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PRELIMINARY OPERATING ASSESSMENT ADVANCED HEAT RECOVERY
INCINERATOR (HRI). (U) SANDERS AND THOMAS INC POTTSTOWN
PA H I HOLLANDER ET AL. JUL 83 NCEL-CR-83.028

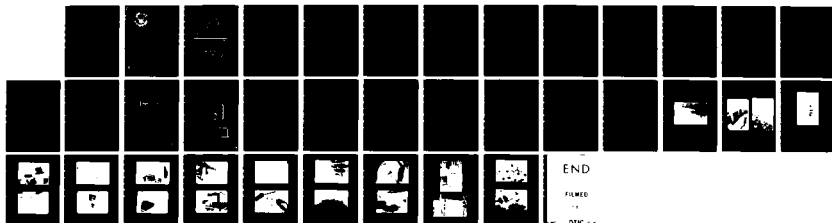
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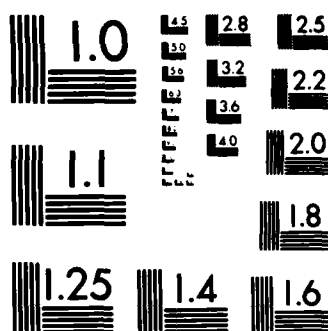
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This is a dark, grainy horizontal strip, likely a scan of a physical object's edge or a very low-quality photograph. It shows a mottled texture with some lighter specks against a dark background.

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A high-contrast, black and white photograph of a textured surface, possibly a wall or a piece of fabric. A vertical line runs down the center, creating a symmetrical effect. The texture is grainy and uneven, with many small, dark spots and larger, lighter areas. The lighting is dramatic, with deep shadows and bright highlights.

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→ This brief evaluation of the first O'Connor (rotary waterwell) Combustor plant built in the U.S.A. describes design features and considerations as well as initial operating advantages and difficulties. A brief general description of a co-located, proprietary fuel preparation system is included. The major conclusion presented alludes to a waste fuel availability— | | |

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requirement approaching 60 tons per day (tpd) for probable cost-effectiveness of this technology.

For further information, contact P.L. Stone, A/V 360-5925 or FTS 799-5925 or commercial (805) 982-5925/5974.

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TASK 2

**Part (1) (a) - System Description Delineating
Major Design Parameters**

I. Introduction

The system is designed for the primary purpose of disposing of all of the municipal solid waste generated in Sumner County, Tennessee in a cost effective and environmentally and socially acceptable manner. This goal is being achieved as demonstrated by its first year's operation, ending in December, 1982. One of the most significant facts about the plant is that since commercial operation commenced in March, 1982, 100% of Sumner County's municipal solid waste has been consumed at the plant. The waste is reduced in volume by as much as 90% and the ash produced is highly compactable and sterile. This reduces all problems associated with landfills to an easily manageable level.

Feasibility studies conducted by Sanders & Thomas indicated that approximately 150 tons per day of waste were generated by Sumner County. This waste, when converted to energy could closely match the energy requirements of three industrial plants in Gallatin, Tennessee. They were located in an industrial park and adjacent land was available for the waste to energy facility. Therefore, three of the most important ingredients for a successful project were available. They are: (1) willingness (and need) of the county to deliver the waste; (2) willingness (and need) of the industrial customers to purchase the energy; and (3) a logical site for the project.

The plant consists of two complete, independent processing trains which allows major maintenance to be performed while still providing energy to customers and producing revenue.

The plant is designed to handle a maximum of 200 tons per day, which allows for short term high throughput periods and allows for future population growth in the community. The plant operates seven days per week, 24 hours per day, with reduced processing on weekends since the industrial energy demand is lower.

Drawings are included in this report which show the combustor-boiler cross section, the plant cross section, and the plant layout. Copies of photographs with self-explanatory captions are also included to show important features of the plant.

The owner and operator of the facility is the Resource Authority in Sumner County. This agency was formed by representatives of the county and the two largest cities within the county. The Authority's Board of Directors makes all major decisions and is legally responsible for disposing of all residential, commercial, and industrial waste generated within the county. The Authority also has responsibility to operate the landfill, which now only receives oversized or non-combustible waste which bypasses the plant, or ash residues from the waste to energy plant.

Sanders & Thomas has been involved with the project beginning with the conception of the idea. A Preliminary Feasibility Study was followed by a Preliminary Engineering Design phase. The project Final Design and Construction was then completed by the fast track method with Sanders & Thomas functioning as the construction manager for the Authority. Ground was broken in June of 1980 and the first solid waste was processed in December of 1981. Sanders & Thomas also conducted the facility startup and operator training.

II. Process Description

Waste is received five days per week from a wide variety of sources, consisting of several sizes and styles of compactor trucks, dump trucks, manually unloaded trucks, and private citizens. Some are private commercial haulers and some are city or county owned trucks.

The trucks back up to an enclosed concrete waste storage pit to discharge their load. The metal siding building extends outward to a point which covers the rear half of the vehicles inside the building, thus affording protection from rain and wind which aids housekeeping. Three large electrically actuated roll-up doors provide access to the pit, yet they can be closed when not in use. All trucks are electronically weighed upon entering and leaving the facility for accounting purposes. The pit has water drainage provisions and holds approximately 550 tons of waste, which provides surge capacity and allows for operation over a three day weekend. All boiler combustion air is drawn from the pit area which provides ventilation to control odors.

A redundant pair of overhead bridge cranes transfer the waste from the pit to either of the two charging hoppers for the boilers. The boilers are each designed to process up to 100 tons per day and produce up to 27,000 pounds per hour of 425 psig steam superheated to 525° F. The boilers are top supported, water wall, two drum type with retractable steam soot blowers. Fuel oil burners are installed only for the purposes of startup and shutdown.

The boilers employ the patented rotary combustor waste firing system. This is the first application of the rotary combustor in the United States. It was invented in the U.S. by the O'Connor Combustor Corporation and has been in successful operation for several years in

Japan and Thailand. The combustor consists of alternating heat transfer tubes with steel plates to form the wall of a cylinder which is open on each end. The steel plates have holes which allow combustion air to enter the cylinder. The tubes are cooled by forced circulation of boiler water. The cylinder is supported horizontally with a slope and penetrates the lower furnace area of the boiler. The very slow rotation of the combustor causes a constant tumbling of the fuel bed for good mixing with combustion air and transferring of the ash out the lower end of the combustor and into the bottom of the furnace area of the boiler.

Refuse is metered by the automatic combustion control system which controls the movement of hydraulic charging rams. The rams push the refuse from the charging chute into the upper end of the combustor. The combustor has hoppers beneath it for the dual purposes of collecting siftings and distributing the combustion air. The air is controlled by dampering in a number of separate zones. The siftings are transported from the bottoms of the hoppers to the boiler bottom ash removal system.

As the refuse is consumed, the radiant heat is absorbed by the water in the tubes and the flue gases pass into the boiler and flow similarly to conventional stoker fired water wall boiler systems.

The remaining bottom ash and non-combustibles fall out the end of the combustor onto a steeply sloped grate to allow any larger, slow burning items to complete combustion. The ash and noncombustibles then drop into a water sealed ash pit where a chain drag mechanism dewateres and transports the ash up and into rolling containers. The containers are lifted onto a truck, electronically weighed, and transported to the landfill during the day shift.

The flue gases pass through a natural circulation convective boiler tube bank for generation of steam and then down through a horizontally tubed air heater section for the low temperature heat removal. Oxygen concentration is monitored and is an input trim to the automatic combustion control loop.

The flue gases then leave the boiler and enter the air pollution control system outside the building. The first step is a cyclone separator and the second step is an electrostatically assisted baghouse. This type of baghouse is in the development stages and was purchased with a research grant from the U. S. Department of Energy. This is the first application of this technology to solid waste flue gases. The induced draft fan moves the gas from the electrostatic baghouse to the 90 foot tall steel stack. Fly ash removed by the cyclone and baghouse is returned and mixed with the boiler bottom ash removal system.

All of the superheated steam from both boilers is headered together and routed through a single stage backpressure turbine generator. The generator is a synchronous unit and can support the plant minimum electric load in case of a main power supply trip-out. The electric power is sold to the Tennessee Valley Authority under their small co-generators policy.

The steam is reduced in pressure by the turbine to 200 psig and certain auxiliary equipment in the plant is driven by a portion of this steam. The remainder is pressure and flow controlled to the three industrial steam customers on a specific priority basis. Steam flow integrators meter the usage by each customer and each is billed monthly on the basis of his equivalent displaced fossil fuel cost with a 15% discount. One customer returns condensate to the facility and

this is metered for credit. Should customer steam demand be below the production rate of the facility, air cooled heat exchangers condense the steam and return the condensate to the boilers.

The facility is designed with extensive instrumentation and controls in a manner similar to utility power plants. The central control room has console displays of all important measured process variables with remote automatic adjustments for the control loops in the main boiler systems, auxiliary systems, and main turbine generator systems. Closed circuit television cameras display the condition of the waste pit area and charging hoppers as well as the actual fire inside the combustors.

A separate, unique system has been incorporated into the front end of the plant which enhances the refuse for use as a fuel. This fuel preparation system is the first of its kind and is being provided and developed by National Recovery Technologies, Inc. The system functions completely independent to the refuse handling of the waste to energy plant and can, therefore, be bypassed without interrupting the operation of the boilers.

Refuse is fed by crane to a conveyor belt which supplies the processing equipment adjacent to the pit area. The proprietary equipment breaks open plastic bags and homogenizes the fuel, then with automatic processes, removes and separates ferrous metals, non-ferrous metals, glass, and grit. Bulky items are removed manually and the remaining combustible materials are returned by conveyor belt to the main waste storage pit where it is kept segregated from unprocessed waste for use as fuel in the boilers. Presently, only the removed aluminum is marketed as a revenue stream.

This processing system differs drastically from present state-of-the-art "refuse derived fuel" systems in that it is very simple and requires very low energy and labor. The major benefits are that even though it is not essential to plant operation, it economically justifies itself with its own revenue and has definite, positive benefits in the operation and maintenance of the boilers and ash removal equipment due to the enhancement of the fuel. The fuel has a higher heating value, lower ash content and is more consistent in its physical properties. The boilers are therefore easier to control and produce the required steam with lower fuel throughput. Additionally, one of the major sources of trouble, the bottom ash removal system, has a noticeable reduction in problems when the "processed waste" is used.

Task 2
Part (1) (b) - System Drawings

1. Plant Layout
2. Plant Cross-section
3. Combustor-Boiler Cross Section

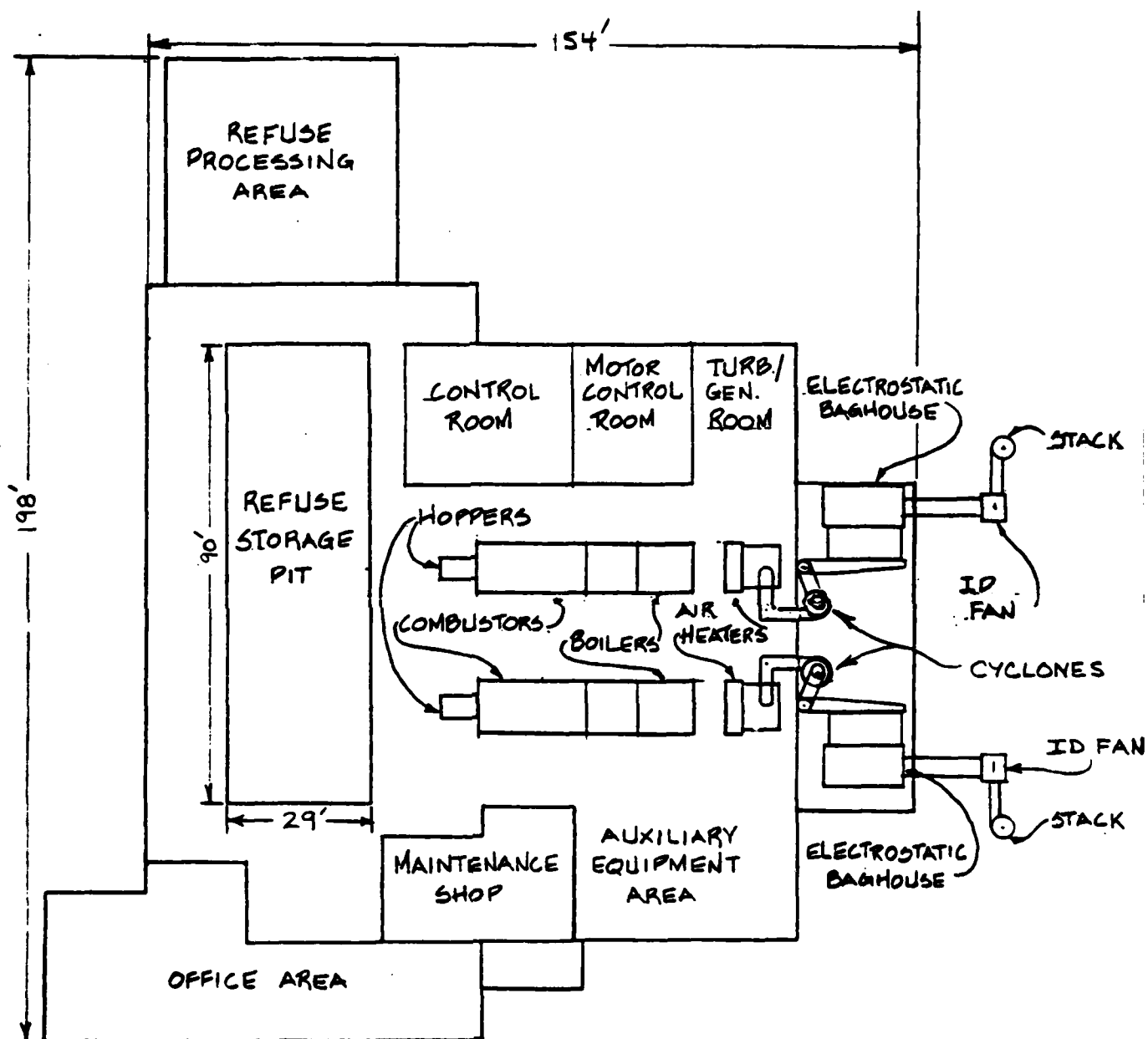


FIG. 1 PLANT LAYOUT

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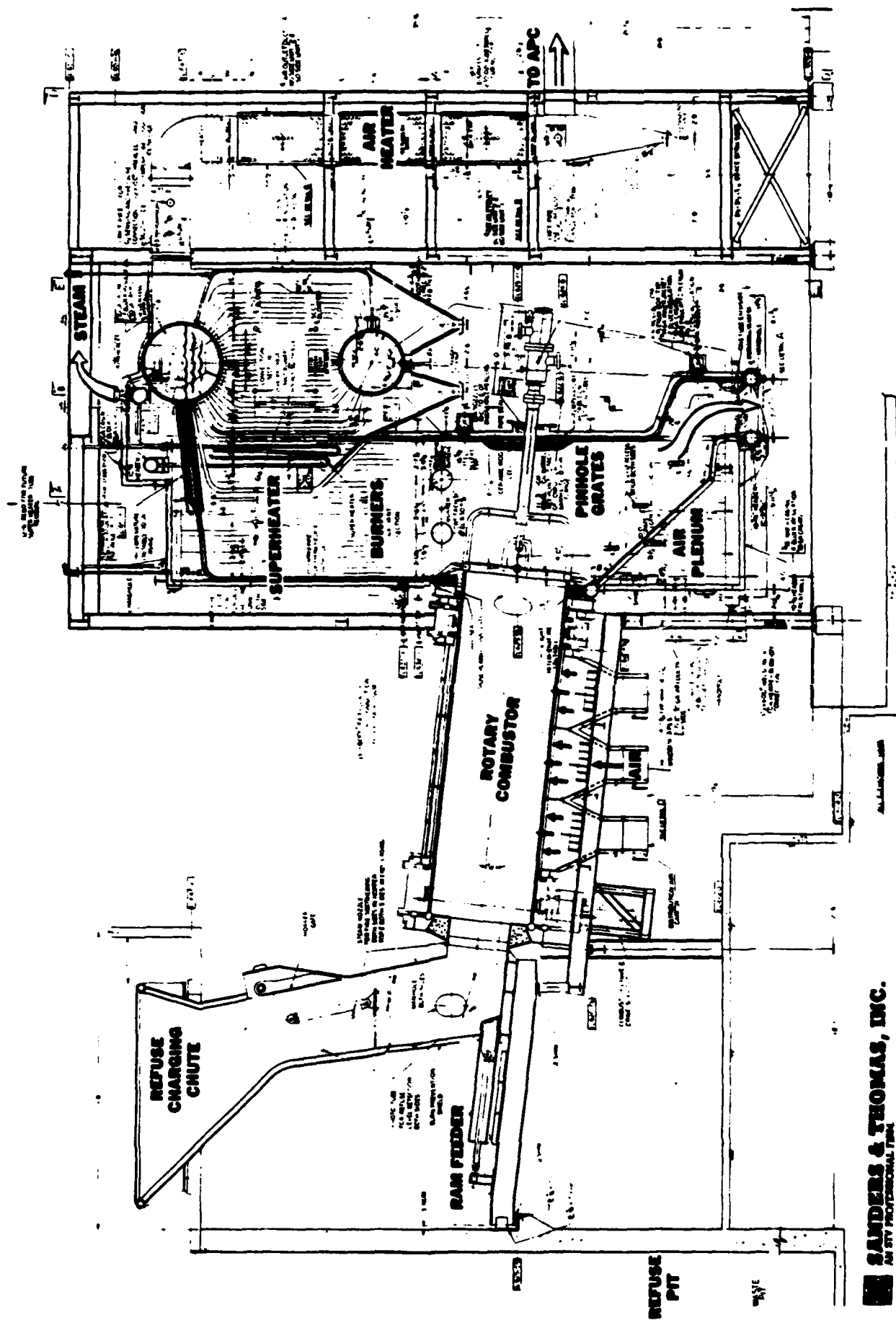
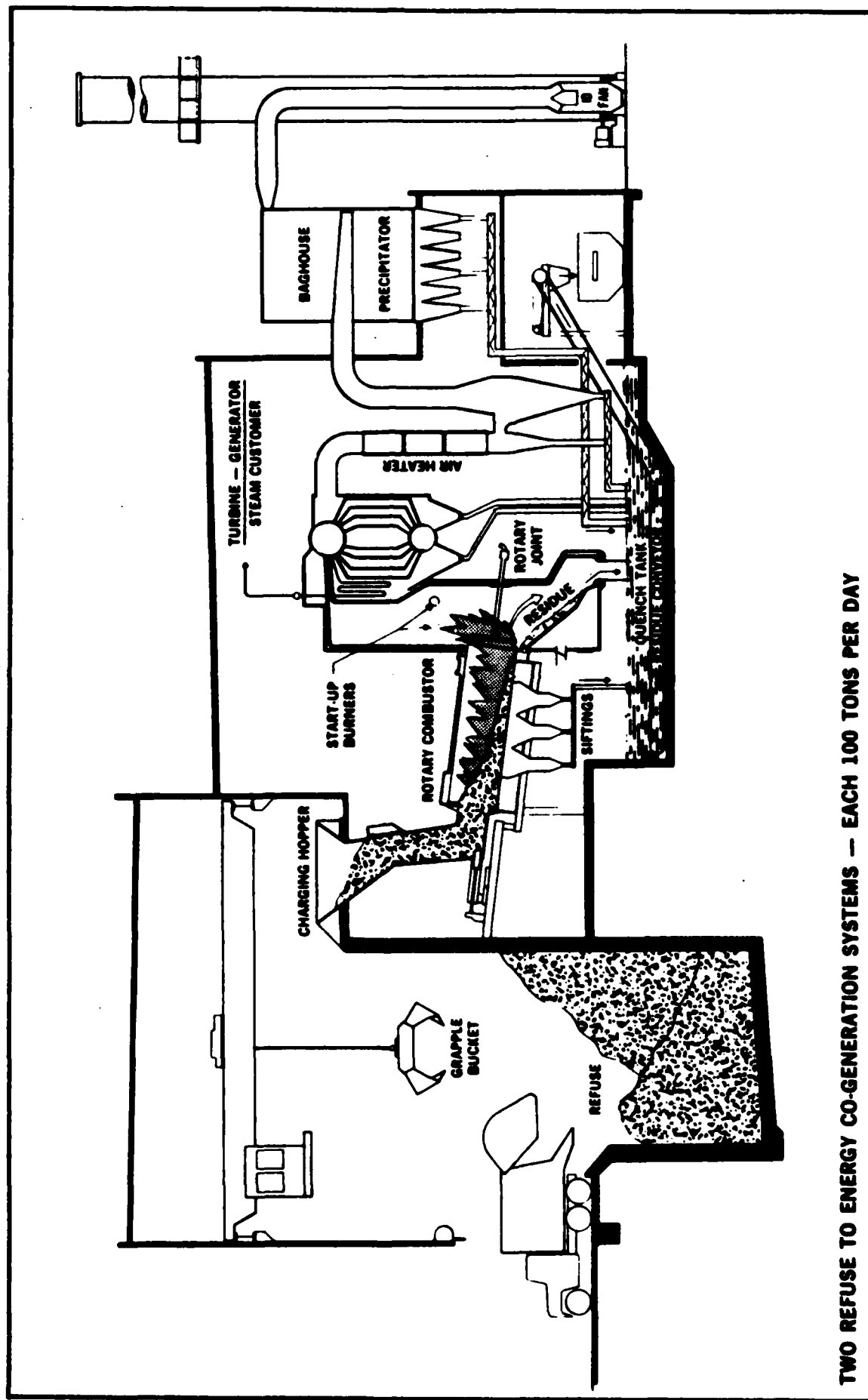


FIGURE 2
PLANT CROSS-SECTION

SANDERS & THOMAS, INC.
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SUMNER COUNTY RESOURCE AUTHORITY — GALLATIN, TENNESSEE



TWO REFUSE TO ENERGY CO-GENERATION SYSTEMS — EACH 100 TONS PER DAY

FIGURE 3
COMBUSTOR-BOILER CROSS SECTION

SANDERS & THOMAS.

Task 2 Part (1) (c) - System Cost

The total plant construction cost, including engineering, administrative, and preliminary development costs was \$9.9 million. Construction could be considered substantially complete in March of 1982, which was the time that both boilers were operable and all of the county's waste began to be processed.

The major plant equipment and construction contract costs are as follows:

| | |
|---------------------------------|----------------|
| Building | \$ 1.1 million |
| Cranes | \$540,000 |
| Boilers | \$ 3.1 million |
| Air Pollution Control | \$320,000 |
| Turbine/Generator | \$96,000 |
| Foundations & Utilities | \$550,000 |
| Mechanical Work | \$1.4 million |
| Electrical Work | \$330,000 |
| Instrumentation | \$280,000 |
| Steam Distribution System (M&L) | \$720,000 |

Task 2
Part (1) (d) - Optimum Operation

Process variable recorder strip charts have been transmitted under separate cover. These recorded the actual operating parameters covering the 136 hour observation period from 7:00 A.M. on December 11, 1982 through 11:00 P.M. on December 16, 1982. The variables are: (1) steam flow; (2) combustor water flow; (3) combustion air flow; (4) furnace draft; (5) flue gas oxygen; (6) steam drum level.

The combustors have an unusually wide waste throughput turndown ratio of at least two to one for stable steam production. They have demonstrated the capability to tolerate refuse feed rates greater than their 100 ton per day design rating. They can handle a wide variety of moisture contents and heating values in the waste due to the inherent advantages of the tumbling action and preheated combustion air with the water cooled surfaces.

The boilers have demonstrated steaming capacities in excess of their 27,000 pound per hour rating on a number of occasions.

Testing municipal solid waste fired boilers for thermal efficiency is very nearly an impossible task. This is fundamentally because the fuel has unknown and constantly changing properties. Meaningful test methods have been debated by the experts for decades. Reasonable indications can be obtained, however, if the conditions, assumptions, and limitations of tests and calculations are well understood by those persons performing and those interpreting and using the test results. Several "thermal efficiency tests" have been performed at the Sumner County Facility and the indications are that the efficiency can run in the neighborhood of 70%. This is unusually high for municipal solid waste fired boilers.

SANDERS & THOMAS.

Final air emissions testing has not yet been performed due to operational problems with the air pollution control equipment. Retrofit modifications have been completed and testing will be performed in the immediate future. From previous preliminary tests, the particulate emissions from the boiler have been less than 2 grains per dry standard cubic foot (corrected to 12% CO₂) and the stack particulate emissions are guaranteed by the baghouse manufacturer to be no more than 0.005 grains per dry standard cubic foot (corrected to 12% CO₂).

The plant is operated with three operators for each of the four shifts. One is the crane operator, one is stationed in the central control room, and the third is the field operator. There are six maintenance men, all assigned to the day shift, five days per week. The administration consists of two office workers, a plant manager, and an operations manager.

Conclusions and Recommendations

This application of the rotary combustor, along with the experience in other countries demonstrates the viability of the technology as a commercial operating system. The materials recovery system is not yet as well proven by time, yet it gives every indication of continuing to be a commercially viable operation. The electrostatically assisted baghouse is still unproven as a reliable air pollution control system. Virtually all of the systems of the plant other than these three innovative technologies are established in other operating situations such as utility and industrial power plants.

The Sumner County waste to energy plant was designed to be as much like a utility power plant as practically possible within the obvious and not-so-obvious constraints that are naturally placed upon it. Reliability and quality were designed in as much as the tight budget would allow. Obviously, the plant could not be built today or even at the end of the construction period for the same price it was actually built for. Moreover, the Resource Authority's economic goals could not have been met and the plant would not have been built without the financial assistance of TVA and the federal government.

The rotary combustor is presently designed for throughputs only as low as 60 tons per day in a single unit. This could restrict the applicability to U. S. Navy Shore Bases unless adjoining municipalities added their waste to that produced by the base. Other than this limitation, virtually all of the technology utilized at Gallatin could be applied in the processing of shore base waste.

Typically, shore base waste is higher in heating value and lower in moisture than municipal solid waste, so boiler operation and control would actually be better for the base than for a municipality. Waste water treatment sludges can be disposed in a rotary combustor as well as other waste streams that may exist on a base such as spent lubricants or solvents. Other unusual items which may exist, such as large rope or large packaging materials like wooden crates could be handled with simple size reduction shears before charging to the boilers.

Typical Navy waste constituents are found in Table 1 - Sample Constituent Weight Distribution (As-sorted), which were determined during a previous S&T project for the Civil Engineering Laboratory conducted at the Mayport Naval Station, Florida. This waste is also shown in photographs and, as mentioned earlier, could be accommodated by a resource recovery facility equipped with rotary combustor technology and heat recovery boilers.

TABLE 1 - SAMPLE CONSTITUENT WEIGHT DISTRIBUTION
AS-SORTED

| <u>Constituent</u> | <u>Sample I</u> | | <u>Sample II</u> | | <u>Sample III</u> | | <u>Sample IV</u> | | <u>Average</u> | |
|---------------------------|-----------------|-----------|------------------|-----------|-------------------|-----------|------------------|-----------|----------------|-----------|
| | Weight, Pounds | Weight, % | Weight, Pounds | Weight, % | Weight, Pounds | Weight, % | Weight, Pounds | Weight, % | Weight, Pounds | Weight, % |
| 1. Corrugated Cardboard | 170 | 15.9 | 444 | 18.5 | 278 | 15.5 | 130 | 12.1 | 1022 | 16.1 |
| 2. Other Cardboard/Paper | 321 | 30.1 | 617 | 25.6 | 541 | 30.1 | 369 | 34.5 | 1848 | 29.2 |
| 3. Textile/Leather | 33 | 3.1 | 156 | 6.5 | 77 | 4.3 | 60 | 5.6 | 326 | 5.1 |
| 4. Plastic/Rubber | 100 | 9.4 | 283 | 11.8 | 203 | 11.3 | 98 | 9.1 | 684 | 10.8 |
| 5. Food Waste | 23 | 2.2 | 146 | 6.1 | 103 | 5.7 | 103 | 9.6 | 375 | 5.9 |
| 6. Wood/Lumber | 38 | 3.6 | 87 | 3.6 | 42 | 2.3 | 34 | 3.2 | 201 | 3.2 |
| 7. Yard/Landscaping Waste | 61 | 5.7 | 147 | 6.1 | 130 | 7.2 | 55 | 5.1 | 393 | 6.2 |
| 8. Fines/Sweepings | 201 | 18.8 | 237 | 9.9 | 139 | 7.7 | 50 | 4.7 | 627 | 9.9 |
| <u>COMBUSTIBLES</u> | 947 | 88.8 | 2117 | 88.1 | 1513 | 84.1 | 899 | 83.9 | 5476 | 86.4 |
| 9. Ferrous Metal | 50 | 4.7 | 113 | 4.7 | 99 | 5.5 | 71 | 6.6 | 333 | 5.2 |
| 10. Aluminum | 10 | 0.9 | 28 | 1.2 | 20 | 1.1 | 10 | 0.9 | 68 | 1.1 |
| 11. Other Metals | 4 | 0.4 | 29 | 1.2 | 43 | 2.4 | 19 | 1.8 | 95 | 1.5 |
| 12. Glass | 53 | 4.9 | 104 | 4.3 | 115 | 6.4 | 25 | 2.4 | 297 | 4.7 |
| 13. Other Inerts | 3 | 0.3 | 13 | 0.5 | 9 | 0.5 | 47 | 4.4 | 72 | 1.1 |
| <u>INERTS</u> | 120 | 11.2 | 287 | 11.9 | 286 | 15.9 | 172 | 16.1 | 865 | 13.6 |
| <u>TOTAL</u> | 1067 | 100.0 | 2404 | 100.0 | 1799 | 100.0 | 1071 | 100.0 | 6341 | 100.0 |

SANDERS & THOMAS.

PHOTOGRAPHS



SUMNER COUNTY RESOURCE RECOVERY FACILITY
GALLATIN, TENNESSEE



VIEW OF WASTE STORAGE
PIT FROM CHARGING FLOOR



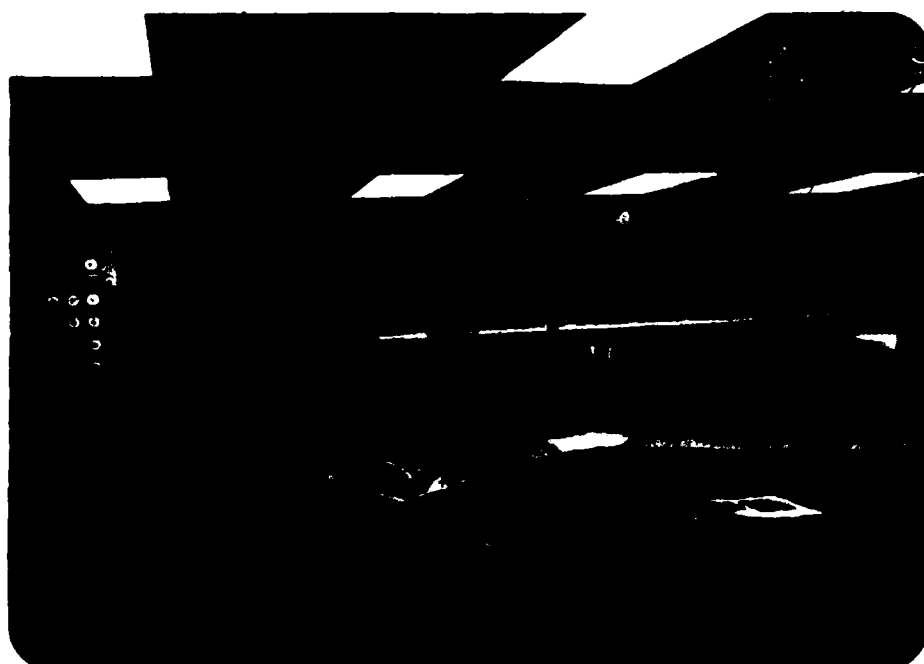
HYDRAULIC CRANE BUCKET
TRANSFERRING WASTE



INLET/OUTLET CONVEYORS TO NRT
PLANT AT SIDE OF WASTE STORAGE PIT



HYDRAULIC CRANE BUCKET AND CAB



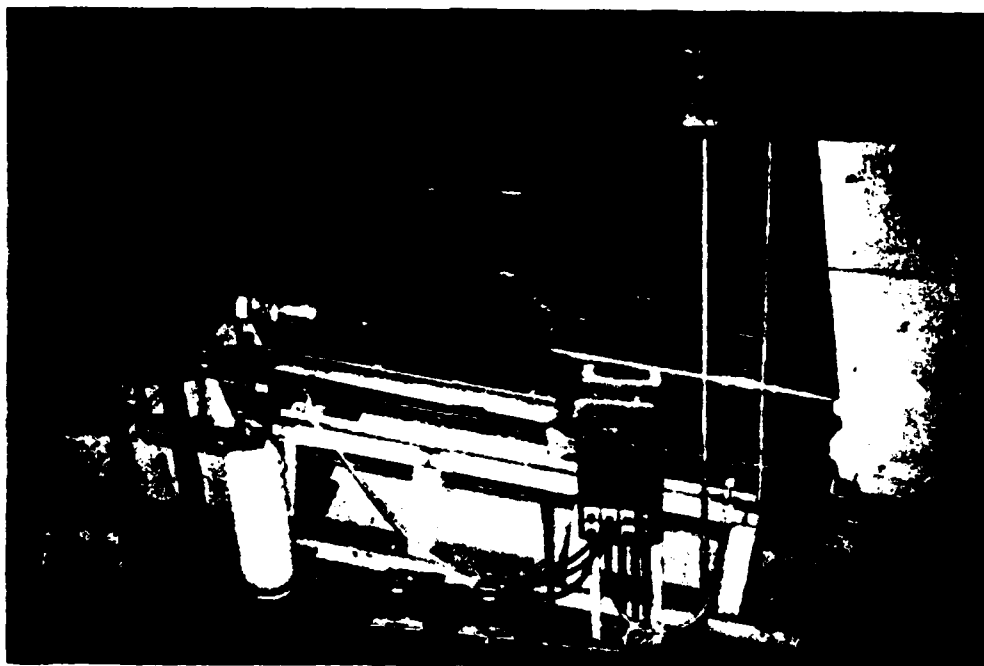
CENTRAL CONTROL ROOM - MAIN CONTROL CONSOLE
WITH TURBINE GENERATOR CONSOLE AT LEFT



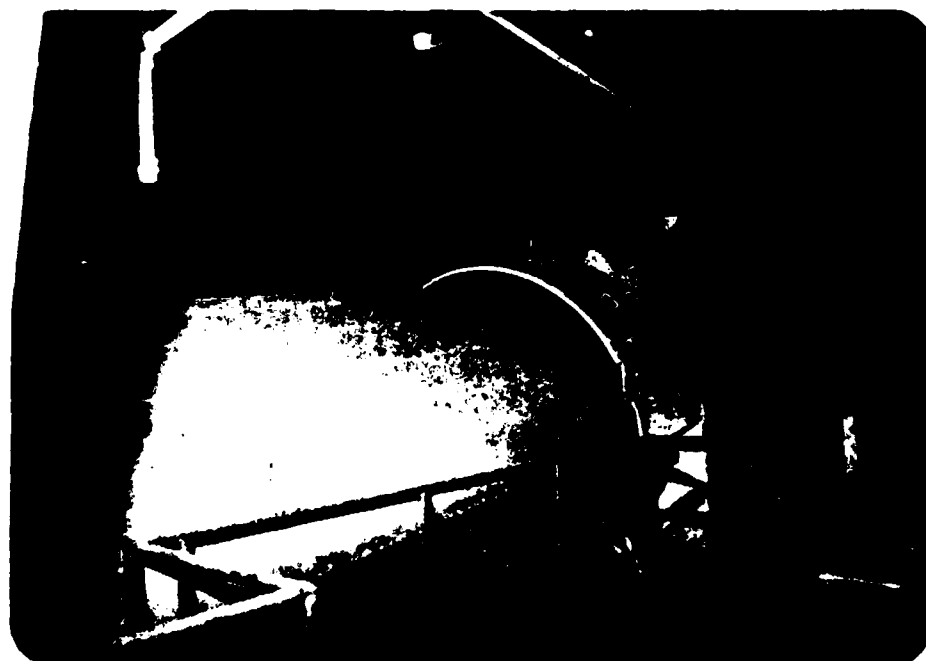
550 KW TURBINE GENERATOR



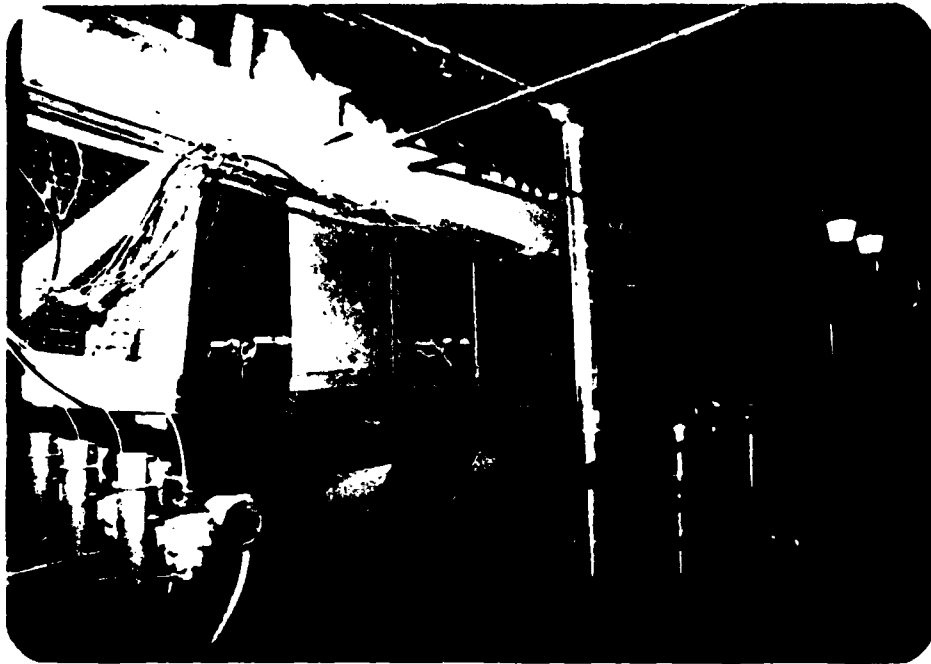
REFUSE CHARGING CHUTE WITH ONE
OF TWO HYDRAULIC RAMS CHARGING



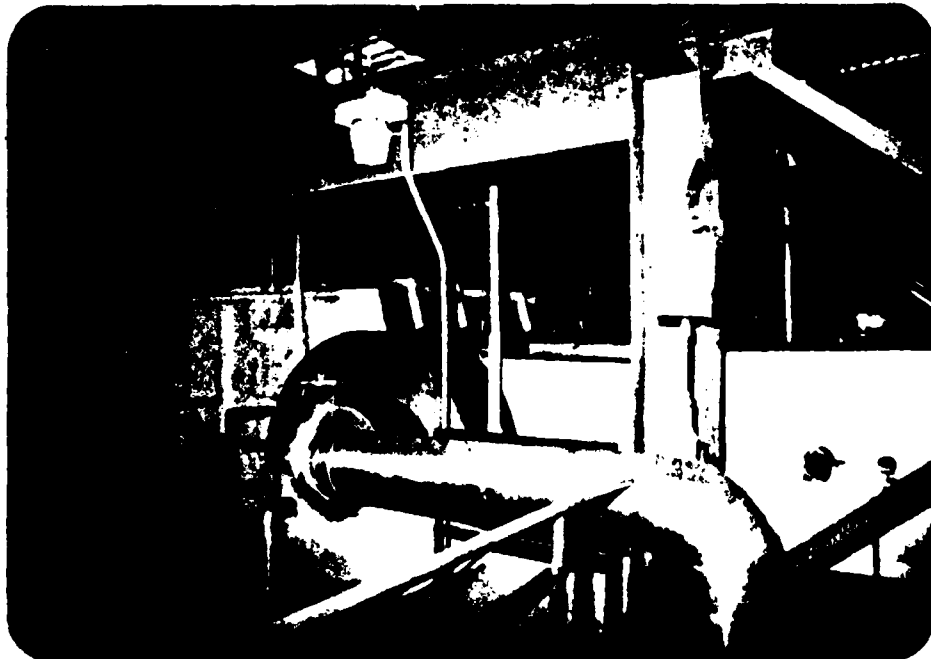
HYDRAULIC CHARGING RAM



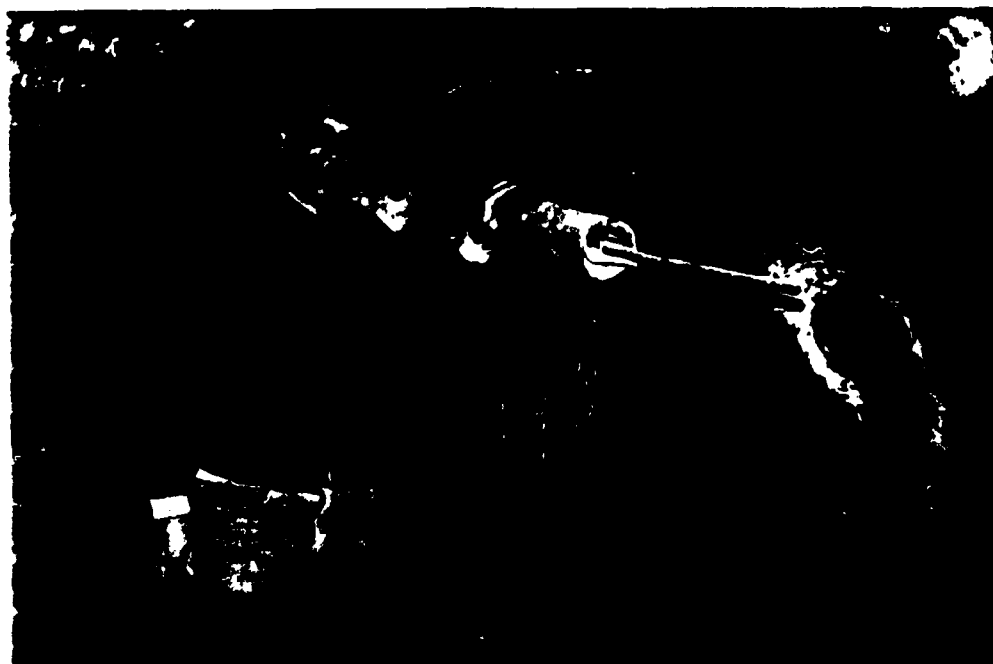
O'CONNOR ROTARY COMBUSTOR



COMBUSTION AIR DISTRIBUTION/SIFTINGS HOPPERS



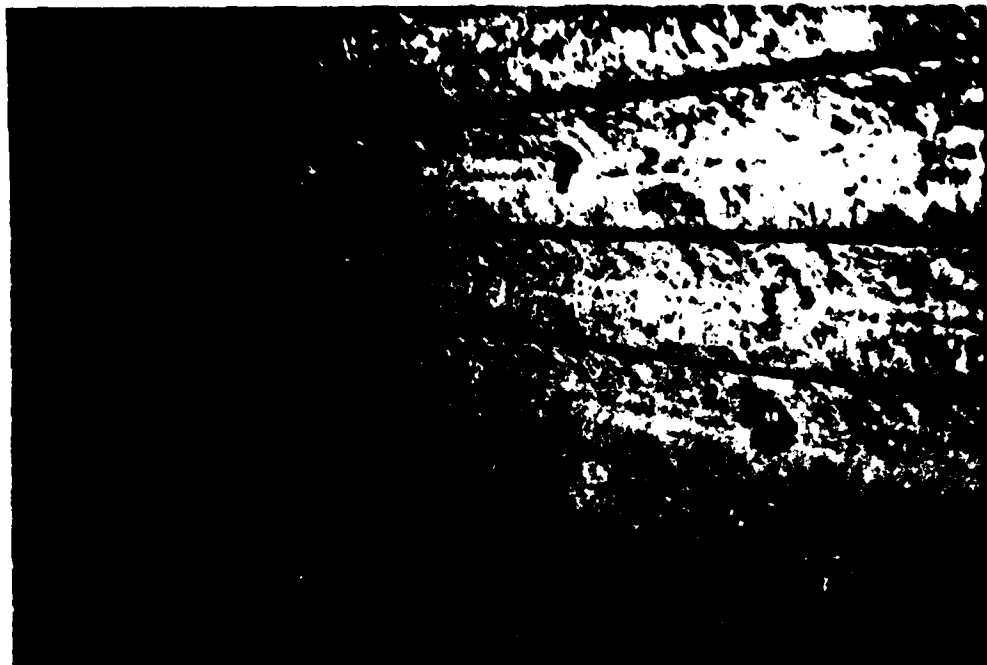
BOILER STEAM DRUM



INTERIOR VIEW OF COMBUSTOR LOOKING
TOWARDS WASTE CHARGING RAMS



CLOSE-UP OF PRIMARY THERMOCOUPLE, LIQUID
WASTE INLET (CENTER), AND IGNITION BURNER (RIGHT)



COMBUSTION AIR OPENINGS IN
WALL OF ROTARY COMBUSTOR



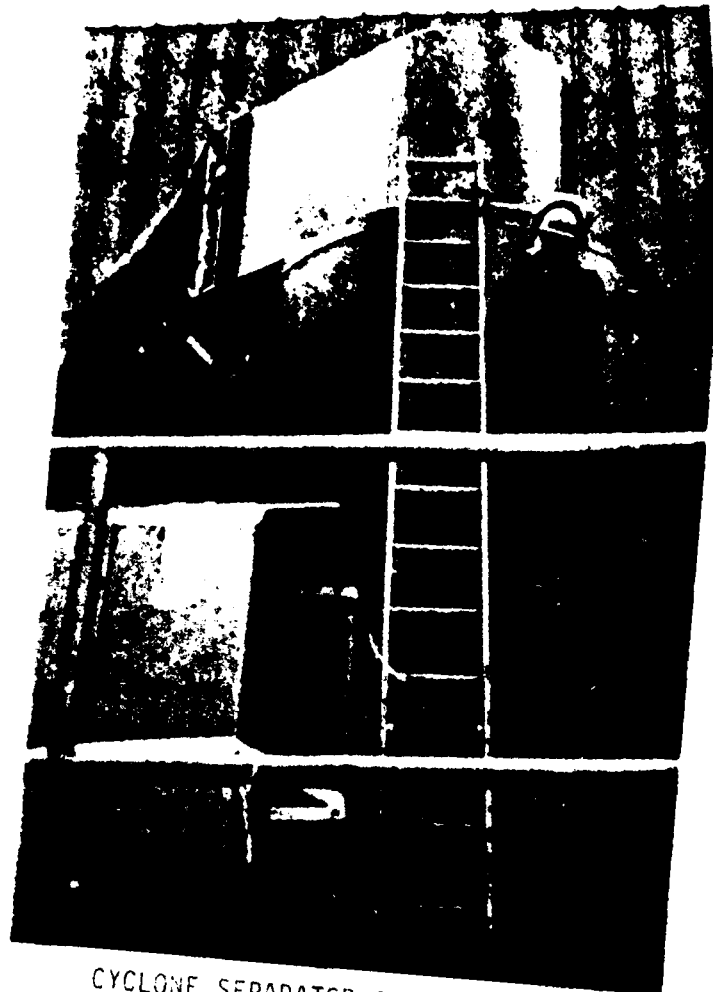
SLOPED AFTERBURNING HEARTH AND OPENING
TO ASH QUENCH TANK AND DRAGOUT



DISCHARGE END OF ROTARY COMBUSTOR
SHOWING WATER DISTRIBUTION HEADERS



TYPICAL ALUMINUM SLAG FROM
HOPPERS BENEATH COMBUSTOR



CYCLONE SEPARATOR INSTALLATION



REAR VIEW OF FACILITY SHOWING ELECTROSTATICALLY-
ASSISTED BAGHOUSES, CYCLONES, IO FANS, AND STACKS



TYPICAL UNITED STATES NAVAL BASE
SOLID WASTE



TYPICAL UNITED STATES NAVAL BASE
SOLID WASTE

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.
- 13.

END

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