AN ENGINEERING REPORT ON CONTROL OF WIGWAM BURNER COMBUSTION

OREGON STATE SCHOOL OF FORESTRY

CORNELL, HOWLAND, HAYES & MERRYFIELD
Engineers and Planners
SEATTLE CORVALLIS BOISE PORTLAND

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CONTROL OF
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TABLE OF CONTENTS

LIST OF FIGURES

SUMMARY

Preliminary field tests made by the Oregon State University Mechanical Experimentation Department on a burner in Benton County indicated that better conbustion control on any given burner, which is in good repair, can be obtained by careful control of the overfire air flow rate.

This report offers various equipment arrangements which can improve burner combustion and recommends a minimum amount of control equipment which would give the burner operator a better system of combustion control.

Estimated costs for the minimum combustion control equipment system would be $5,000.00 for a 40-foot burner and $7,000.00 for a 65-foot burner.

INTRODUCTION

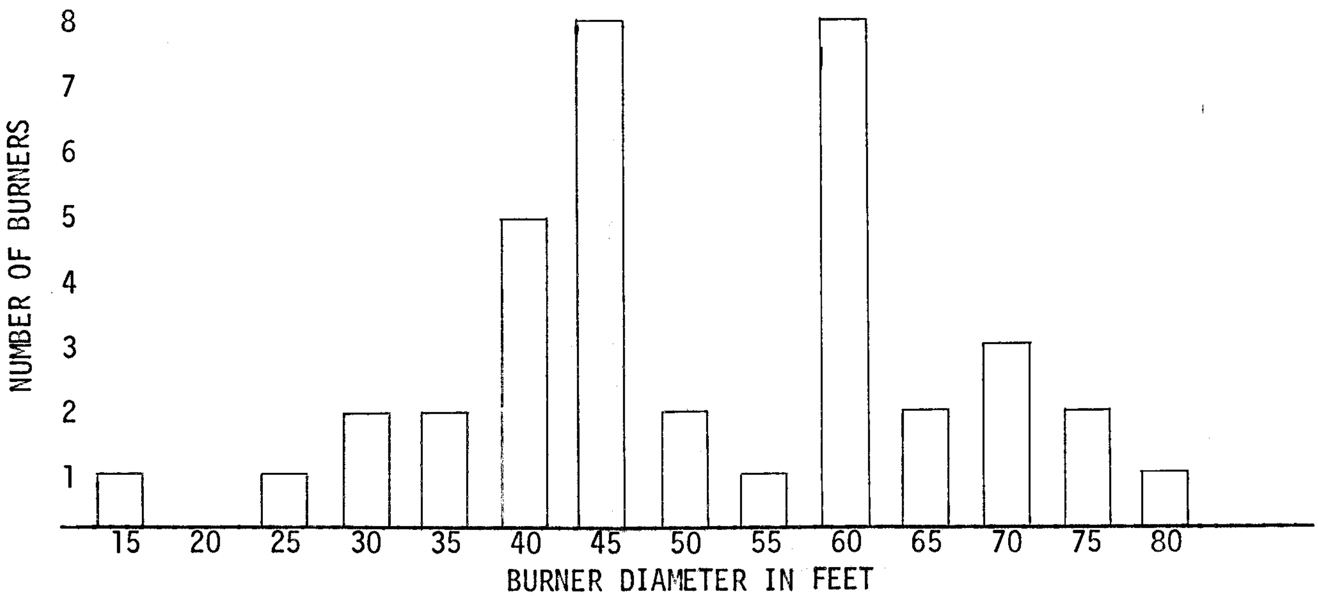
The purpose of this report is to outline some methods of improving fuel combustion within wigwam burners. The addition of automatic control equipment, hogging and drying of mill residue, preheating of combustion air and addition of a dutch oven furnace are the possible improvements considered in this report.

This report includes preliminary sketches, layouts and construction cost estimates for each of the methods considered.

THE TYPICAL WASTE BURNER

Information obtained by the Oregon State School of Forestry personnel at Corvallis, Oregon, on thirty-eight (38) burners in the Benton and Lane County areas provided information for Figure 1 showing the burner size distribution in these areas.

FIGURE 1



In order to limit the number of burners considered, it was agreed with the School of Forestry that the study would include two typical sizes of burners, those being burners with 40-foot and 65-foot base diameters.

AUTOMATIC COMBUSTION CONTROL SYSTEM

In order to obtain complete combustion of any fuel it is necessary to provide a system which will cause an intimate mixing of the fuel with the oxidizing atmosphere (air) in proper amounts at proper temperatures for a sufficient amount of time to complete the combustion reaction. This can only be done by burning the fuel in a closed space of adequate size at temperatures above 1000 degrees F. and using controlled air to fuel ratios.

In considering combustion control for the wigwam burner, it is important to first consider the installation of an automatic device for controlling the rate of air flow into the burner to maintain a low total air input, consistant with the maximum desired combustion temperature. Figure 2 shows a schematic diagram of a somewhat inexpensive system for accomplishing control of air flow rate. Air flow control is accomplished by a temperature sensing device (thermocouple) which activates a recorder-controller instrument. The controller in turn activates the duct damper drive motors to open or close them depending on the temperature set point in the controller.

The cost of such a system for a wigwam waste burner would be:

Item	Burner Diameter 40 Ft.	65 Ft.
1. Primary Sensing Element	$ 200.00	$ 200.00
2. Electrical Hookup	600.00	600.00
3. Recorder - Controller	700.00	700.00
4. Air Compressor	400.00	400.00
5. Damper Control Motors	500.00	1,800.00
6. Dampers, Ducts, Tangential Inlets	1 700.00	1,900.00
Subtotal	$4,100.00	$5,600.00
Contingencies (Add 25%)	1,000.00	1,400.00
TOTAL	$5,000.00	$7,000.00

SMOKE DENSITY MEASUREMENT

From a legal position it may be desirable to substantiate wigwam burner performance by keeping accurate data on the actual emissions from a burner. As such, it would be necessary to continuously measure and record the smoke density of the gases being discharged. This measurement could be accomplished using a system as shown on Figure 2, where a sample of the burner emission gas is brought out of the top of the burner and down to the Bolometer. The Bolometer is a sensing device which measures the opacity value of the emission gases. This value is then plotted on a recorder chart as a Ringelman number. An alarm can be included in the device to warn of smoke conditions. The costs for such a system for 40-foot and 65-foot diameter burners would be:

1. Stack Sample Piping	$ 400.00
2. Sampling Fan and Motor	300.00
3. Bolometer and Recorder	1,000.00
4. Electrical, Install	1,100.00
Subtotal	$2,800.00
Contingencies (Add 25%)	700.00
TOTAL	$3,500.00

IMPROVEMENT IN WASTE FUEL PREPARATION

Fuel Sizing. Another method for improving wigwam burner combustion would be to supply the wood waste to the burner as a relatively homogeneous hogged fuel mixture. This, of course, would require the installation and maintenance of a hog to size all of the wood waste. In addition, it would also be desirable to even out the fuel feed rate to the burner to maintain a uniform fuel pile size inside the burner. The latter could be accomplished by the installation of a hogged fuel storage bin. Figure 3 shows a system for waste burner fuel sizing and storage. The costs for such a system would be:

	Burner Diameter 40 Ft.	Burner Diameter 65 Ft.
Blow-Hog Machine and Motor	$10,500.00	$12,300.00
Conveyors	5,000.00	5,700.00
Electrical	3,600.00	5,200.00
Foundations	1,100.00	1,300.00
Cyclone and Ductwork	1,100.00	4,000.00
Storage Bin	4,400.00	4,400.00
Subtotal	$25,700.00	$32,900.00
Contingencies (Add 25%)	6,400.00	8,200.00
TOTAL	$32,100.00	$41,100.00

Fuel Drying. In the cases where waste fuel has a moisture content above 50 percent, such as that which occurs when burning Hemlock, Bull pine, or wet Douglas fir, drying the fuel prior to putting it in the burner would substantially improve the combustion. Figure 4 shows a fuel drying system which could be used for this purpose. Effective fuel drying can be accomplished only if the fuel surface area to weight ratio is increased. As shown in Figure 4, sizing and surge control would be accomplished with a hog and a storage bin. The costs for such a system would be:

	Burner Diameter 40 Ft.	Burner Diameter 65 Ft.
Hog and Motor	$ 9,000.00	$10,800.00
Conveyors	6,800.00	8,100.00
Electrical	4,700.00	7,000.00
Foundations	1,100.00	1,300.00
Storage Bin	4,400.00	4,400.00
Cyclone, Ductwork, Rotary Dryer	25,000.00	53,700.00
Subtotal	$51,000.00	$85,300.00
Contingencies (Add 25%)	12,800.00	21,300.00
TOTAL	$63,800.00	$106,600.00

AIR PREHEATING

Wigwam waste burners presently provide relatively poor combustion conditions when supplied with particularly high moisture content fuels and also when first fired up in the morning from cold conditions. The burners are normally supplied with low temperature (ambient) air for both their primary (underfire) and their secondary (overfire) air. Preheating of this air up to 400 degrees F. would materially improve the combustion and thereby reduce smoke and cinder emissions. This would be very beneficial especially during startup conditions.

Air preheating could be accomplished by either of two methods. These are:

1. The use of interruptable natural gas or oil-fired preheating.

2. Recirculation of a portion of the wigwam burner emission gases either directly to the air supply or to a gas to air heat exchanger system for preheating the air.

However, for startup conditions preheating with gas or oil-fired preheating would be the only practical method. The recirculation method would shorten the startup period, but would not be as effective as the direct fired preheating method.

Since either system will permit controlled operation of the waste burner at temperatures in the order of 800 degrees F. to 1000 degrees F., the systems should be designed to provide up to 400 degrees F. of preheating for air quantities of sufficient volume to cool the emitted gases to 800 degrees F.

Preheating would be required for the following air volumes:

Burner Size	Air Volume scfm	Air Wt. lbs/hr.	Heat to Raise Temp. (40^o F. to 400^o F.)
40 feet	19,000 cfm	85,000 lbs/hr.	7,350,000 Btu/hr.
65 feet	83,500 cfm	375,000 lbs/hr.	32,500,000 Btu/hr.

Assuming that interruptable natural gas would be available at approximately $0.04 per therm, the costs for preheating from 40 degrees F. to 400 degrees F. would be:

Burner Size	Btu/Hour	Fuel Cost/Hour
40 Foot	7,350,000	$ 2.94
65 Foot	32,500,000	$13.00

Figure 5 shows an installation which could be used to accomplish the required preheating.

The costs of installing natural gas preheating equipment for primary and secondary (underfire and overfire) air would be:

	Burner Diameter	
	40 Ft.	65 Ft.
Natural Gas Burner and Combustion Chamber	$ 9,500.00	$13,000.00
Ductwork	1,300.00	5,500.00
Foundations	200.00	300.00
Electrical	900.00	1,100.00
Primary Air Fan	600.00	1,500.00
Subtotal	$12,500.00	$21,400.00
Contingencies (Add 25%)	3,100.00	5,300.00
TOTAL	$15,600.00	$26,700.00

The costs of recirculating air to heat primary and secondary air would be:

	Burner Diameter	
	40 Ft.	65 Ft.
Primary Air Fan	$ 600.00	$ 1,500.00
Secondary Air Fan	1,350.00	3,100.00
Blending Air Damper	250.00	350.00
Temperature Controls	1,200.00	1,400.00
Ductwork	2,100.00	9,550.00
Electrical	2,100.00	2,700.00
Foundations	100.00	150.00
Subtotal	$7,700.00	$18,750.00
Contingencies (Add 25%)	1,900.00	4,700.00
TOTAL	$9,600.00	$23,450.00

Figure 5 shows the arrangement of ducts, heaters, and fans to accomplish the heating. The circular masonry wall would improve combustion for two reasons:

1. The cold overfire air would not be directed toward the fuel pile. Instead, it would be admitted between the masonry wall and the burner. This would allow combustion of the fuel pile at higher temperatures since the overfire air would not impinge in the fuel pile causing a cooling effect.

2. Radiant heat would be reflected back toward the fuel pile by the masonry wall. Together with the introduction of heating air to the inner chamber, combustion could be improved with the increased temperatures. The cost of such a wall would be:

	Burner Diameter	
	40 Ft.	65 Ft.
Masonry (8" Block)	$ 900.00	$1,800.00
Foundations	500.00	1,100.00
Subtotal	$1,400.00	$2,900.00
Contingencies (Add 25%)	350.00	700.00
TOTAL	$1,750.00	$3,600.00

DUTCH OVEN

The addition of a dutch oven, as shown on Figure 6, would greatly improve combustion. A more complete incineration of the fuel in a smaller chamber at higher temperatures would be made possible by reflected radiant heat and by closely controlling secondary (overfire) air. However, a wigwam burner is not too suitable as a secondary combustion chamber. In addition, firebrick replacement and grate cleaning for the dutch oven would be high in maintenance costs. The addition of a dutch oven would cost:

	Burner Diameter	
	40 Ft.	65 Ft.
Brickwork	$ 5,000.00	$10,100.00
Grates	2,500.00	5,000.00
Concrete and Foundations	4,000.00	6,800.00
Electrical	1,000.00	1,800.00
F.D. Fan System	2,400.00	5,000.00
Subtotal	$14,900.00	$28,700.00
Contingencies (Add 25%)	3,700.00	7,200.00
TOTAL	$18,600.00	$35,900.00

CONCLUSIONS

1. Previous tests on wigwam burners and accepted principles for obtaining good combustion show that controlling of the overfire air input to maintain gas temperatures at the burners exit of 800° F. to 1000° F. will improve combustion and reduce smoke and cinder emissions without destruction of the burner structure.

2. Presently on most existing wigwam waste burners, an attempt is made to manually control overfire air and exit temperature. The addition of automatic overfire air damper controls would relieve a man of routine overfire damper adjustments, would provide better temperature regulation than can be obtained manually, and, thus, would provide protection against either too high or too low burner temperatures.

3. Combustion in wigwam burners could be improved further by uniform fuel sizing, continuous uniform fuel feeding to the burner, and in some instances by predrying of the waste fuel. The magnitude of the combustion improvements which could be accomplished by these methods, as evidenced by a reduction in smoke and cinder emissions, can only be determined by experiments.

4. Similarly, the practicality of air preheating, reflective refractory walls, and the use of precombustion chambers (dutch ovens) which would all improve combustion could only be evaluated by field testing.

5. It is logical that the search for and testing of methods for the improvement of wigwam waste burners be performed by an industry-wide agency such as the Forest Research Laboratory of the Oregon State University School of Forestry.

RECOMMENDATIONS

To initiate improved combustion performance from wigwam burners, it is recommended that:

1. Where needed, burners should be refurbished and made as leak-tight as possible.

2. An adequately sized underfire air system with a manually controlled damper be installed in those burners that have no underfire air system.

3. All burners be equipped with the minimum equipment shown on Figure 2 of this report. This equipment consists of:

   a. Thermocouple probe and recorder-controller

   b. Automatic dampers with drive motors

   c. Bolometer with recorder and smoke alarm.

4. A testing program be pursued to evaluate the improvements that can be made by the methods suggested in this report and any other logical means which may present itself in further review of this study.

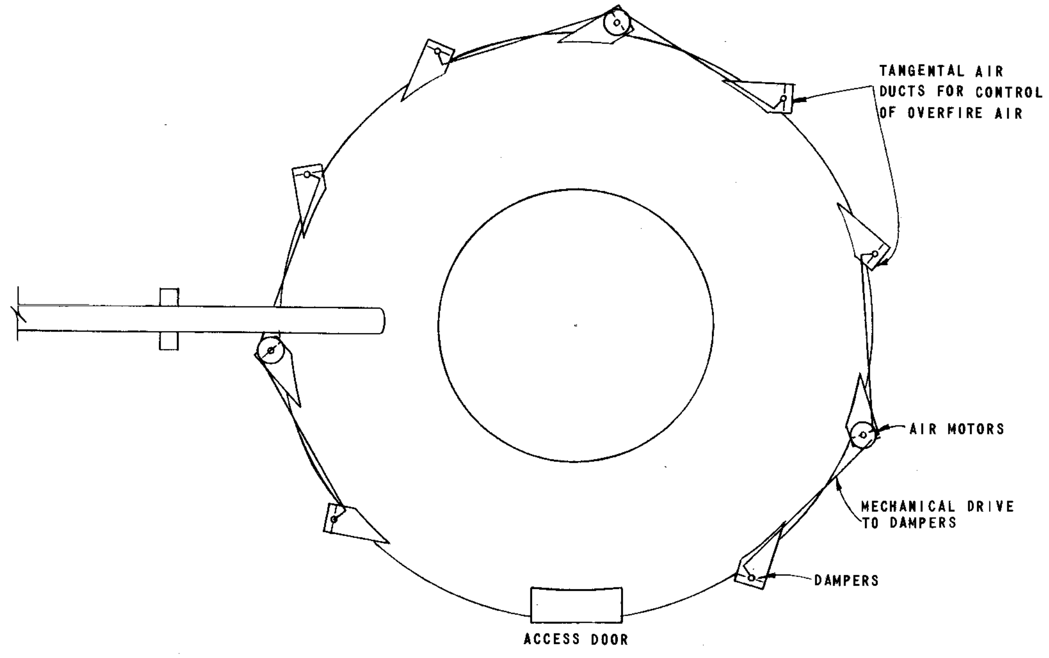
The suggested order of testing listed in declining order of expected combustion improvements as evidenced by smoke and cinder emission is:

a. Resizing of waste fuel by hogging and controlled fuel feed rate.

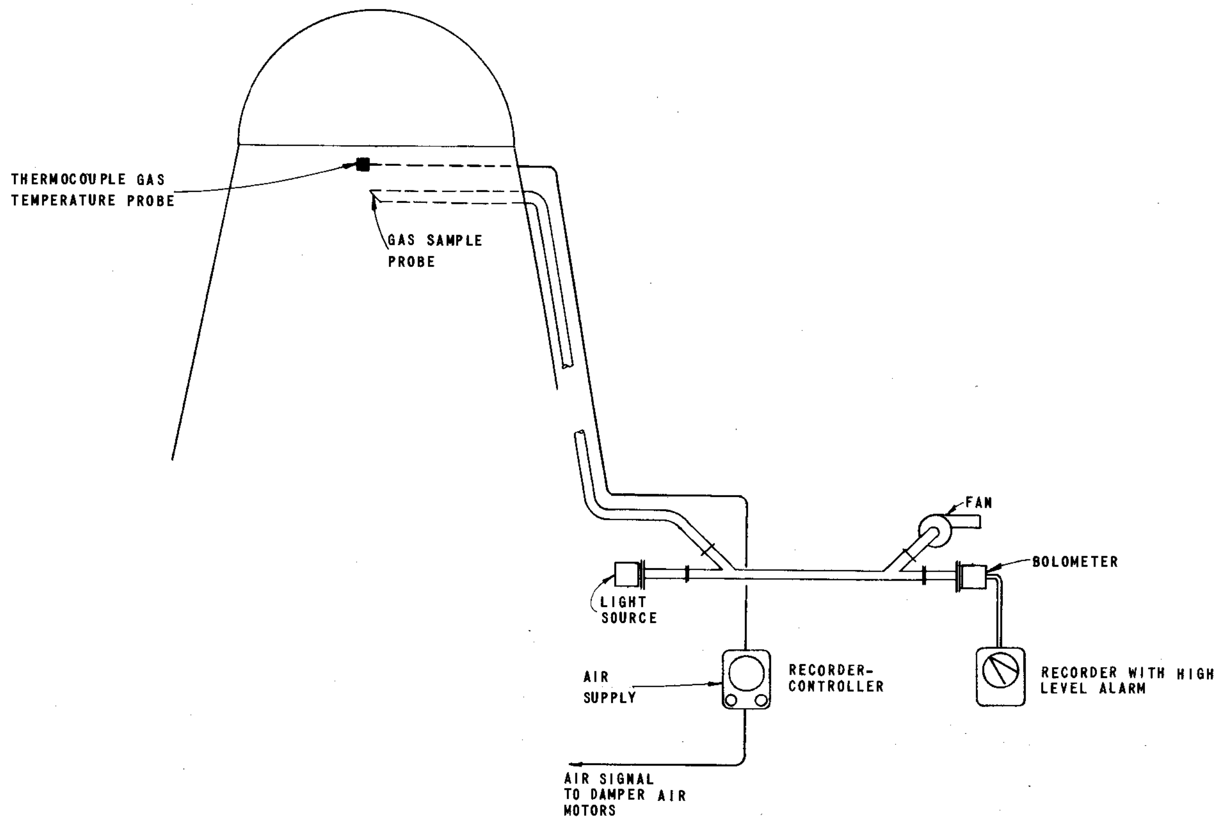
b. Resizing of fuel and controlled feed rate combined with fuel drying.

c. Preheating of combustion air by using combustion gas or an auxiliary air heating system.

d. Installation of a precombustion chamber (dutch oven) and refractory walls.



PLAN VIEW



WIGWAM BURNER
COMBUSTION CONTROL SCHEMATIC

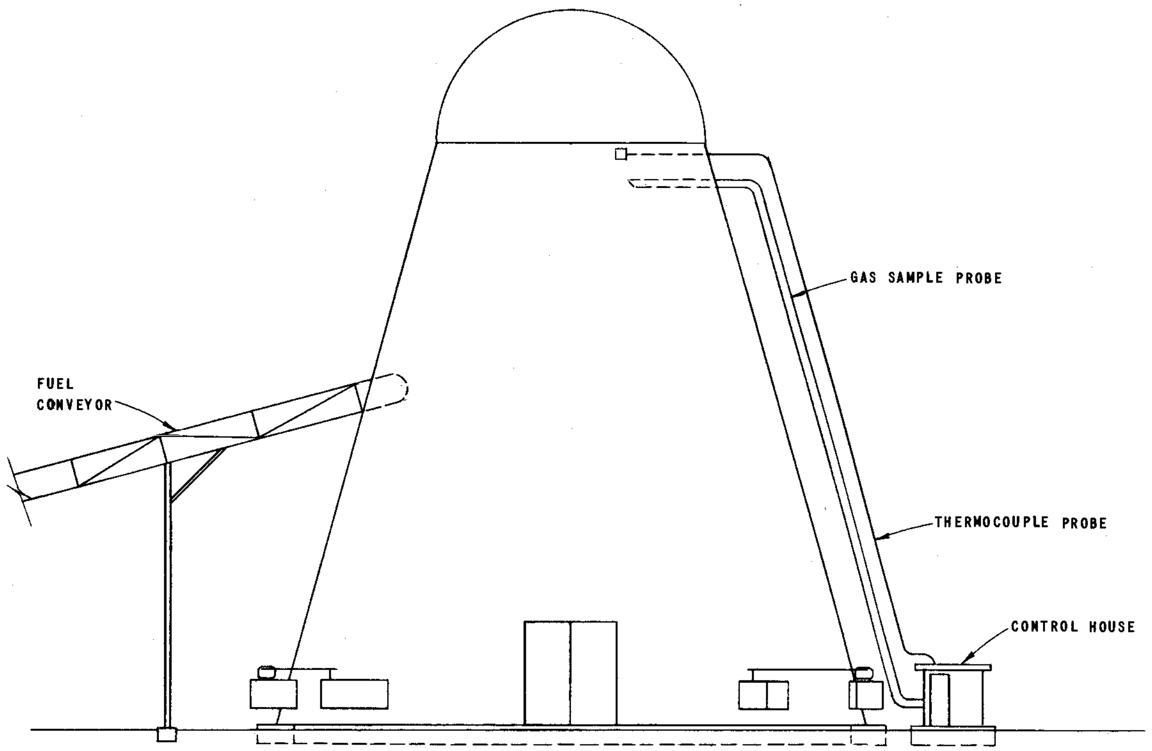


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FIG. 2

CONTROL INSTRUMENTION SYSTEM

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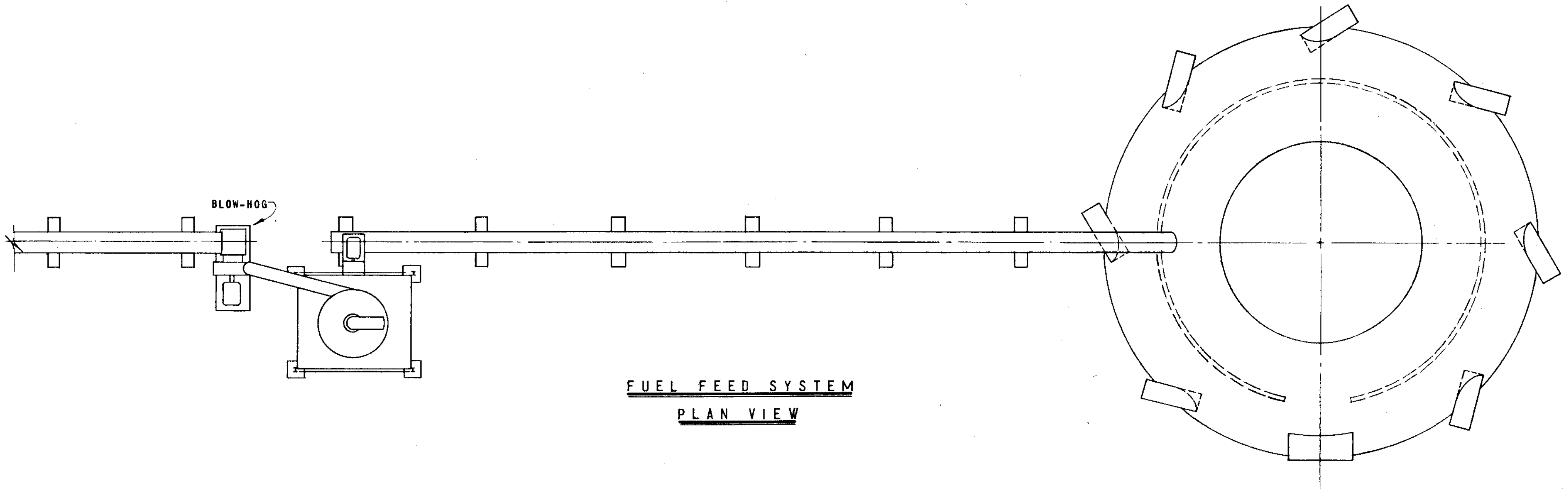
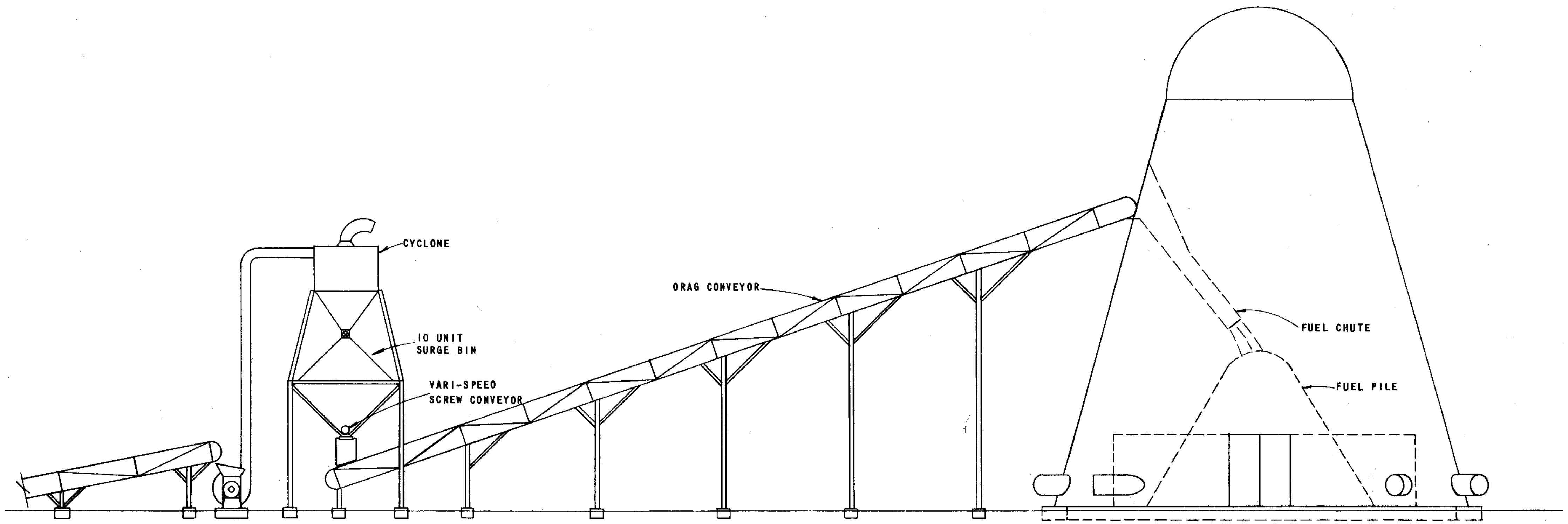


FUEL FEED SYSTEM
PLAN VIEW



FUEL FEED SYSTEM
ELEVATION VIEW

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FIG. 3

FUEL FEED SYSTEM

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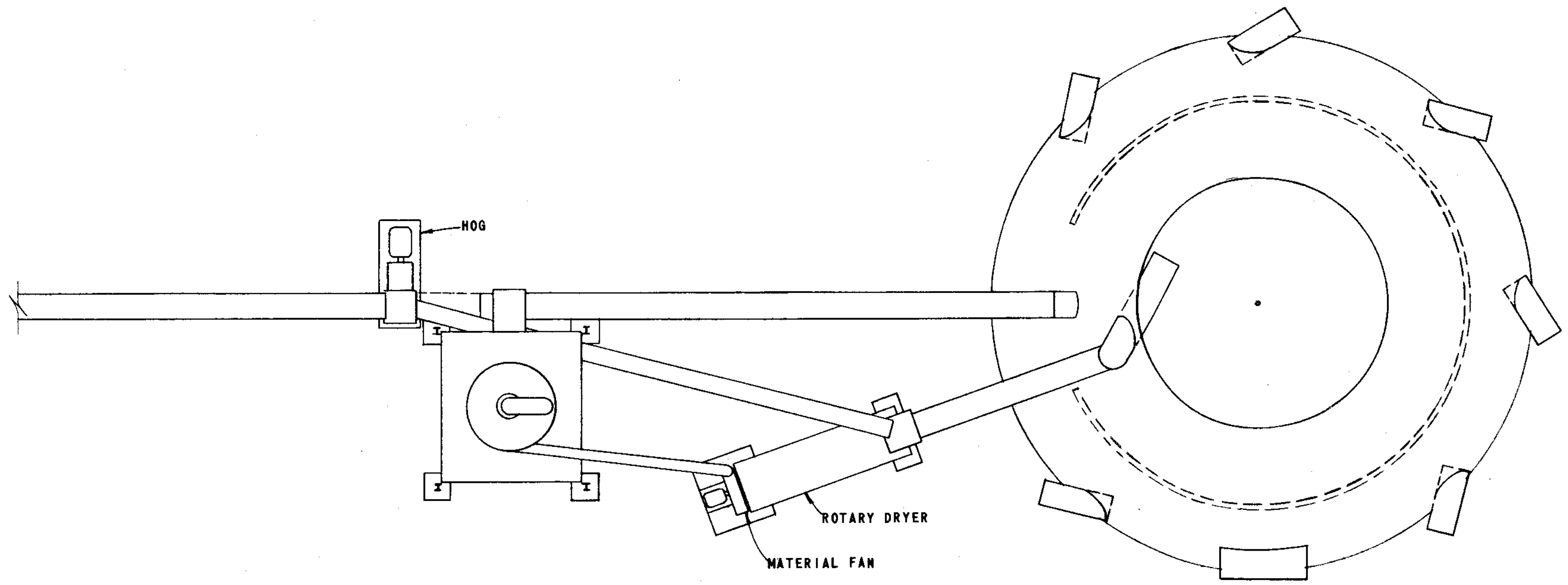

FUEL FEED AND DRYER SYSTEM

PLAN VIEW

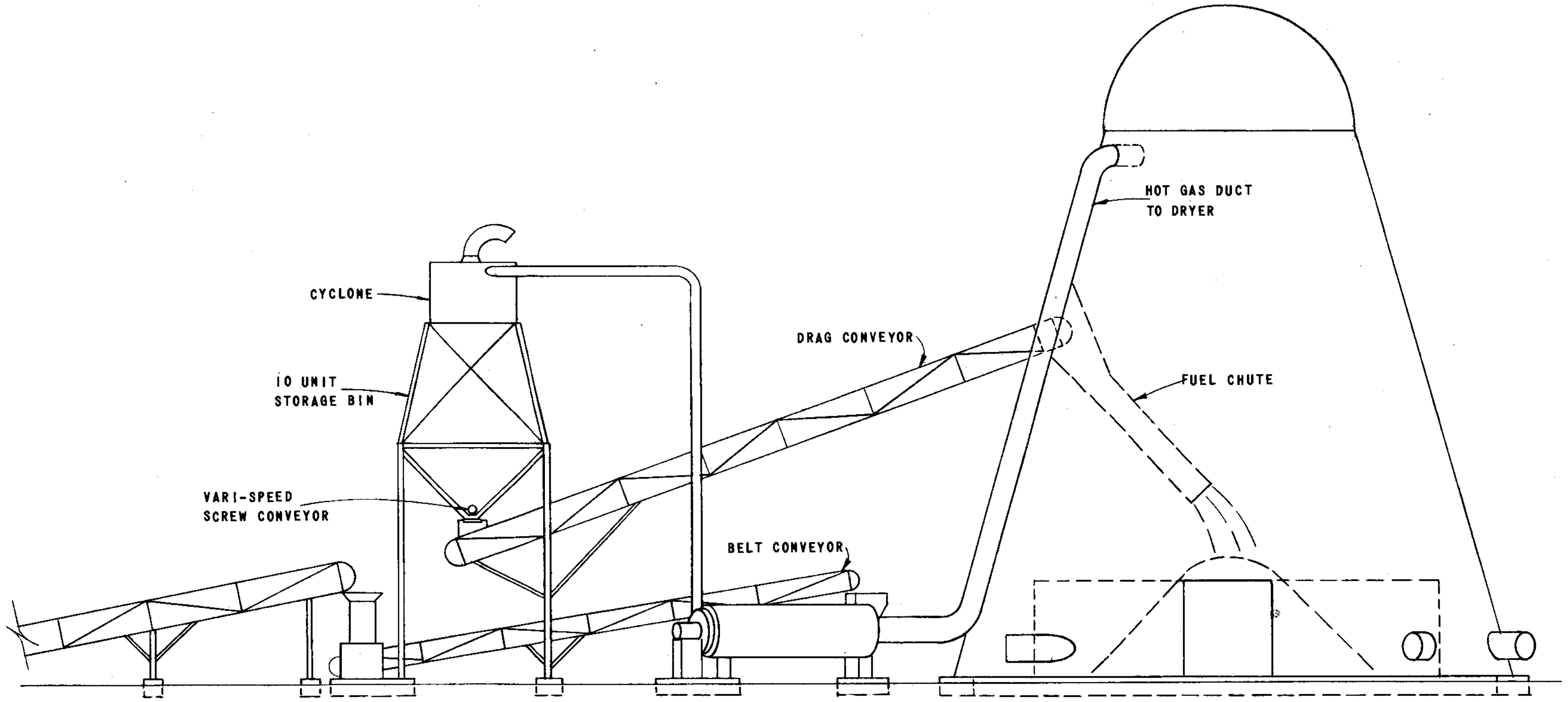

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FIG. 4

FUEL FEED & DRYER SYSTEM

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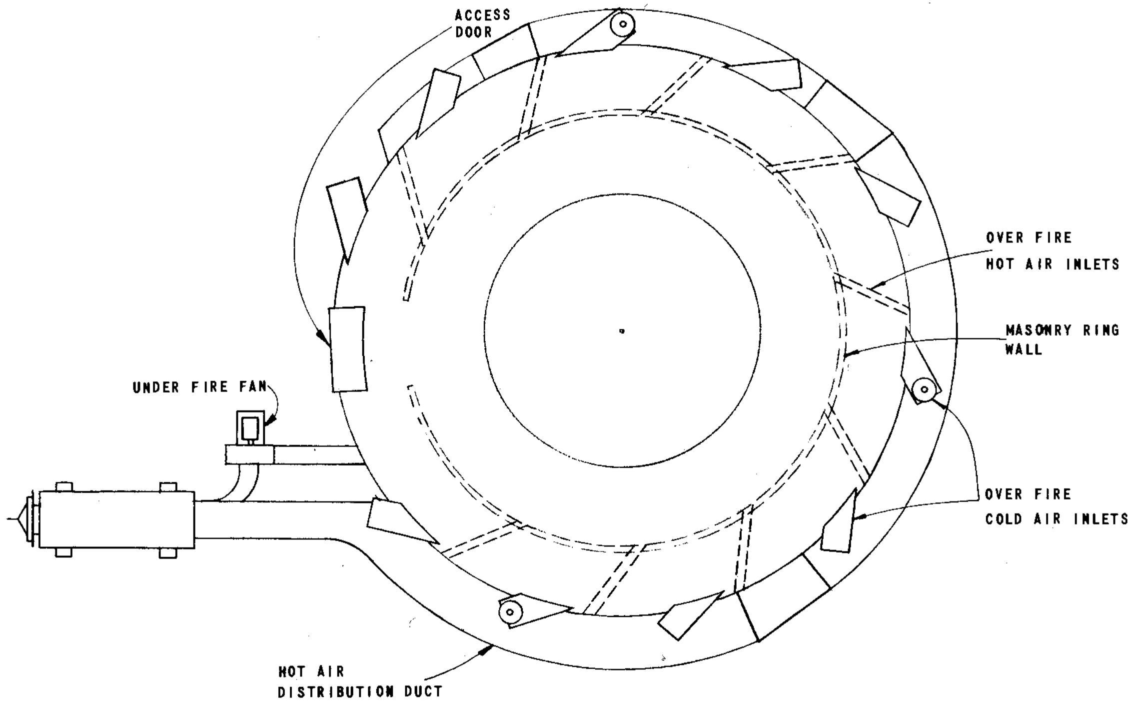
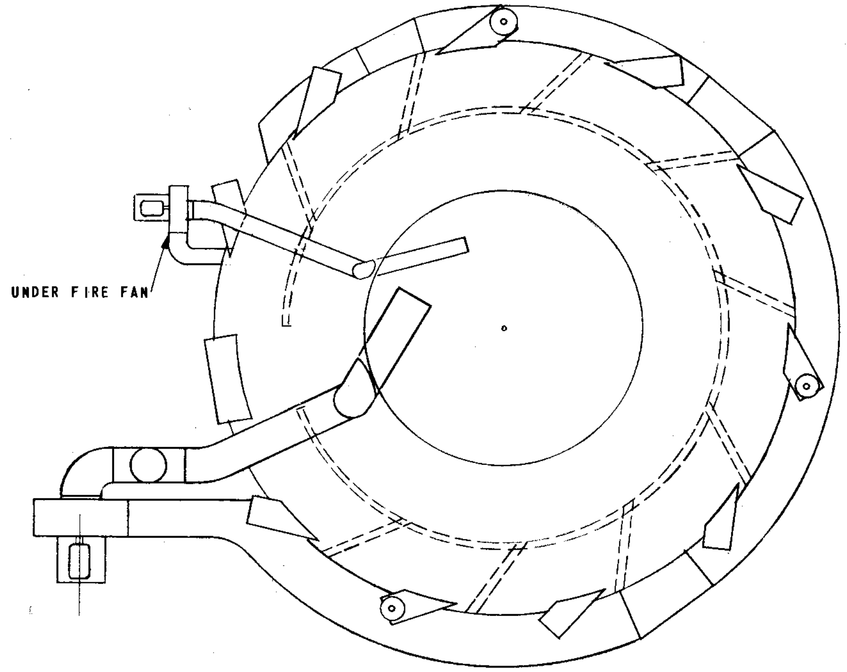
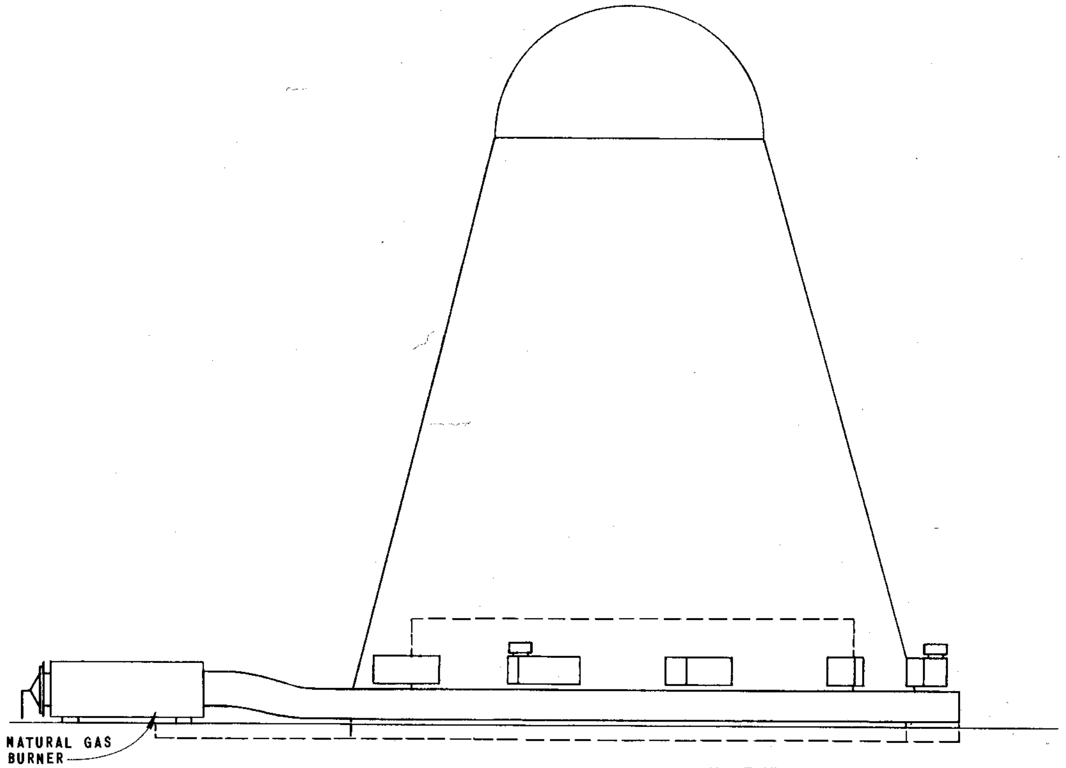


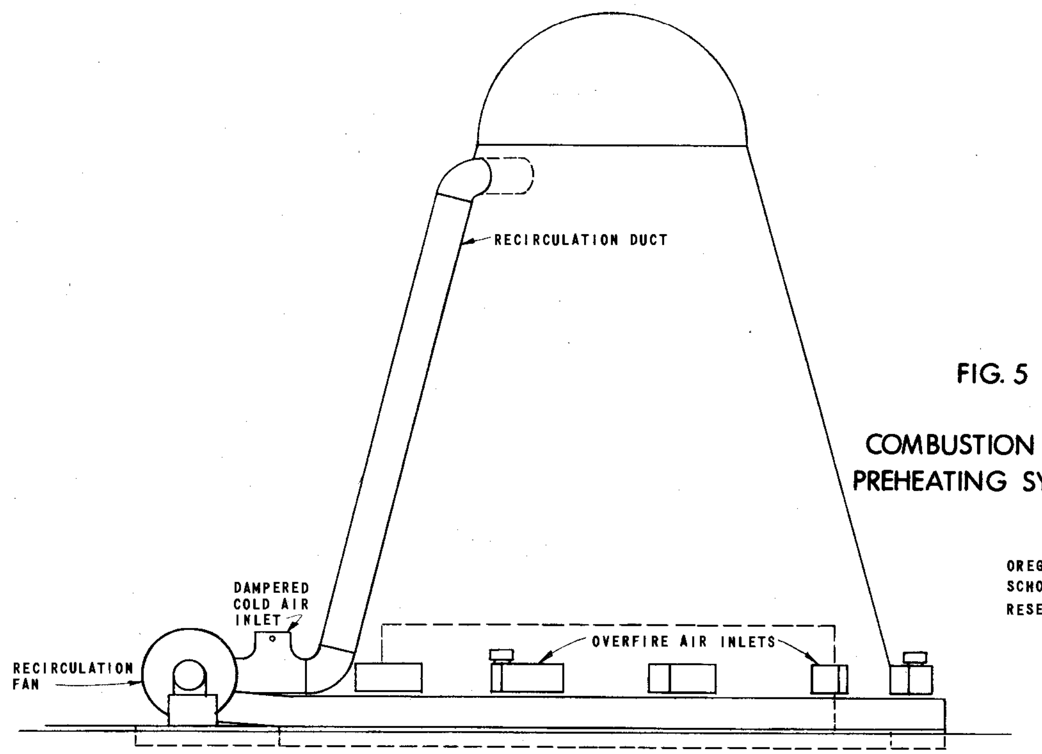
PLAN VIEW
PREHEATED AIR SYSTEM



PLAN VIEW
RECIRCULATED HOT AIR SYSTEM



ELEVATION VIEW



ELEVATION VIEW

FIG. 5

COMBUSTION AIR PREHEATING SYSTEM

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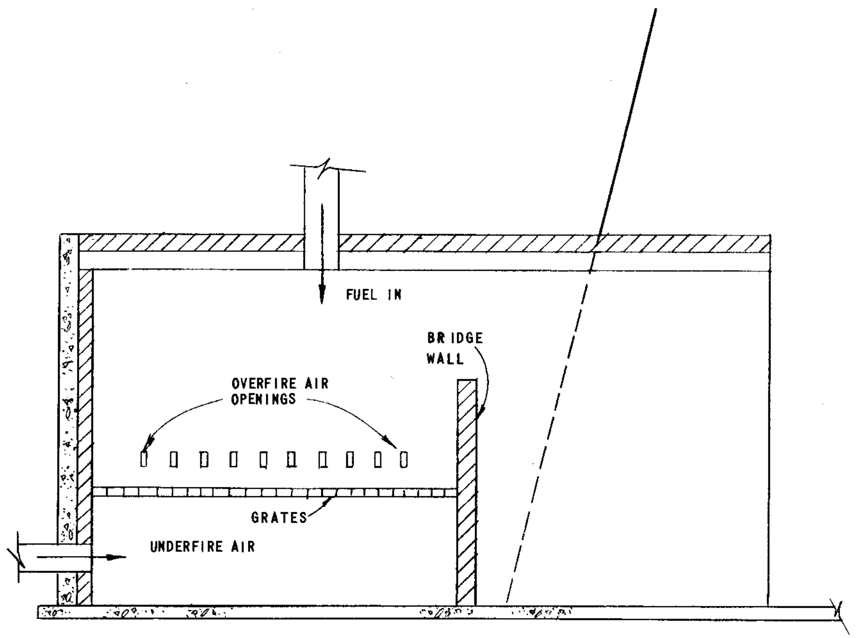
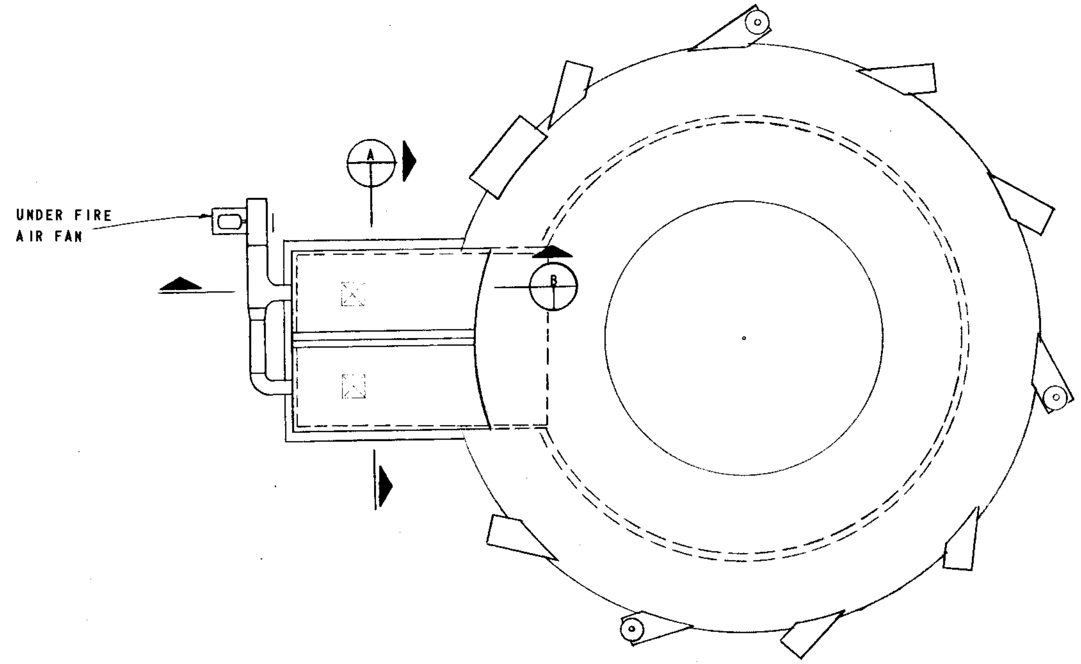
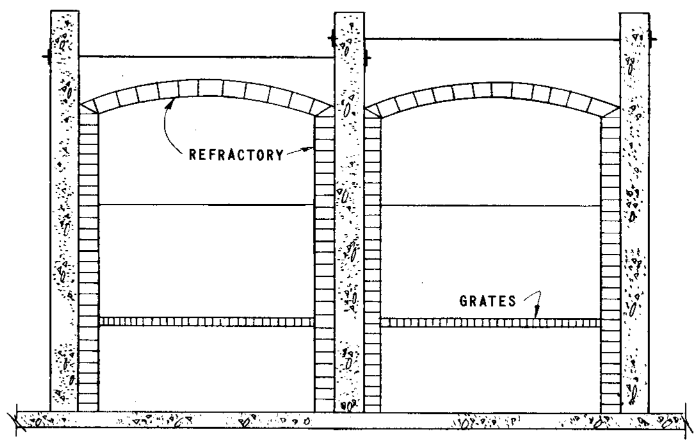


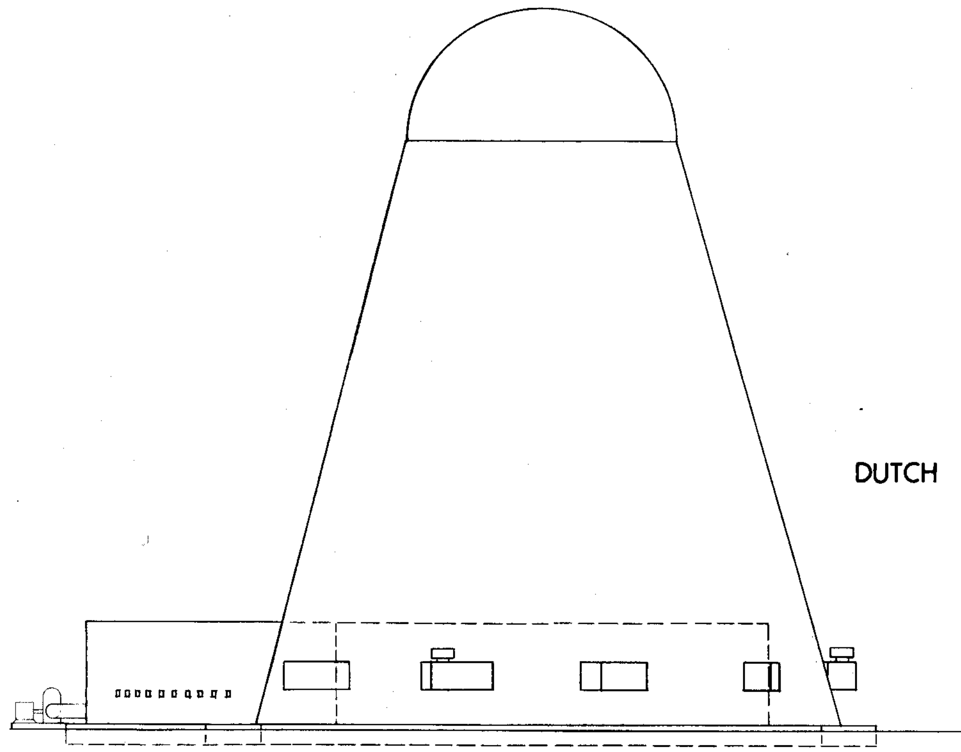
SECTION B



PLAN VIEW
DUTCH OVEN AND WIGWAM BURNER



SECTION A



ELEVATION VIEW

FIG. 6

DUTCH OVEN ARRANGEMENT

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