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ENCLOSURE (B)

ENCLOSURE (B) 1

DESIGN STUDIES OF CARBONIZATION APPARATUS FOR PINE ROOTS

by

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LIST OF TABLES AND ILLUSTRATIONS

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I. INTRODUCTION

A. History

Pine root oil has been manufactured in our country for many years. The carbonization of pine roots is a domestic industry, and the operation a very expensive one. Under ordinary conditions it would not be a successful method of producing fuels. In September 1944, however, this industry was expanded as the result of war time necessity, and the design of a simplified unit for carbonization of pine root was given high priority. In this connection, a visit was made to NAGANO Prefecture for the purpose of inspecting, and sketching pine root installations. These installations had daily carbonization capacities of 500 - 750 kg of pine roots and consisted of 2 vertical retorts. On the basis of this survey and other considerations, it was decided to design according to the following conditions:

1. The construction of the apparatus would be as simple as possible using a minimum of critical materials.

2. The retorts would be of the vertical type with a daily charge capacity of 375 kg of pine roots each.

After this apparatus was designed, in December 1944 experiments were made to study the following:

1. Temperature distribution in the retort.

2. Relation between firing and distillate.

3. Comparison of "A" and "B" type distillation units as shown in Figure 5(B)1.

On the basis of these experiments, type "A" apparatus was adopted for large scale installations.

B. Key Research Personnel Working on the Project

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Nav. Chem. Eng. Lt. Comdr., S. SANKA
Nav. Chem. Eng. Lt. (jg), Y. MORI
Nav. Chem. Eng. Lt. (jg), H. KINGO
Nav. Ass't. Eng., M. KUBOTA

II. DETAILED DESCRIPTION

A. Design and Operating Procedure

A flow sheet of the plant is shown in Figure 1(B)1. The pine roots are cut into pieces about 2.5 cm^2 and 30 cm in length, and 270-380 kg are packed into the retort. After about 2 hours of firing, the oil and pyroligneous liquor flow from the condenser and are separated into two layers in the water separator. Tar is separated in the tar-separator and is collected in the tar receiver after about 3.5 hours of firing. Gas produced after about 5.5 hours of firing is used as fuel.

B. Experimental Results

1. Yield and material balance (based on 375 kg charge of pine roots). See Table I(B)1.

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The yield was much affected by the quality of pine roots. Between rich and poor pine roots, there was a range from 8 to 40% by wt. yield of tar plus oil, the average yield being about 20%. Under actual operating conditions the yield was very much influenced by leakage at the joints of the bamboo cooler. Painting the joints with boiled tar was tested, but when the temperature reached 30°C this was not effective.

2. Properties of product. See Table II(B)1.

3. Performance data. The relations between yield of distilled oil, fuel consumption and time is shown in Figure 2(B)1. The temperatures distribution in the retort and the effect of water content of the charge, on the carbonization pine stems was also studied and the results are given in Figure 3(B)1 and Figure 4(B)1. Labor and utility requirements are summarized below:

Operating Cycle

Carbonization of pine roots.....	10 -12 hr
Cooling of retort.....	8 - 9 hr
Preparation and charge.....	3 hr
Total	18 - 24 hr

Fuel Consumption

Wood (Using gas from carbonization retort). 100-150 kg/retort/day.

Condensing Water

Cooling water (average)
1 m^3/hr x 13hr/day=13 m^3/day for 2 retorts.

Labor

Chipping pine roots.....	6 men
Fire man	1
Oil receiver man.....	1
Total	8

III. MISCELLANEOUS DESIGN CONSIDERATIONS

A. Basis for Selection of the Vertical Retort--(Type A).

1. Professional pine root workers had used the vertical type retort more than the horizontal type. Accordingly, to develop the dry-distillation method most rapidly, it was considered best to use the vertical type.

2. It was generally believed that to get terpene oil of good quality from pine roots containing much resin, the vertical type retort was more suitable than the horizontal due to less oil cracking.

3. A retort of 375 kg (100 kan) was adopted since this size could be made simply by rolling a 5 ft x 10 ft steel plate and welding.

From the standpoint of yield, a smaller retort would be slightly better, but on the basis of labor requirements, working hours and actual quantity of oil obtained, the 5 ft x 10 ft retort was superior.

B. Comparison of Two Types of Carbonization Apparatus

Two types of dry-distillation retorts as shown in Figure 5(B)1 were studied. Test runs were made and results are tabulated in Table III(B)1. The temperature distribution in each retort is given on Figure 5(B)1. On the basis of these experiment it was concluded that "A" type is more efficient than the "B" type.

C. Basis for Selecting Bamboo for Cooling Pipe

1. There was a shortage of copper and iron pipe in Japan, and bamboo was conveniently available.

2. The cooling effect of bamboo was fairly good, the overall heat transfer coefficient being approximately 30-40 kcal/m^2/hr/^oC as compared with 60 for iron pipe.

Table I(B)1
YIELD AND MATERIAL BALANCE

Product	Quantity		Wt % based on charge
	Liters	Kg	
Gas and loss			15
Pyroligneous liquor	150	165	44
Pine root crude oil	27	26	7
Pine root tar	45	54	14
Pine charcoal		75	20
Total	222	320	100

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Table II(B)1
PROPERTIES OF PRODUCT

		Crude oil	Tar	Oil and tar mixed
Specific gravity		0.964	1.070	0.990
Distillation (°C)	Initial point - 150	3.4	4.0	3.7
	150 - 200	50.5	5.8	31.0
	200 - 250	11.2	6.0	12.1
	250 - 300	11.2	9.0	7.1
	300 - 330	10.3	55.5	25.5
	Residue in 100cc (gm)	19.1	15.2	19.0

Table III(B)1
TEST RUN RESULTS

	Charge of Pine roots	Operating hours	Fuel consumption (wood charcoal)	Yield of tar and oil*	Cooling time** hours
Type A	300 kg	10-12	60-80 kg/cycle	about 20%	4-6
Type B	300 kg	12-14	80-100 kg/cycle	about 20%	9-12

* Weight per packed pine root
** Cooling time: The retort must be cooled to below 150°C before opening to prevent combustion of the charcoal.

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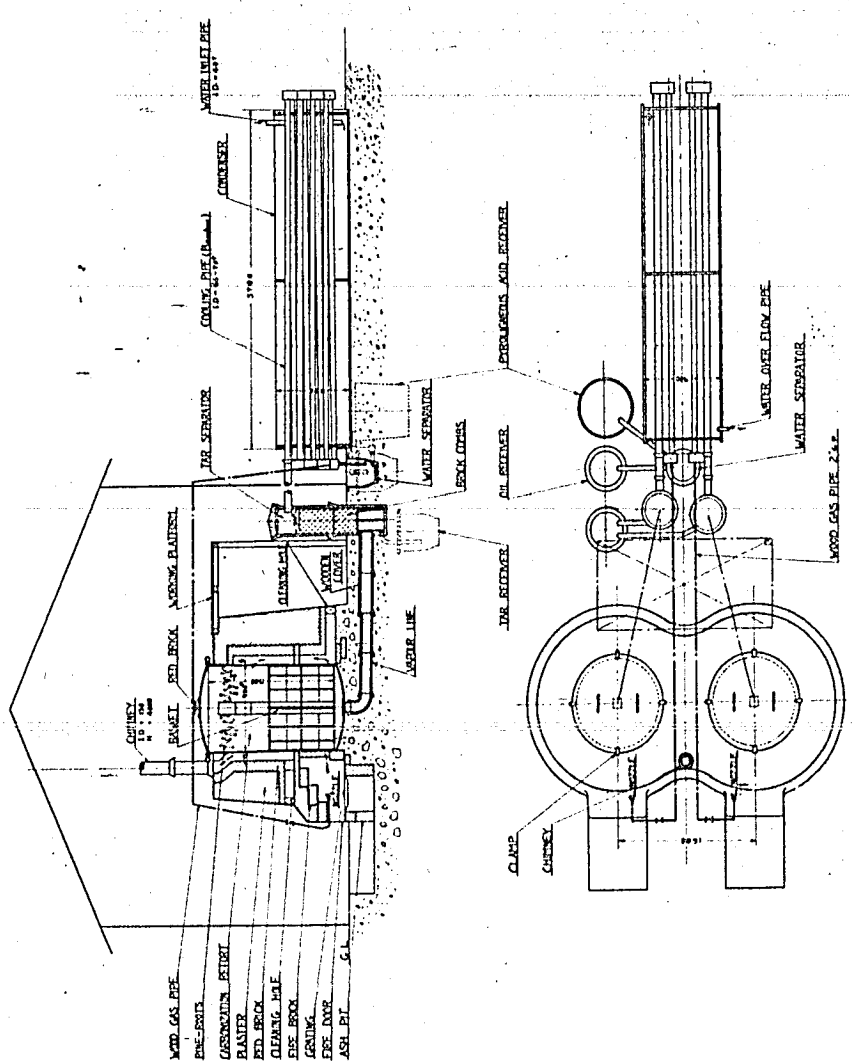

Figure 1(B)1
GENERAL ARRANGMENT OF PINE-ROOT CARBONIZATION APPARATUS
Daily Capacity 750kg/1set.

ENCLOSURE (B)1

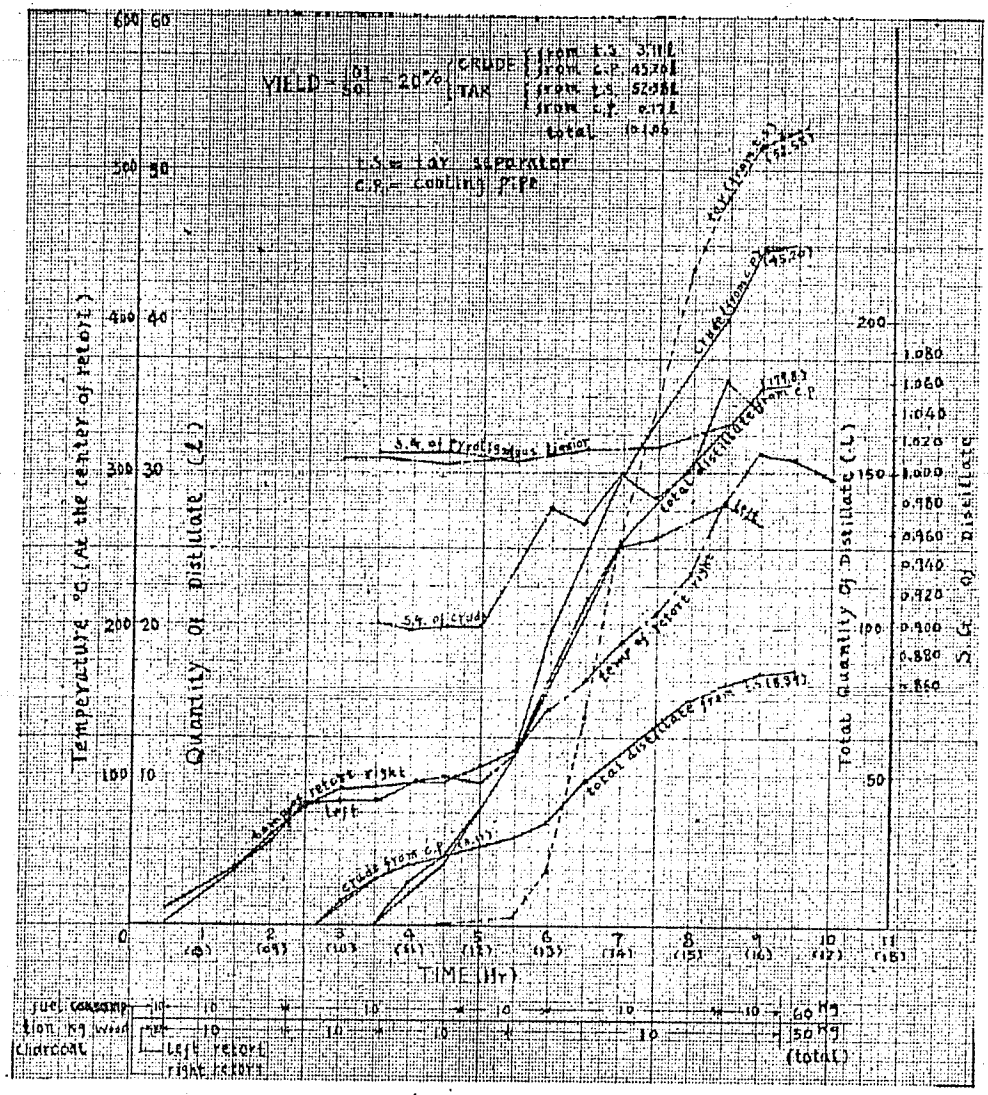

Figure 2(B)1

CURVES OF THE TEMPERATURE OF RETORT,

FEED OF DISTILLATE AND THE SPECIFIC GRAVITY OF DISTILLATE

The weight of packed pine root left 248kg., right 253kg.

ENCLOSURE (B)1

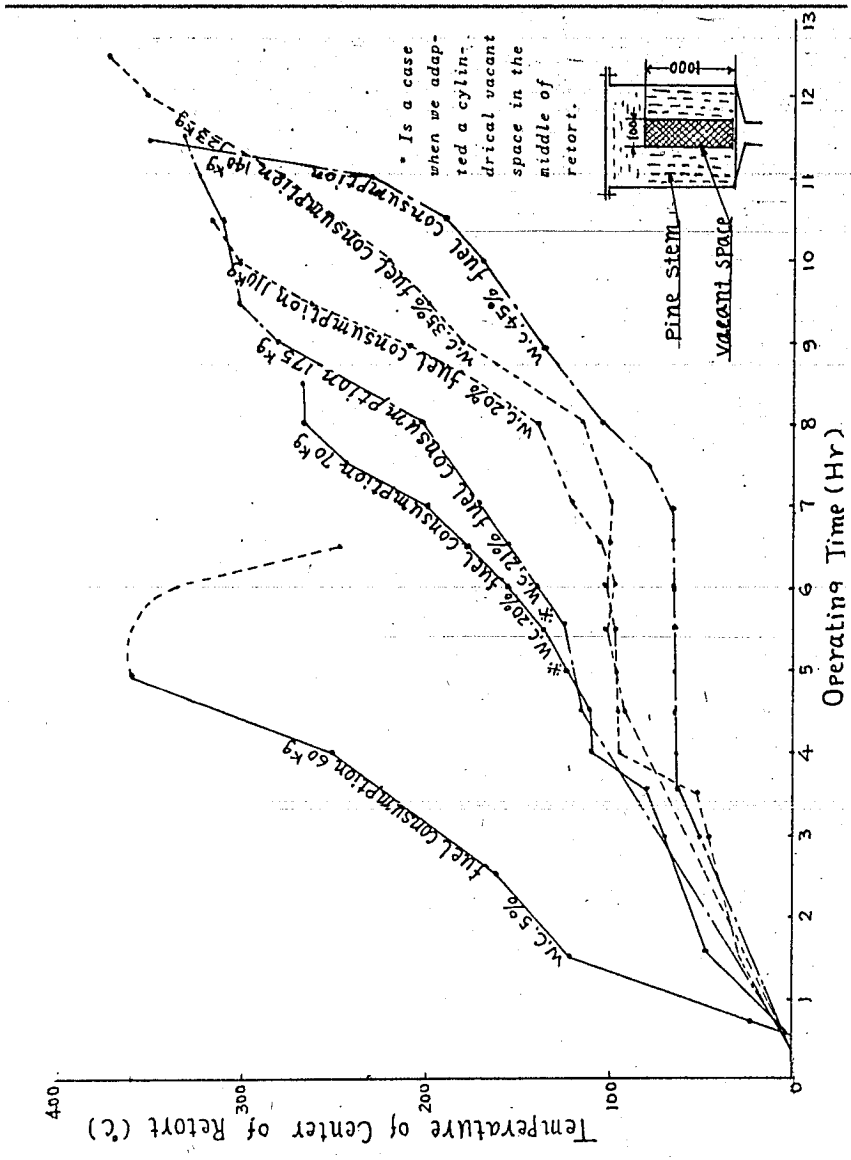

Figure 3(B)1

RELATION BETWEEN THE TEMPERATURE OF THE CENTER OF RETORT AND THE WATER CONTENT OF PACKED PINE STEM

ENCLOSURE (B)1

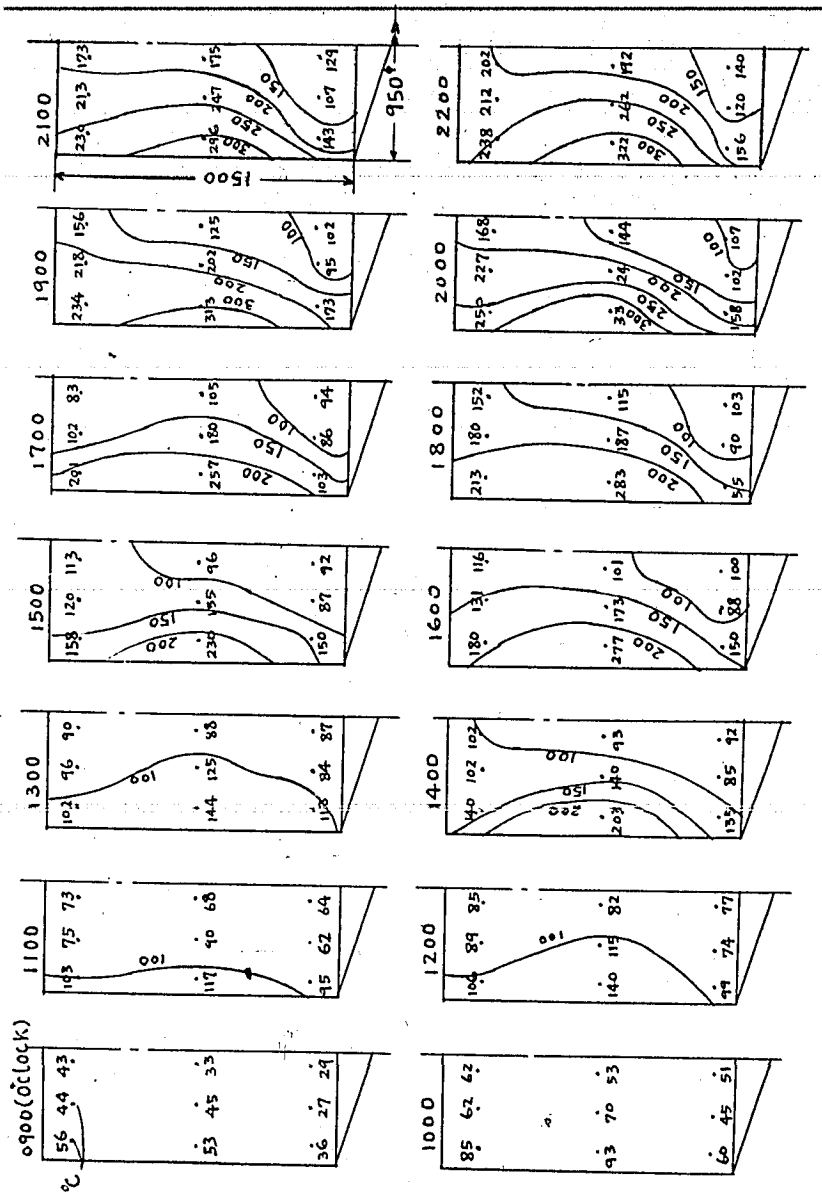

Figure 4(B)1
THE CHANGE OF THE TEMPERATURE DISTRIBUTION
IN THE RETORT (USED THE PINE STEM) ('A' TYPE RETORT)

ENCLOSURE (B)1

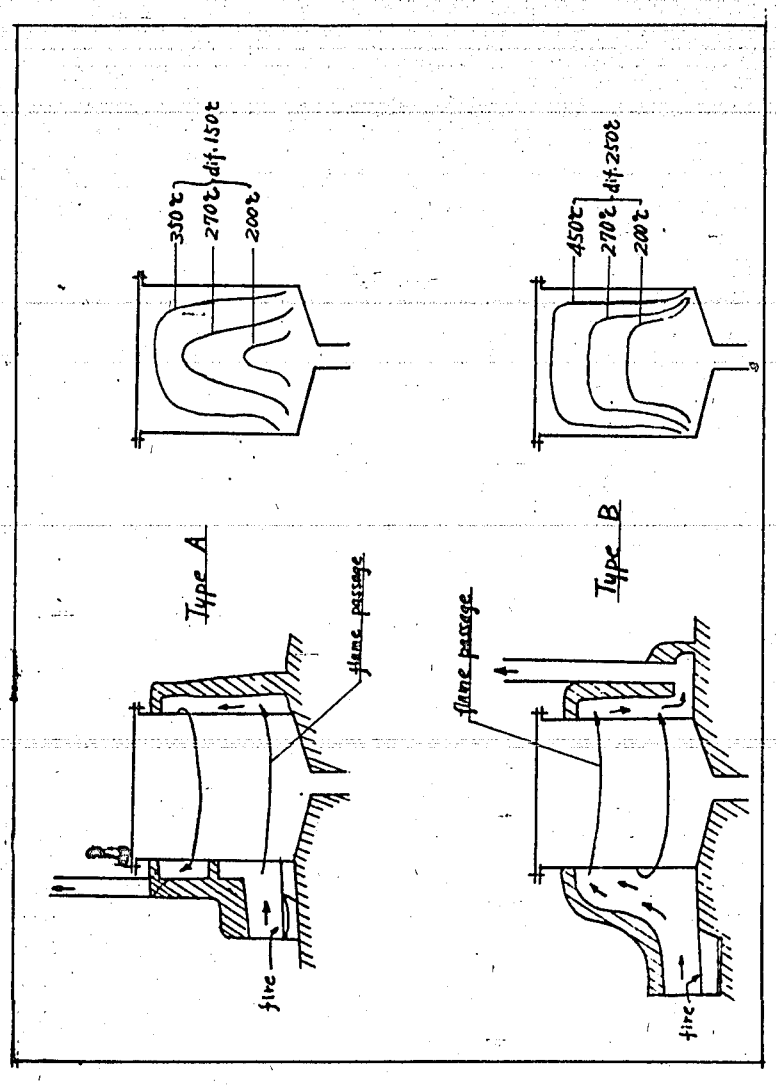

Figure 5(B)1
THE COMPARISON OF A AND B DISTILLATION APPARATUS

ENCLOSURE (B)1

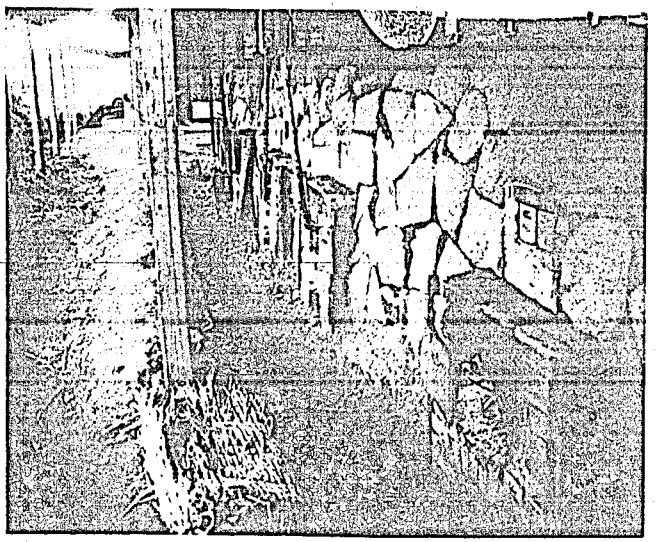

Figure 6(B)1
TYPICAL VIEW
OF PINE ROOT
CARBONIZATION
FACTORY IN
THE COUNTRY.

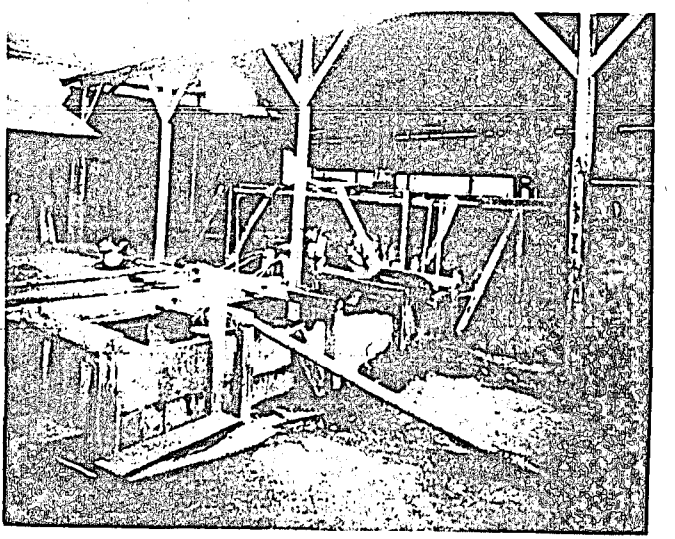

Figure 7(B)1
TYPICAL VIEW
OF PINE ROOT
CARBONIZATION
FACTORY IN
THE COUNTRY