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# ASSISTANCE TO ENERGY PRODUCTION FROM BIOMASS WASTE MATERIALS

DP/PHI/78/022

PHILIPPINES

Technical Report *

14 October to 13 December 1984

Prepared for the Government of the Philippines
by the United Nations Industrial Development Organization,
acting as executing agency for United Nations Development Programme

Based on the work of Robert O. Williams
Consultant on Biomass Gasification

* This document has been reproduced without formal editing.

# TABLE OF CONTENTS

## SUMMARY

This report describes work accomplished during the period October 1984 to March 1985 by the Consultant. The mission required the installation of a rice hull gasifier system.

Modifications to the original design of the system, and a description of the installation are presented in Section 1. Furnace conversion and design of the low-Btu gas burner are given in Section 2. The on-site monitoring program is described in Section 3. Fabrication drawings and photographs of the equipment are included in the Appendices.

# A C K N O W L E D G M E N T

The author would like to thank UNIDO for inviting him to undertake this mission; Dr. Myint Maung, Vienna; and Dr. Ivan E. Pluhar, Manila, are acknowledged for their assistances during the mission.

Dr. Ibarra E. Cruz, Manager, PNOC-ERDC, assisted the consultant during his work as did. Mr. Mel Milo T. Cruz, Mr. Melchor M. dela Cruz, and Mr. Mario P. Carlos of the Conventional Fuels Department, PNOC-ERDC.

1/

## Introduction

As part of a program to transfer alternate energy technology being developed at PNOC-ERDC to the commercial sector, the consultant was asked to assist with the installation and testing of a gasifier system.

Low-Btu gas from the system is used as fuel in an aluminum melting furnace. Rice hull fuel for the gasifier is obtained from a neighboring rice mill.

The consultant was asked to modify the designs of the rice-hull gasifier system he prepared on the previous mission. After this was accomplished, a suitable fabricator was selected, and the consultant supervised construction of the equipment (Figures 2 - 4). A method of furnace conversion and a new low-Btu gas burner were designed and submitted to the host industry for implementation and fabrication. With the advice of the consultant, a Memorandum of Agreement (Appendix 4) was drawn up between PNOC-ERDC and the host industry covering obligations of the host industry, particularly concerning furnace conversion and the provision of a fuel supply for the gasifier.

## 1. System Modifications

### 1.1 Modifications to System Design

The arrangement of components within the system and the interior configuration of the two reactors were modified from those presented in the Consultant's previous report (December 1982). These modifications facilitated simplication of manufacture and installation of the gasifier system, reducing costs and fabrication time.

The rice hull gasifier system is shown in Appendix 1. On exiting the reactors, low-Btu gas is delivered to the following components of the gas conditioning train in turn:

- A hot cyclone to remove coarse (< 10 μm) particulate matter carried over from the grate.
- A packed filter to remove fine ash and carbon soot.
- An air-cooled heat exchanger in which heavy tars are condensed, collected and removed.
- A packed filter to remove tar aerosols, entrained in the gas as it leaves the heat exchanger.
- A scrubber tower in which final gas cleaning is accomplished.

The gas fan and flare are located downstream of the scrubber tower. Gas streams from each reactor combine as they enter the scrubber tower. The fan pulls gas out of the scrubber and delivers it to either the flare or the aluminium furnace. Switching between flare and furnace is accomplished by two manually-controlled gate-valves. The

flare is used to dispose of unwanted gas during start-up and after shut-down.

A design drawing of the scrubber is given in the previous report. The filters and heat-exchanger are identical to those used on gasifier systems currently installed at the ERDC facility and at the University of the Philippines.

## 1.2 Modifications to Reactor Design

Design drawings of the reactor are given in Appendix 1. Major modifications involve the use of a rotating grate and a "wet" ash removal system. The grate is rotated by a pinion and bevel gear (detail in Appendix 1). A stationary scraper bar is mounted immediately above the grate to import a "stirring" action to the fuel bed. The sub-grate section of the reactor wall is cylindrical and open at the botton end. This end is partially submerged in a water bath. Ash, falling through the grate, is collected in the water bath, which is drained periodically. The water seal also acts as a safety device in the event of an internal explosion.

The two gasifier reactors have a combined output capability of 1300 MJ/hour, for a rice hull fuel consumption rate of 185 kg/hour. Each reactor has an internal diameter, measured at grate level of 60 cm. Other aspects of the internal configuration and function, including the throat section, dual-fire zone and ignition system are described in the previous report. Unlike in the first design, however,

the reactor now operates in suction mode which simplifies the feed system and eliminates the bridge-breaker.

Structural support of both reactors can be seen in the drawings in Appendix 1. Two 4 inch "I" beams, passing through the reactor wall, intersect at right angles in the center of the reactor. The reactor legs are located at each end of these two beams. The bevel gear and grate arrangement is supported on a shaft, riding in a collar welded to the two beams at their point of intersection.

## 2. FURNACE CONVERSION

### 2.1 Burner Design

A design drawing of the low-Btu gas burner to be installed in the aluminium furnace is included in Appendix 2. A nozzle-mixing tunnel burner will be employed; both gas and air are delivered to the burner under pressure. The furnace is a reverberatory type with two fuel oil burners installed at one end (Figure 1). The initial stage of furnace conversion requires one of the oil burners to be replaced by the low-Btu gas burner. The existing air supply to the oil burner will also be used with low-Btu gas. In this way, no structural alterations need be made to the furnace and returning it to full fuel oil operation is easily accomplished.

Independent modulation of the burner air supply is accomplished by the installation of a valve in the air line.

In the event of an emergency shut down and during start-up and after shut-down, gas is diverted to the flare located outside the furnace building. It is assumed that gas will only be delivered to the furnace after the one oil burner has been ignited and the furnace is hot.

## 3. ON SITE MONITORING PROGRAM

The primary objective of the consultant's monitoring program is to determine the feasibility of using rice hull-fired gasifiers to provide an indigenous, alternate fuel for use in industrial furnaces and boilers. To this end, the program speaks to the practical aspects of gasifier operation rather than investigating gasification theory. Priority is given to determining the ease with which gasifier operation can be integrated into the furnace operating cycle. Key issues are:

- Reliability of fuel (rice-hull supply).
- Frequency of refueling and fuel consumption rate.
- Labor requirements for operation and maintenance.
- Level of skill required by operating labor.
- Operating and maintenance costs.

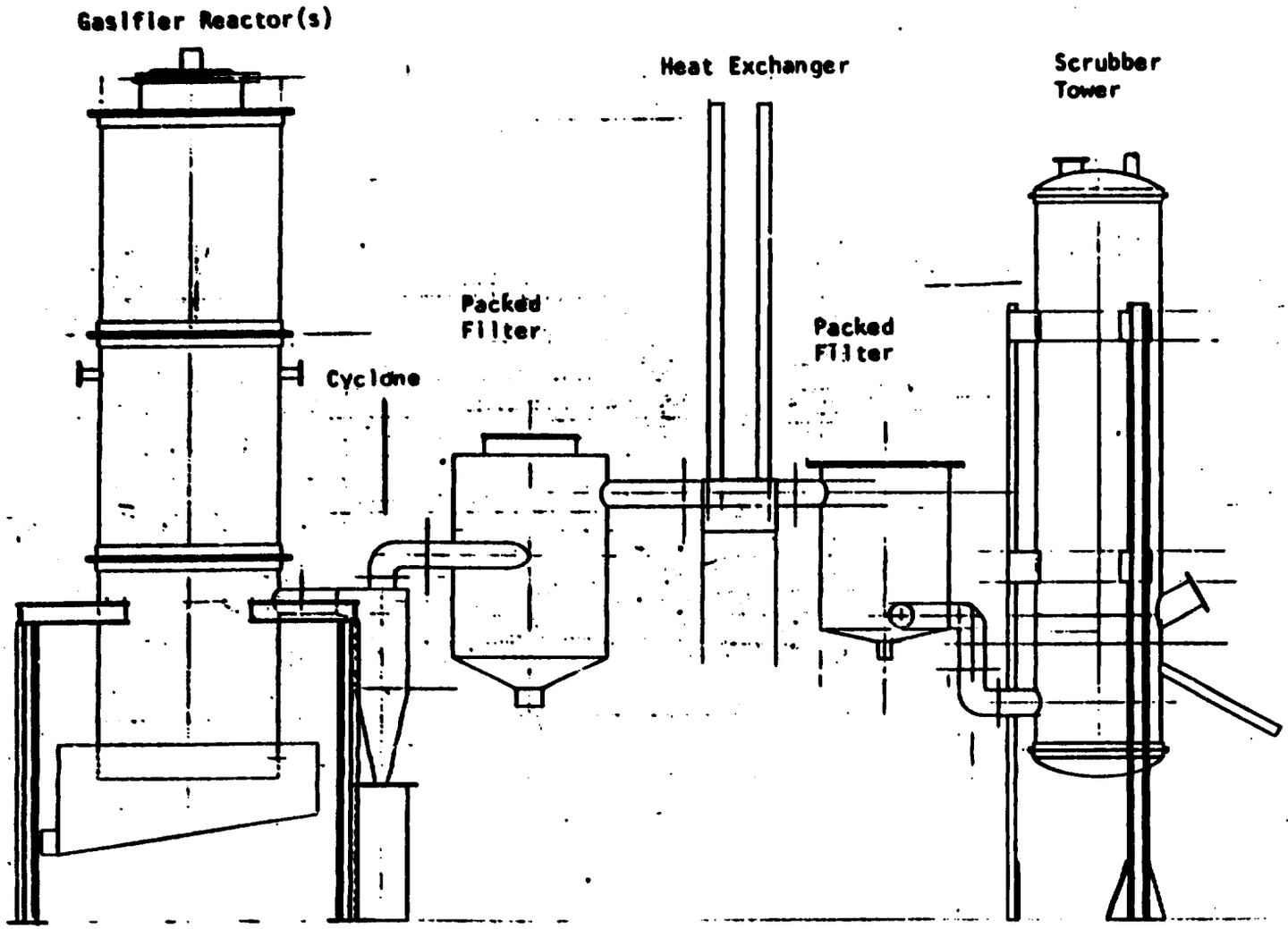
The extent to which the low-Btu gas contains tars, aerosols and particulate contaminants has not been quantified. In the event these contaminants are delivered to the furnace, operating problems with pipes, valves and burners will occur. Certain elements, possibly present in

aluminium inside the furnace. Consequently, it was necessary to install the complete gas conditioning train described in Section 1.1. One aspect of the on-site monitoring program involves the determination of whether or not the conditioning train can be simplified and possible eliminated altogether. Elimination of the clean-up train reduces system capital and operating costs and avoids cooling the gas, with the attendant loss of sensible heat and system efficiency.

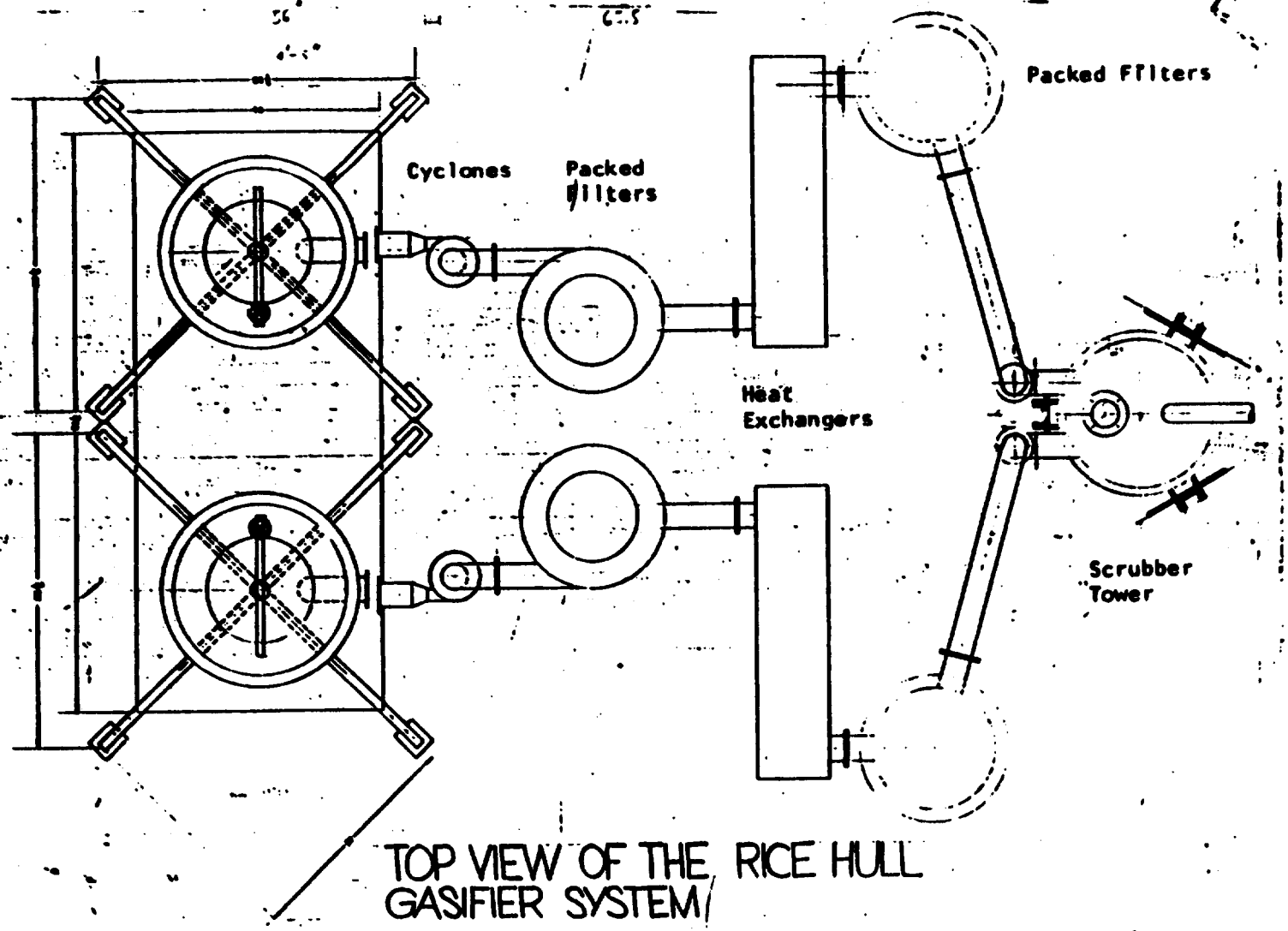
The on-site monitoring program is outlined in Appendix 3.

APPENDIX 1.

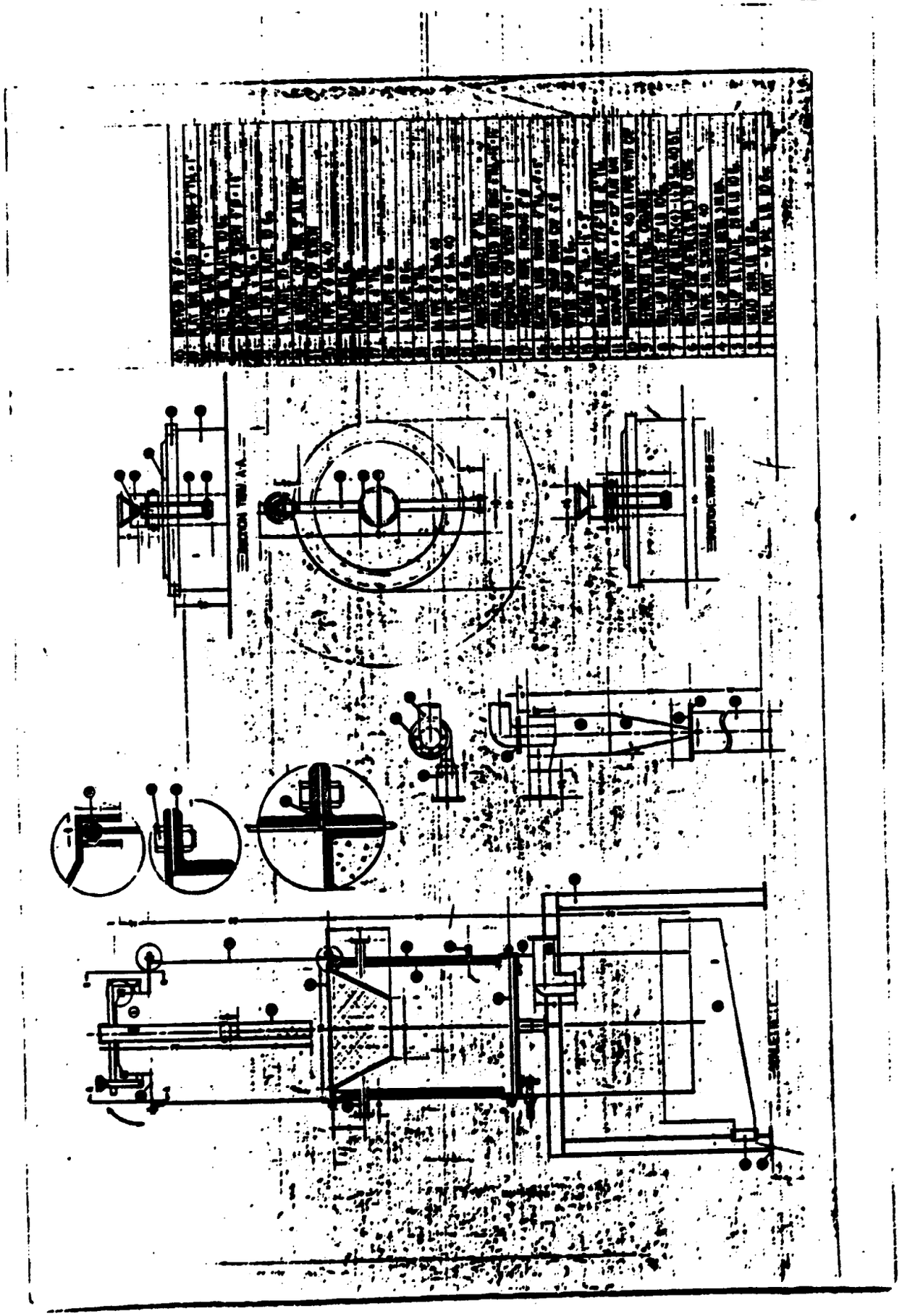
Rice-hull Gasifier System and Reactor Design




SIDE VIEW OF THE RICE HULL GASIFIER SYSTEM



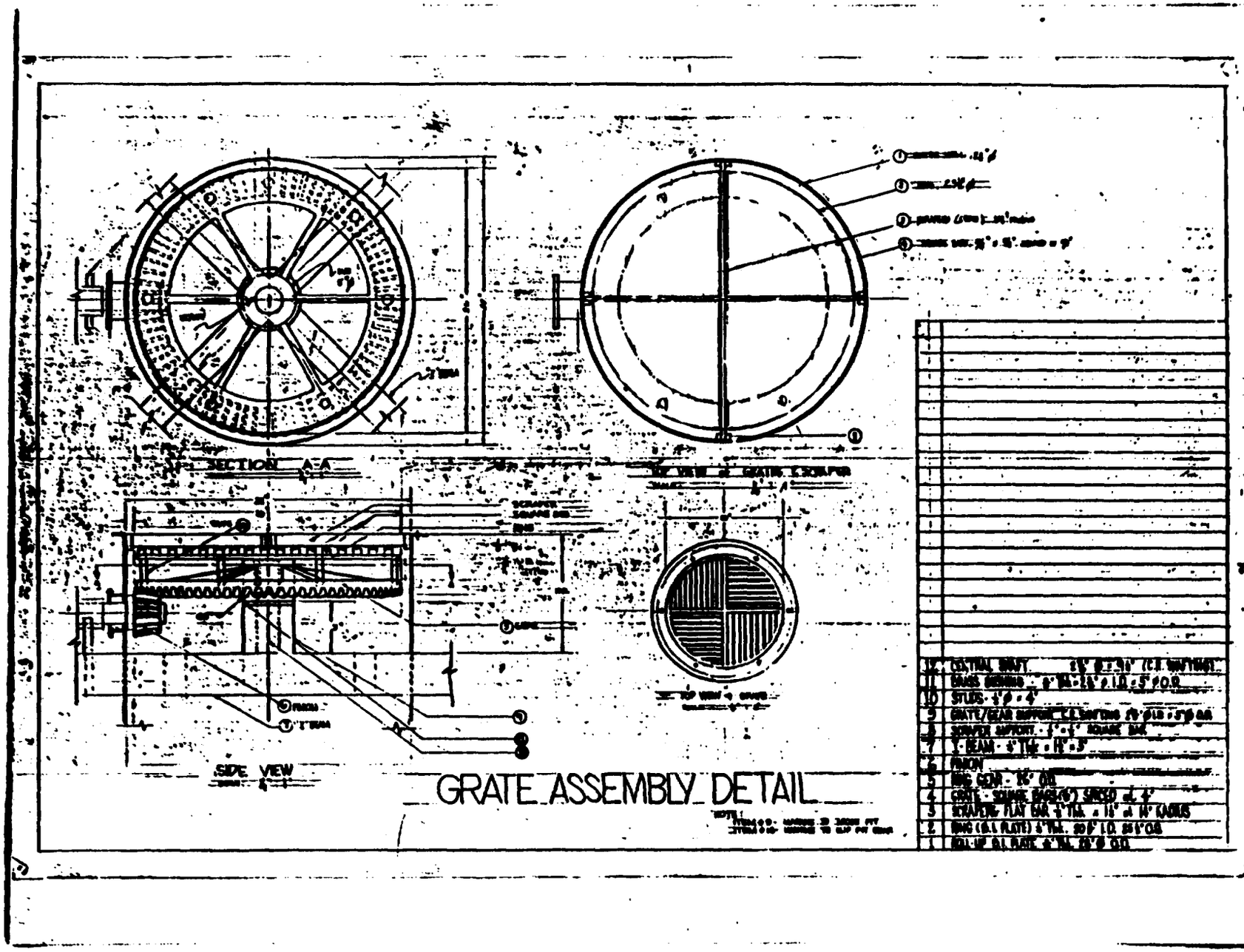

TOP VIEW OF THE RICE HULL GASIFIER SYSTEM



## RICE-HULL GASIFIER - REACTOR LAYOUT

Legend

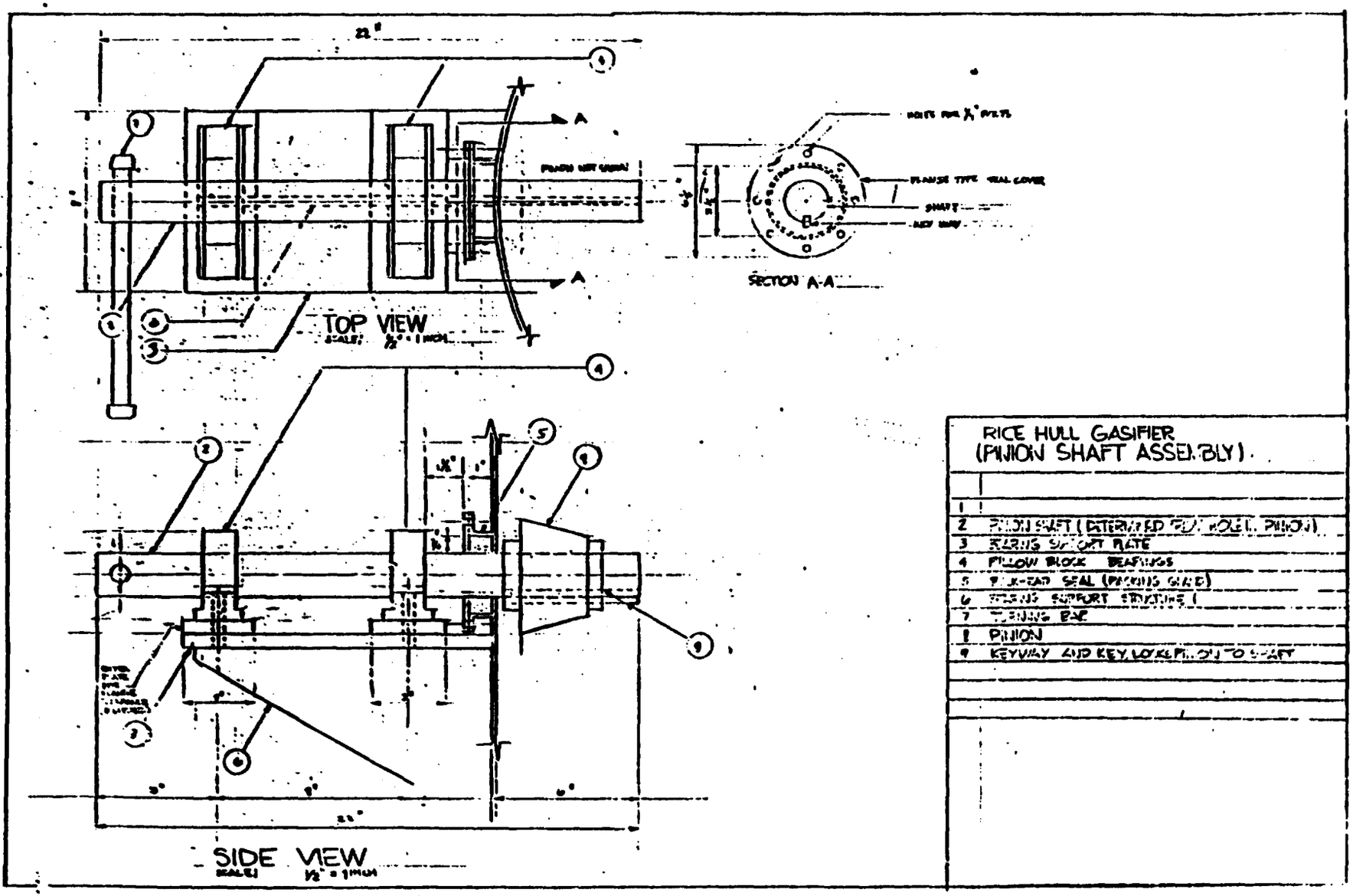
1. Fuel Port - 16 inch I.D. 10 Ga.
2. Head 28 in. L.D. 10 Ga.
3. Roll-Up B.L. Plate 28 in. L.D. 10 Ga.
4. Roll-Up Expanded Metal 3 inch dia.
5. B.I. Pipe 3 inch Schedule 40
6. Roll-Up exp. Metals (S. Stl.) to cone
7. Secondary air inlets (4) - 1½ Ø Sch. 40 B.I.
8. Roll-Up B.L. Plate 28 I.D. 10 Ga.
9. Refactory 1½ inch thick. Castable.
10. Ignition port 1" Sch. 40 B.I. Pipe with Cap
11. Scraper ½ inch thick x 1 inch x 27 inch flat bar
12. Roll-Up B.L. Plate $27\frac{5}{6}$ inch L.D.
13. I-Beam ½ inch thick x 1½ inch x 3 inch
14. Water Sump 10 Ga.
15. Water Sump Drain Cap 4 inch Ø
16. Reactor legs footing ½ inch thick x 4 inch x 5 inch
17. Asbestos Rope Packing ¾ inch Ø
18. Hexagonal Cap Screw 3/8th inch Ø x 1 inch.
19. Angle Bar rolled into ring
20. Asbestos Gasket 1/8th inch thick
21. B.L. Plate 10 Ga.
22. B.I. Pipe 4 inches Ø Sch. 40.
23. B.L. Pipe 4 inch Ø Sch. 40.
24. Flange 3/16th inch thick
25. B.L. Plate 10 Ga.
26 B.L. Plate 10 Ga.
27. Flange 3/16th inch thick
28. Flange 3/16th inch thick
29. B.I. Plate 10 Ga.
30. B.I. Pipe 4 inches Ø Sch. 40
31. Hexagonal Cap Screw
32. Air Intake Cap for 3" B.I. Pipe
33. B.L. Plate 10 Ga.
34. Roll-Up B.I. Plate 10 Ga.
35. Flat Bar ½ inch thick x 1 inch
36. Hexagonal Cap Screw 5/8th inch Ø x 1¾ inch.
37. Roll-Up B.L. Plate 10 Ga.
38. Square Bar 1 inch x 1 inch
39. Flat Bar Rolled into Ring ½ inch thick x 1 inch
40. Riveted Pin 7/8th inch Ø.


SECTION A-A
SIDE VIEW
GRATE ASSEMBLY DETAIL

## RICE HULL GASIFIER - GRATE ASSEMBLY DETAIL

Legend

1. Roll-up, BI Plate, 3/16th inch thK. 28 inch O.D.
2. Ring, (B.I. Plate) ½ inch thK. 25½ inch O.D.
3. Scrapers, flat bar ½ inch thK x 1½ x 14 inch radius.
4. 5/8th inch sq. bar at 3/8th inch spacing.
5. Ring gear 26 inch O.D.
6. Pinion
7. 3 inch I-beam.
8. Scraper support, ½ inch sq. bar.
9. Grate/gear support C.R. Shaft 5 inch O.D.
10. Studs, 4 x ½ inch dia.
11. Brass bushing, $\frac{3}{8}$ x $2\frac{9}{16}$ x 5 inch O.D.
12. Shaft, $2\frac{9}{16}$ x 9½ inch length.




RICE HULL GASIFIER
(PINION SHAFT ASSEMBLY).

| | |
|---|---|
| 1 | |
| 2 | PINION SHAFT (INTERRUPTED TEETH OVER HALF PINION) |
| 3 | BEARING SUPPORT PLATE |
| 4 | PILLOW BLOCK BEARINGS |
| 5 | V-RING SEAL (PINION SIDE) |
| 6 | BEARING SUPPORT STRUCTURE |
| 7 | TUBING BASE |
| 8 | PINION |
| 9 | KEYWAY AND KEY LOCATION TO SHAFT |

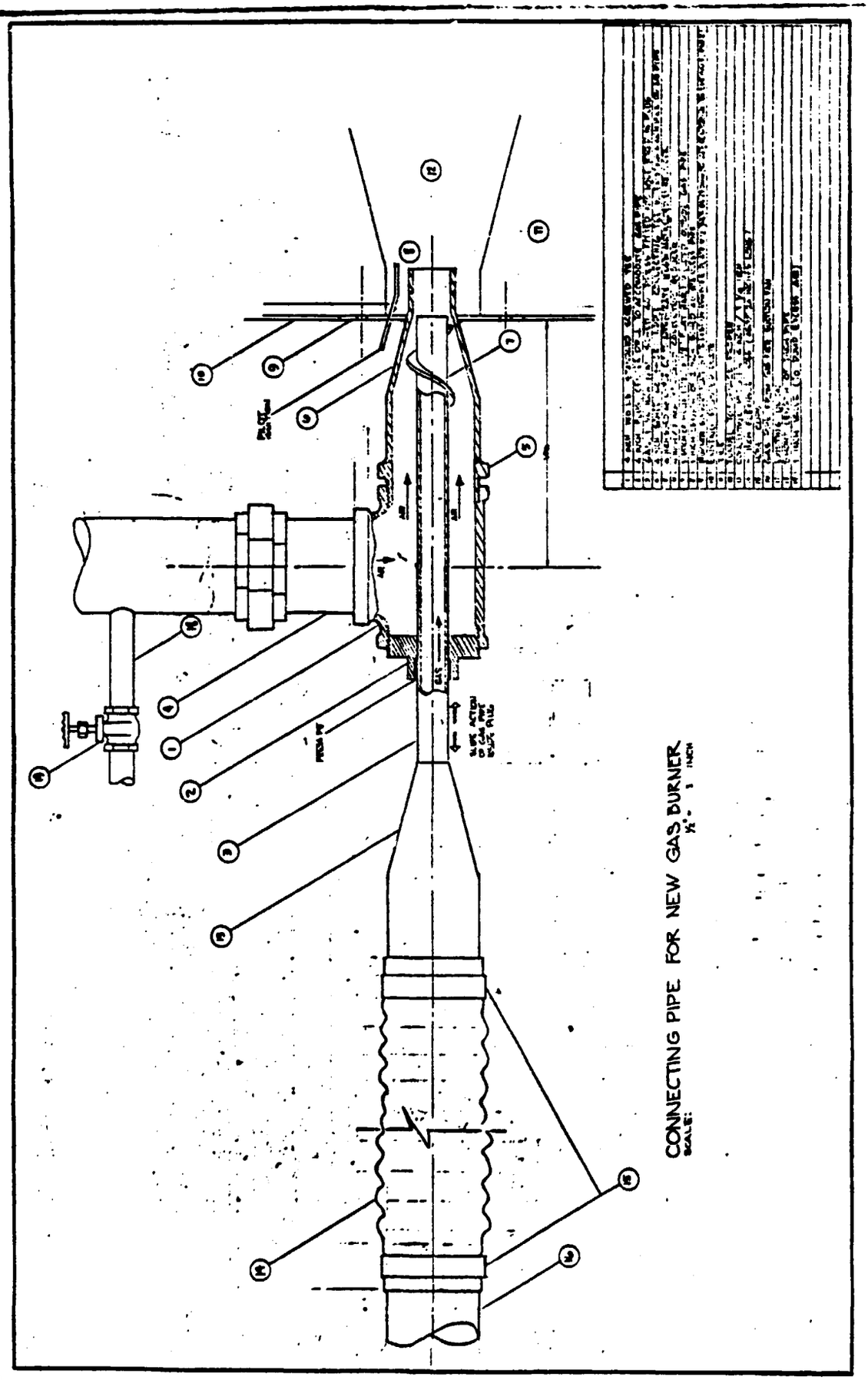
## RICE HULL GASIFIER - PINION SHAFT ASSEMBLY

Legend

2. Pinion Shaft
3. Bearing support plate
4. Pillow block bearings
5. Bulkhead Seal (packing gland)
6. Bearing support structure
7. Turning bar
8. Pinion
9. Keyway (1/8th inch)

# APPENDIX 2.

## Low-Btu Gas Burner



CONNECTING PIPE FOR NEW GAS BURNER

# LOW-BTU GAS BURNER

Legend

1. 4 inch 150 lb standard Screwed Tee
2. 4 inch plug
3. 1¼ inch dia. sched. 40 pipe
4. 4 inch sched. 40 short nipple
5. 4 inch sched. 40 nipple, cut to length
6. 4 inch/2 inch concentric reducer
7. 1 pitch of helix (½ inch x 1/8th inch flat bar
8. 1 inch length of 2 inch sched. 40 stainless pipe
9. Burner Register Plate
10. Furnace Wall
11. Tile
12. Tunnel
13. Concentric Reducer, 4 inch/1¼ inch
14. 4 inch dia. flexible hose
15. Hose Clamps
16. Pipe from gasifier suction fan
17. Existing Union
18 and 19. 1 inch short pipe and gate valve

APPENDIX 3.

On-Site Monitoring
(Precautionary Measures at Start Up)

ON-SITE MONITORING
(Precautionary Measures at Start-Up)

Fuel Input. Weight of fuel charged/set, read to determine rates of fuel (rice hull) consumption and ash production.

Equipment. Platform scale, buckets, stop-clock.

Energy Output. Output from the gasifier system is best determined from the fuel savings realized on the furnace as a result of installing the gasifier. With conventional fuel (bunker C) it takes from six to seven hundred liters to accomplish one melting cycle. Following installation of the gasifier the savings in Bunker C consumption over one melting cycle can be computed. This will give the aggregate energy output from the gasifier over one melting cycle.

System Efficiency. A comparison of energy output with fuel (rice hull) consumption rate determined above, will be the overall system efficiency.

Burner Optimization. Two adjustments are available for optimize performance of the new low-Btu gas burner. Burner air supply can be varied using the new damper on "dump valve", and the location of the gas jet within the burner can be adjusted [illegible]. Visual observation of the flame through [illegible] necessary to optimize burner adjustment.

[illegible]

After starting up the gasifier, poor quality gas should be disposed of at the flare. [illegible]

After ensuring that the furnace is hot by igniting the oil burner nozzle, before admitting low-Btu gas to the furnace.

See previous consultant's report for operating instructions.

APPENDIX 4.

Memorandum of Agreement

MEMORANDUM OF AGREEMENT

KNOW ALL MEN BY THESE PRESENTS:

This Memorandum of Agreement, made and entered into this th day of 1994, by and between:

The PHILIPPINE NATIONAL OIL COMPANY through its ENERGY RESEARCH AND DEVELOPMENT DIVISION, hereinafter referred to as ERDD, with principal office at Don Mariano Marcos Avenue, Diliman, Quezon City, Philippines, represented in this Agreement by its Manager, DR. IBARRA E. CRUZ;

- and -

The MILLMORE PRODUCTS/IMPACT CORPORATION, hereinafter referred to as the RECIPIENT, with postal address at 121 Pinatubo Street, Mandaluyong, Metro Manila, and has an aluminium plant in Guimba, Nueva Ecija, represented in this Agreement by its President, MR. RICARDO DE LEON.

W I T N E S S E T H :

WHEREAS, ERDD is undertaking a project entitled "Assistance to Energy Production from Biomass Waste Materials";

WHEREAS, one of the objectives of the project is to test in the field, a RICE HULL GASIFIER SYSTEM;

WHEREAS, RECIPIENT is willing to operate the unit and perform the duties associated with it and further warrants that it is capable of operating the unit;

WHEREAS, the RECIPIENT feels that they can benefit from the unit;

NOW THEREFORE, for and in consideration of the above premises and their mutual covenants hereinafter set forth, the parties herein agreed as follows:

OBLIGATIONS OF THE RECIPIENT

1) That the unit shall be operated by the RECIPIENT for a period of ONE (1) YEAR so that meaningful operational data could be obtained.

2) The RECIPIENT shall provide a cover shed for the gasifier system where basic infrastructure such as electricity and water are available. Also, provision of a covered area for storage of rice hulls shall be provided.

3) The RECIPIENT shall provide labor and materials required for the installation/setting up of the gasifier system inside their (compound) plant and for the conversion of the furnace to low-Btu gas operation (provision of gun-type gas burner to be installed in one of the existing oil-burner ports).

4) The RECIPIENT shall be able to organize a system that will involve the people in the area, either in the operation or other activities associated with the unit and in the end show that the people are benefited from the unit.

5) The RECIPIENT shall be maintain an operational log book recording therein the time and duration of operation, actual consumption of raw materials, and any operational problems or breakdown experienced. A sample of blank log book form would be provided by ERDD engineers.

6) The operational data shall be made available to ERDD. Further, ERDD shall have a free access to the plant to demonstrate and study its operation and take any technical data suitable for the development of the unit. Samples of raw materials, by-products, and finished products shall be made available to ERDD engineers as and when required for analysis in ERDD Laboratories.

7) The RECIPIENT shall be responsible for the preventive and breakdown maintenance of the unit. However, if the breakdown occurs due to faulty design and/or manufacturing defects, it shall fall under the preview of modifications where ERDD will be held responsible. A preventive maintenance schedule shall be provided by ERDD. The plant shall be operated within the capacity limits envisaged by ERDD to avoid frequent breakdowns.

8) Any modifications to improve the yield, capacity and quality of the products shall be carried out with the prior consent of ERDD engineers in charge of the unit. Minor modification costing up to 2.5 per cent of the cost of unit limited to the maximum of TWO THOUSAND FIVE HUNDRED PESOS (P2,500.00) shall be carried out by the RECIPIENT.

9) The RECIPIENT is required to furnish every type of cost data, as and when required by ERDD to enable them to carry out socio-economic cost/benefit analysis. These shall include:

a) pattern of collection of raw materials
b) cost of raw materials paid to the producers, if applicable
c) cost of collection
d) in-plant raw material cost
e) cost of auxiliaries - in this case, water, power, if any, and fuel lighting, etc.
f) labor benefits and other payroll expenses
g) finance charges
h) cost of both direct and indirect labor involved in processing
i) pattern of sale of products and by-products
j) sale promotion expenses
k) in addition to the basic infrastructure, all types of auxiliary equipment such as storage bins - buckets or sacks, weighing scales, etc., other consumable and non-consumable hardwares and tools

10) Under no circumstances, the unit should be removed from the selected site to any other premises without the prior consent of ERDD. Exception can be made in the case of mobile kiln. In case of its movement to a new site, its new location should be immediately communicated to ERDD engineers.

11) Any stage during the development of the technology under the field conditions if the RECIPIENT gets disinterested and is unable to operate the plant due to any unforeseen reasons, ERDD should have the right to take back the plant/unit and transfer it to another party or individual. This termination shall be equally applicable in case the RECIPIENT do not honor their commitment to the project including non-cooperation and their inability or refusal to give technical, economic and other relevant data vital to the development of this project.

In the event of termination of association on the above grounds, the capital share of the RECIPIENT should not be paid back.

OBLIGATIONS OF ERDD

**12) ERDD shall be responsible for the transfer of equipment to site. However, the RECIPIENT shall extend their assistance whenever necessary.**

13) ERDD shall supervise the installation of the unit.

14) ERDD shall train personnel in the area in the operation of the system.

15) ERDD shall train personnel in the area in the operation of the system.

16) ERDD shall provide technical assistance whenever necessary in the operation of the sytem.

17) Any major modifications suggested and/or approved by ERDD costing more than the above limits shall be carried out by ERDD. However, ERDD at their discretion may claim twenty per cent (20%) of the capital cost of the expenditure from the recipient. This is applicable only during the period, until the ownership of the unit has been fully transferred to the recipient.

18) Any instruments installed for the purpose of testing and generation of data which do not form the integral part of the unit and not specifically required for its operation shall be the property of ERDD.

RECIPIENT shall have no claim on these instruments and/or other peripheral equipment installed for the purpose of testing.

PNOC-ENERGY RESEARCH AND DEVELOPMENT DIVISION

BY:

DR. IBARRA E. CRUZ
Manager

MILLMORE PRODUCTS/ IMPACT CORPORATION

BY:

MR. RICARDO DE LEON
President

SIGNED IN THE PRESENCE OF:

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APPROVED BY:

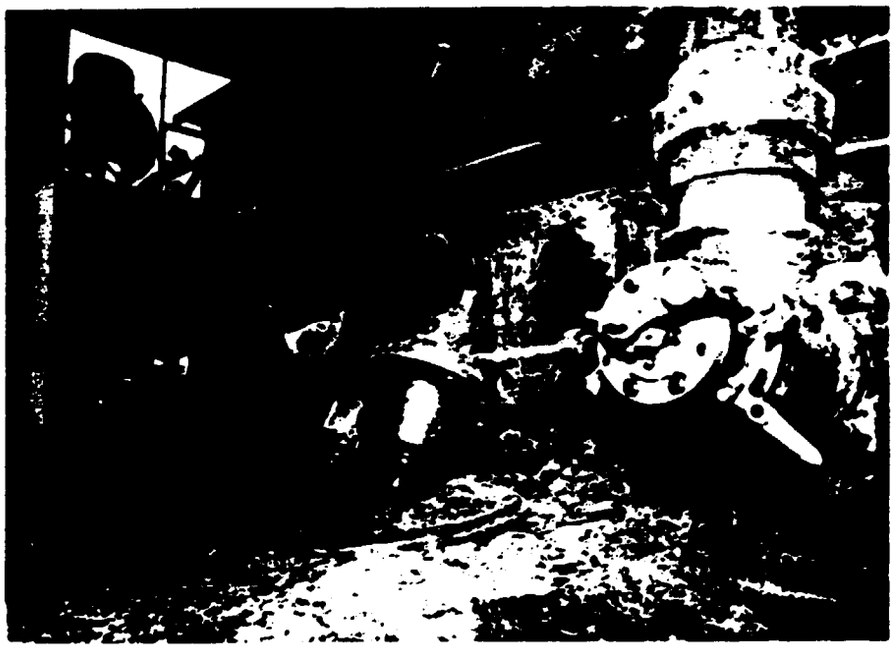
WENCESLAO R. DE LA PAZ

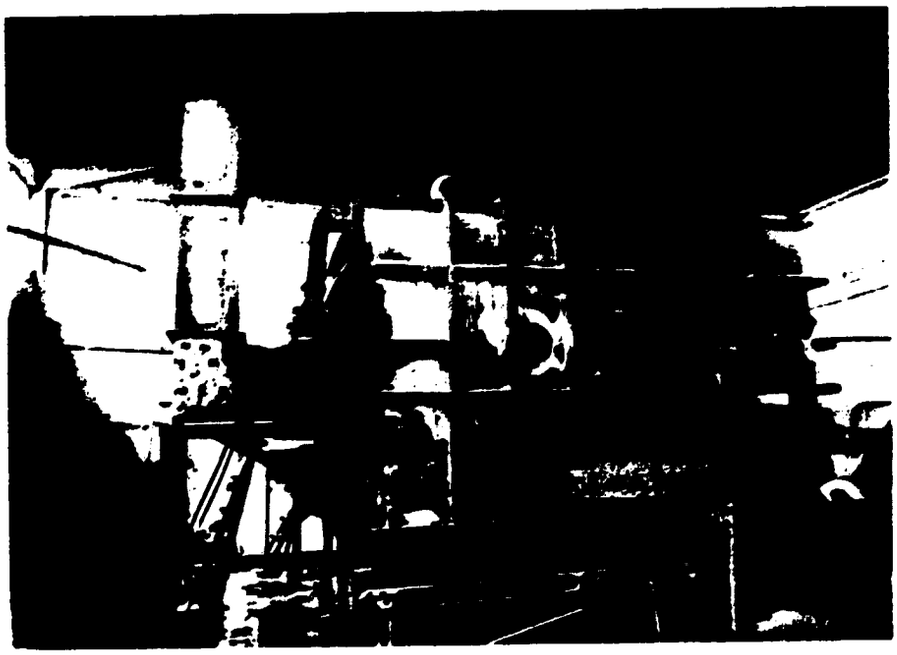
APPENDIX 5

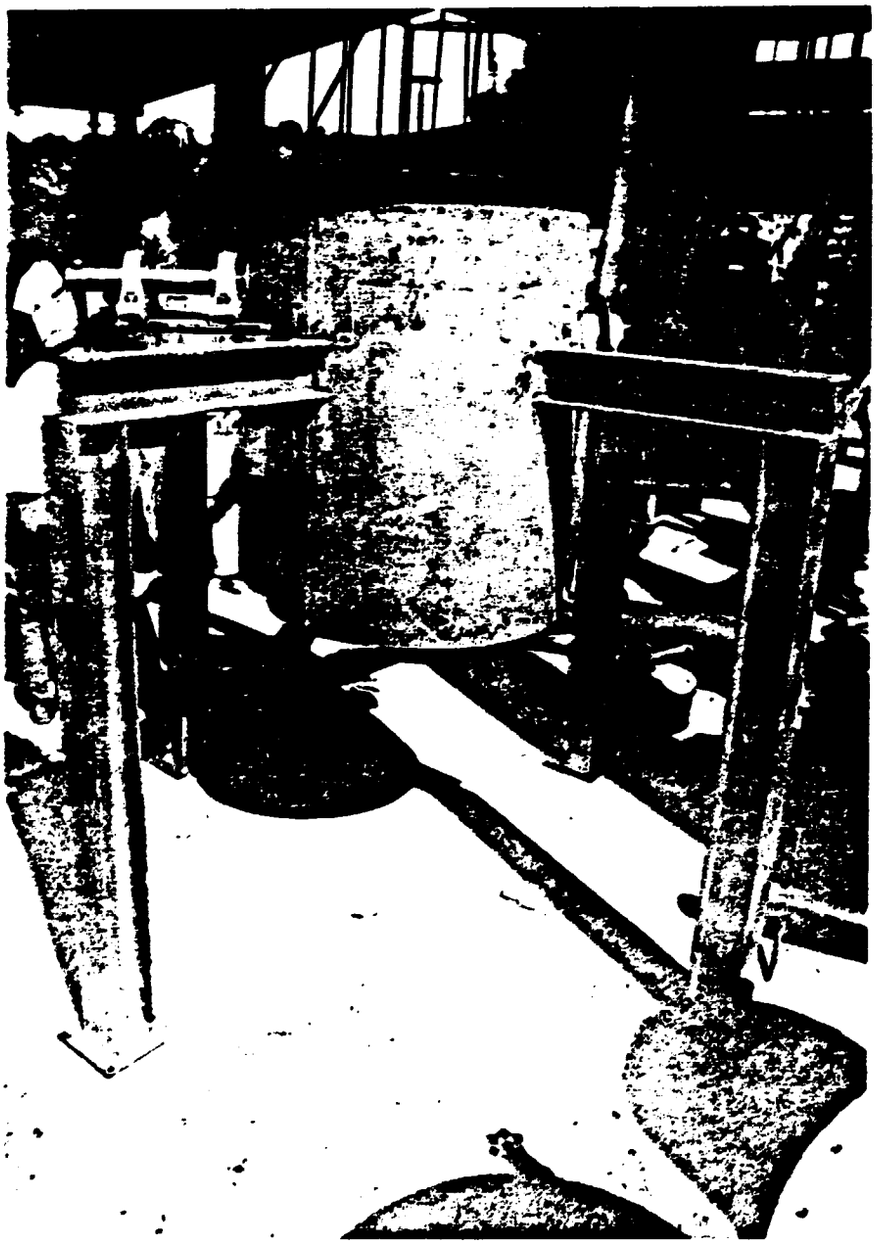
Photographs

[illegible]

[illegible] FURNACE & BURNER FULL BURNER







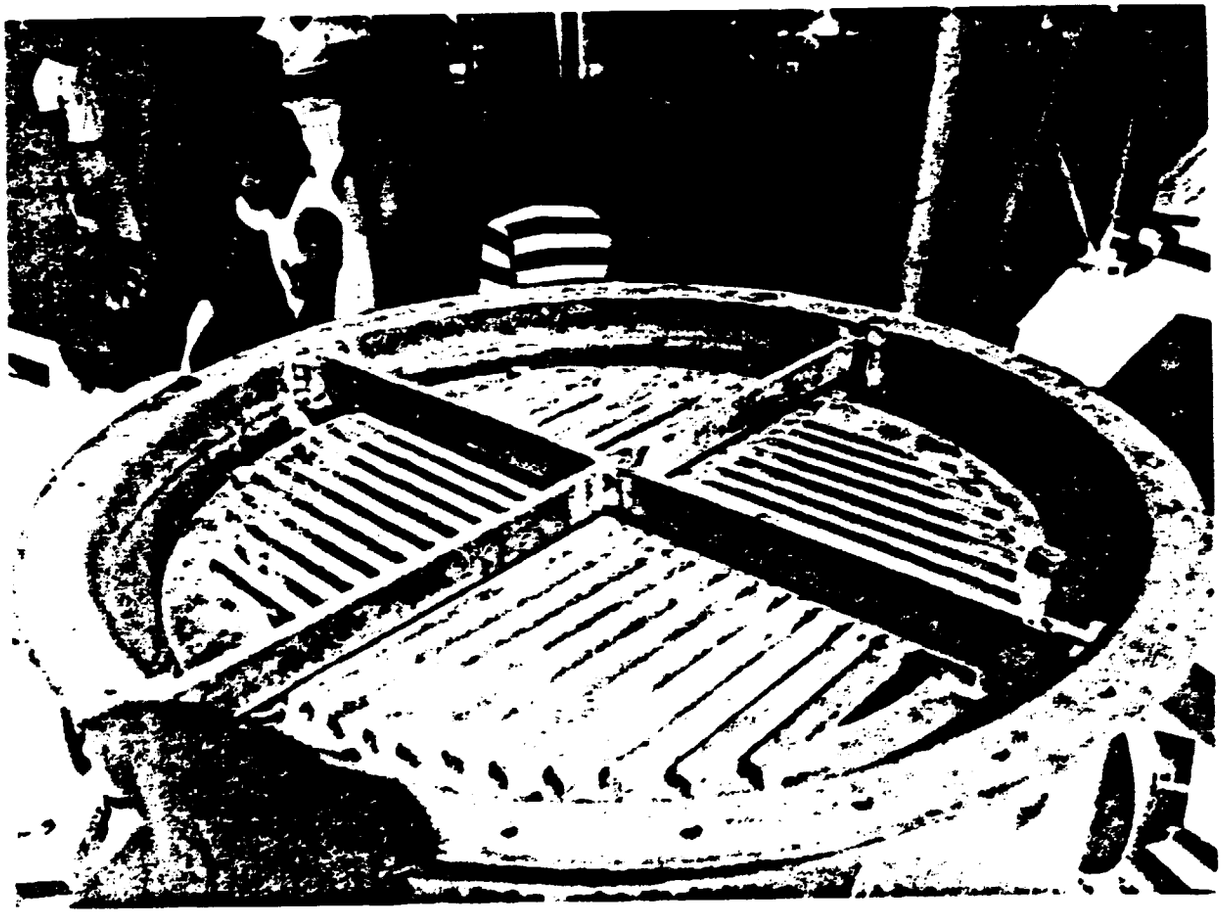


FIGURE 4

SCRUBBER TOWER