited to a maximum operating temperature of around 200°C and a maximum operating pressure of 25 bars. These limits, especially the maximum pressure, are relatively low if we are to consider the operating conditions of SNGP's reinjection lines.

### AIR HEATERS (EC-100)

The drying plant will utilize seven identical HTTI tubular air heaters (labeled EC-100 A/B/C/D/E/F/G in Figure 1) shown in Figure 2. Each heater will consist of a bank of six parallel streams of 28 horizontal 25.4-mm finned tubes in the tube side. Ambient air in the shell side will be heated to 75°C during normal operation by the hot water flowing in the tube side. The system will be completely counter flow.

Each heater will be provided with a centrifugal air blower with a design capacity of 16,000 kg/hr of air at static pressure of 71-mm water. Manual variable inlet vanes will be provided to allow for the variation of the air flow rate which is required in drying different kinds of crops.

## DRYERS

A series of experiments on the drying of coconut meat, fruits, root crops, spices and aquatic products was conducted by PNOC-ERDC to establish the process conditions and drying parameters to be used. for the design of the dryers. Results from these experiments led to two modular dryer designs which will allow simultaneous processing of different raw materials at a time. Figure 2 shows the concept of using dryer boxes for the dehydration of coconut meat. This design reduces the labor and material handling needed to dry the projected 12 MT of coconut meat per day.

For the dehydration of fruits, root crops and spices, a cabinet-type dryer with trays is deemed to be more suitable because of the special handling required. This design is shown in Figure 3.

Each dryer basically consists of a 1-m wide x 0.5-m deep x 6-m long trench which distribute the hot air to the drying boxes/dryer trays and carts stacked on top. The seven trenches (one trench for each dryer module) can accommodate a total of 12 MT of fresh coconut meat. Each drying module may consist of two or three layers of boxes with five boxes per layer, or five carts with five dryer trays per cart, The dryer boxes/trays will be lined with stainless steel sheet inside and stainless steel mesh wires will be used. The hot air (at 75°C), after passing through the stainless steel mesh at the bottom of each box/tray, will provide heat to dry the materials. Loading of the boxes will be accomplished using a forklift whereas the carts will be wheeled into the the drying cabinets.

**DRYING PLANT BUILDING**

The demonstration plant building has a total floor area of 650 square meters on a 1000 square meter land area. It has a "dry" area which houses the seven dryer systems and provision for a "wet" area which will be dedicated for small scale food processing and preparations necessary for the dehydration of fruits, other crops and aquatic products, A small laboratory equipped with instruments for quality control/raw material analysis will also be provided.

All the major equipment except for the primary heat exchanger will be housed inside the building. The primary heat exchanger will be located outside the building to minimize food contamination in the event of a leakage on the geothermal brine side of the heat exchanger and its lines.

OPERATIONAL AND MARKETING STRATEGIES

**OPERATING SCHEME**

The proposed drying plant has been designed to handle an estimated 12 MT/day of coconut meat equivalent to about 6 to 7 MT of copra (at 7 to 10 % moisture content). An operating capacity of 85 to 95 % of rated is targeted to ensure the operational viability of the drying plant.

While the demonstration plant is planned to primarily process copra, it is designed to consist of independent (modular type) drying units capable of simultaneously handling several agricultural and marine products (e.g., mango, jackfruit, papaya, pineapple, root crops, spices and to a certain extent seaweeds and fish). Expectedly, the choice of the alternative products as,well as the drying capacity will be dictated by the assured availability and quantity of the particular agricultural raw material. However, it is expected that over 50 % of the total available capacity shall be devoted to coconut meat drying.

RAW MATERIAL SOURCING

Initial surveys conducted indicated abundant supply of coconut meat in the Dumaguete area. The project staff and the local consultant conducted a series of meetings with different cooperative groups in the area. The cooperative groups, in particular the Valencia Multi-Purpose Agricultural Cooperative, Inc. (VAMPACI) has indicated interest in supplying the coconut meat required by the facility.

A raw material study is currently being undertaken with the objective of identifying actual supply sources and pick-up points of the coconut meat and other agricultural and aquatic products to be dehydrated in the drying plant.

MARKETING SCHEMES

There are currently four major copra traders in Dumaguete and an undetermined number of small and marginal traders as well. Market for copra (currently required to have a maximum of 12 % moisture content) are the major and medium sized oil millers in Negros, Cebu and Mindanao.

A fixed premium on a per kilogram basis (based on the guidelines of the Philippine Coconut Authority) is added to the prevailing copra buying price in the trading area for high quality, dried product, considering, among others, physical appearance (preferably whitish and free of molds and other impurities) and final moisture content. A 7 to 12 % final water content in the dried product is acceptable to ensure aflatoxin-free condition.

Copra drying by geothermal brine as a closed system as well as the plant's operating conditions will ensure the maintenance of high quality finished product.

Marketing of the finished product shall be done through a combination of direct selling to traders or through the cooperatives, particularly if the raw materials are sourced through them.

POTENTIAL PROBLEMS

The following potential problems have been identified and are being addressed in the design phase:

1. Hastening of silica deposition in the reinjection well due to thermal drop.

For reinjection to TC2RD at a flow rate of 80 kg/s, the thermal drop in the primary heat exchanger will **result** in a **drop** of only 3°C in the mixing temperature, i.e., the resulting fluid temperature when the fluid coming from the heat exchanger is returned to the reinjection line. At this temperature, (157°C) the silica saturation index practically change **very** little and hence will not hasten the deposition process in the reinjection well.

2. Deposition in the heat exchanger tubes.

It is expected that deposition will occur in the tubes because the fluid will be supersaturated with respect to amorphous silica as the temperature drops. However, to determine how fast the deposition rate would require experience as baseline data. Nevertheless, we have provided measures for this by designing the primary heat exchanger such that the tubes could be easily pulled out for mechanical cleaning and by incorporating a dosing tap upstream of the primary heat exchanger for introducing scale inhibiting agents.

## CONCLUSION

The establishment of the agro-industrial demonstration plant in Palinpinon may be considered as a pioneering effort in the Philippines insofar as direct-heat applications of geothermal energy is concerned. Although there had been earlier attempts to harness low-enthalpy geothermal fluid for process heat and other agricultural applications, these have not **been** pursued systematically and most have failed and were discontinued for various technical reasons.

The design of the present agro-industrial demonstration plant incorporates the knowledge and experience gained during the last twenty years in the United States, Iceland, New Zealand, Japan and other countries on direct applications of geothermal heat. Once proven technically and economically viable, similar installations will be established in other parts of the country where geothermal heat are available and where useful applications may be identified. In this regard, PNOC-Energy Research and Development Center is now undertaking a survey of potential sites in the Philippines.

## ACKNOWLEDGMENTS

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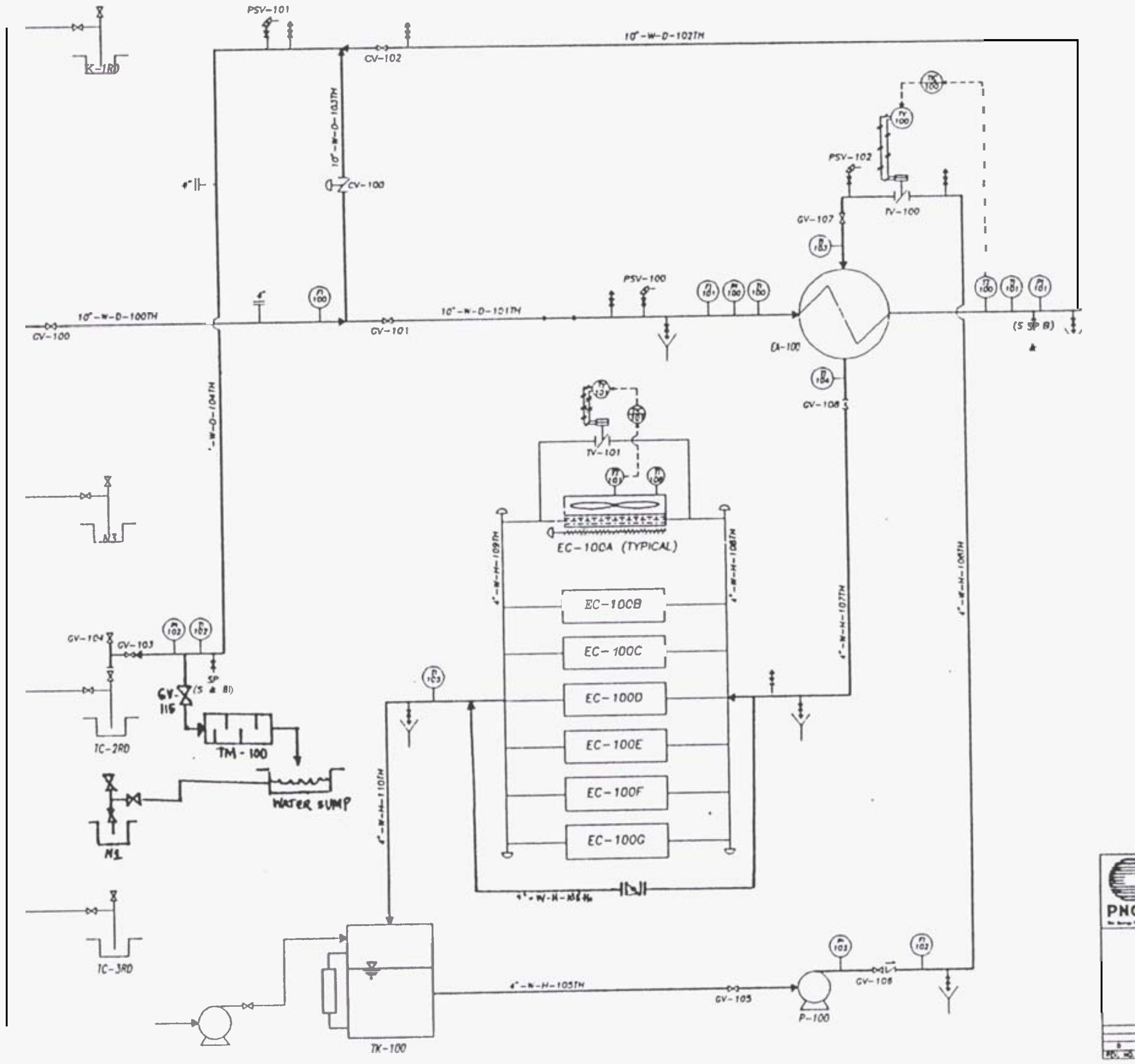

PSV-101
10"-W-D-102TH
CV-102
10"-W-D-103TH
CV-100
K-1RD
10"-W-D-100TH
CV-100
CV-101
10"-W-D-101TH
PSV-100
PSV-102
GV-107
TV-100
EA-100
GV-106
TV-101
EC-100A (TYPICAL)
EC-100B
EC-100C
EC-100D
EC-100E
EC-100F
EC-100G
GV-104
GV-103
TC-2RD
TM-100
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P-100
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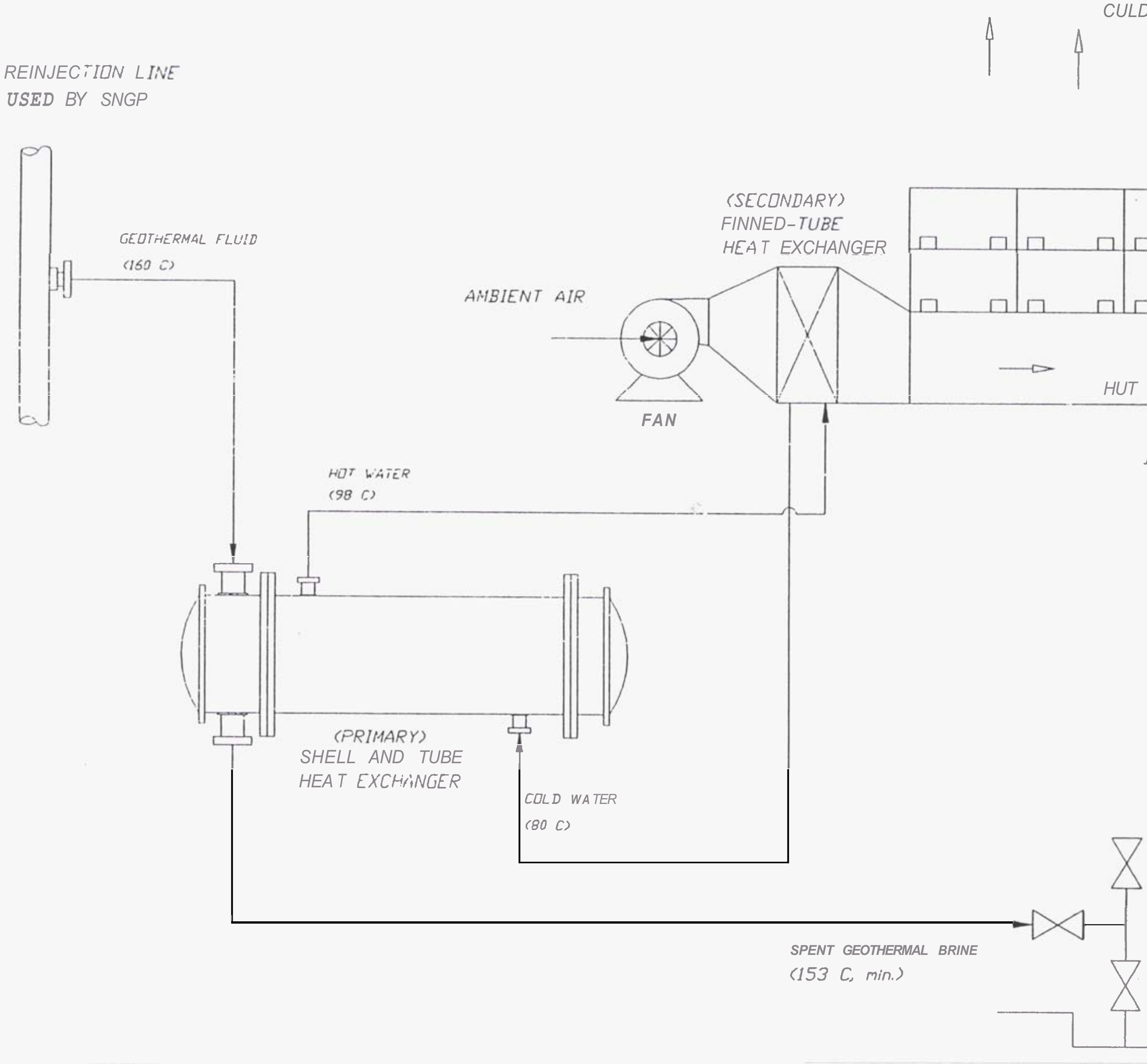
CULD
REINJECTION LINE
USED BY SNGP
(SECONDARY)
FINNED-TUBE
HEAT EXCHANGER
GEOTHERMAL FLUID
(160 C)
AMBIENT AIR
HUT
FAN
HOT WATER
(98 C)
(PRIMARY)
SHELL AND TUBE
HEAT EXCHANGER
COLD WATER
(80 C)
SPENT GEOTHERMAL BRINE
(153 C, min.)

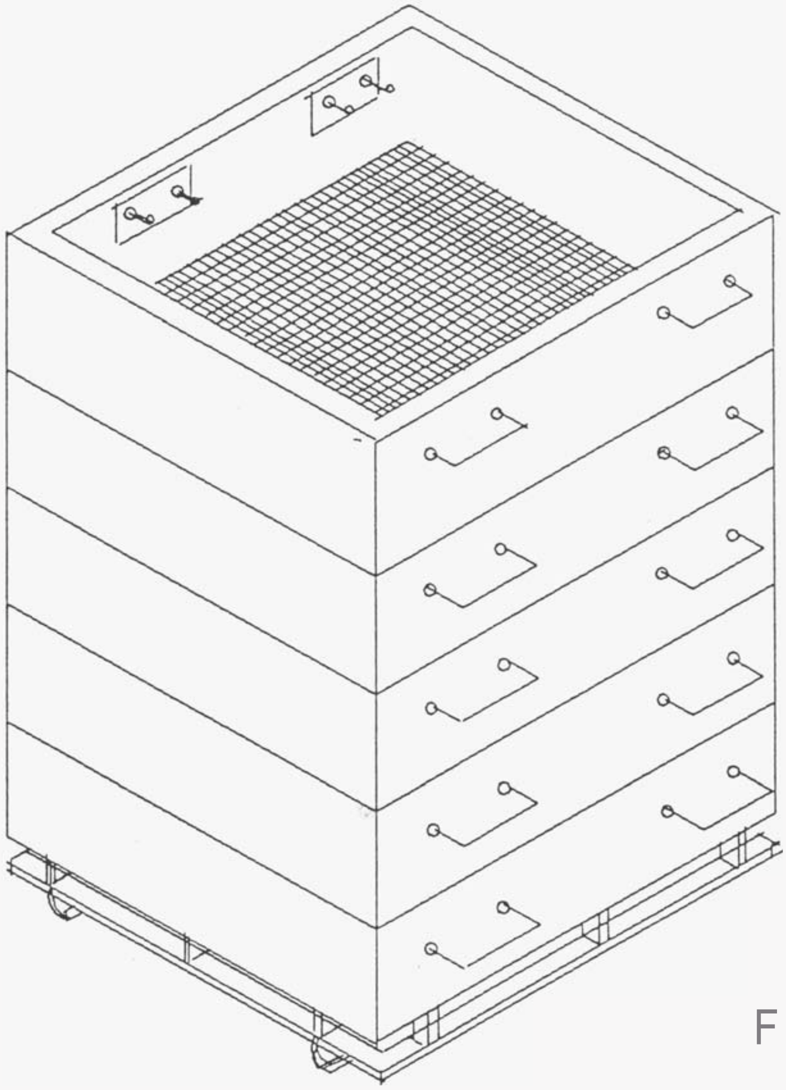

FIGURE *3*