File Copy

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Performance Test of a Mobile Hydroneal Gas Generating Plant

Report Number: T-58-47
Date: June 1958

U S Army
Engineer Research And
Development Laboratories

FORT BELVOIR, VIRGINIA

United States Army
Engineer Research and Development Laboratories
Ft. Belvoir, Virginia

Performance Test of a Mobile Hydroneal Gas Generating Plant

Report Number: T-58-47
Date: June 1958

Submitted by
Evaluation Engineering Branch
Laboratory Section

Prepared by:

S. S. SHERRIFF
Senior Engineer
Gas Lab Unit

R. DONAGHY
Test Engineer

Approved by:

N. H. PETERSEN
Ch., Laboratory Section

A. J. RUTHERFORD
Ch., Evaluation Engineering Branch

TABLE OF CONTENTS

SUMMARY

This report covers the evaluation testing of a Mobile Hydroneal Gas Generating Plant for the Office of Naval Research, Department of the Navy.

Extensive changes were made to the piping system and flow controls prior to the performance test. Operational performance was run continuously for 165 hours, at which time the test was stopped due to failure of the retorts under high temperature conditions. Major cause of failure was cracking in the torus rings at the bottom of the retorts. Successive modification and cyclic testing proved that this source of trouble was eliminated by increasing the radii and reducing the wall thickness of the rings, and lowering the operating temperature of the retorts from 2150°F to 1800°F.

The evaluation results indicate that the Hydroneal Gas Generating Plant is capable of making a product gas of specification purity at the lower operating temperature with no equipment failure. Consideration should be given to the relocation of the retorts and ammonia reservoir in the future redesign of the unit.

LABORATORY SECTION
EVALUATION ENGINEERING BRANCH

Report Number: T-58-47 Date: June 1958

Project Number: FB-79-b

PERFORMANCE TEST OF A MOBILE HYDRONEAL GAS GENERATING PLANT

I. INTRODUCTION

1. Subject. This report covers the performance testing of a mobile Hydroneal Gas Generating Plant submitted for test by the Department of the Navy.

2. Background. This testing was requested by Mr. S. Haven, Project Engineer, Office of Naval Research. Previous to this evaluation request the operation of the plant was erratic and insufficient for its design purpose. The purpose of this test was to give the plant a thorough study, check out and possible modification prior to shipment for field operation.

3. Personnel. Testing was conducted by laboratory personnel under the supervision of Mr. S. S. Sherriff, Senior Engineer, Gas Generating Unit, Laboratory Section, Evaluation Engineering Branch.

II. INVESTIGATION

4. Description. The Hydroneal Gas Generating Plant was designed and built by Baker and Co., Inc., Newark, N. J. The plant is mounted inside a 1953 International Harvestor 1½ ton (Metro) panel truck, Model PM152, Serial Number 1393, Engine Number 240607.

The gas production process consists of endothermally splitting of aqueous ammonia into a gas mixture of three (3) parts hydrogen to one (1) part nitrogen by using an Englehard catalyst. The ammonia content of the efficient gas stream is held below 5% by volume.

The process equipment consists of an ammonia storage tank, with electric vaporizing heaters and heat exchanger, first and second stage preheaters, three (3) oil fired retorts, external superheaters, and a product gas delivery outlet.

The plant is a self-supporting unit containing its own power supply, ammonia pump, air compressor for pneumatic controllers, ventilating equipment and necessary controls.

5. Test Procedure. The tests were conducted at the Gas Generating Equipment Laboratory, U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Virginia, during the period 9 August 1957 to 9 May 1958. The unit was started and run in conformance with the operating instructions of the manufacturer. Duration of the test was to be 24 hour operation, five (5) days per week, for a period of two (2) weeks.

6. Test Results.

a. As a result of initial inspection and check tests the following modifications were made:

(1) The cover of the electrical switch box mounted on the front side of the ammonia storage tank was lined with asbestos to protect the equipment from heat radiated from the retorts.

(2) A small blower was installed on the control cabinet for ventilation purposes (See figure 1). The blower was connected to the main electrical circuit to insure continuous operation while the plant was running.

(3) It was found that the 3 KW Homelite electric generator was not of large enough capacity to fill the operating requirements of the plant. Two (2) immersion heaters in the ammonia storage tank were disconnected to relieve the overload but the tank pressure dropped from 130 psig to 58 psig within two (2) hours while maintaining the same flow. A 5 KW engine generator set was installed and provided enough power to operate all the units of the plant at maximum capacity.

(4) A mercoid switch was installed to actuate the immersion heaters between the limits of 80 psig and 100 psig tank pressure. A manual cut-out switch was connected to the mercoid switch.

(5) The product outlet line was relocated to the left-hand center door due to the proximity of the valve to hot piping in the original position.

(6) The original insulation around the furnaces was supplemented by adding a layer of castable high-temperature refractory on the interior of the fireboxes.

(7) A sheet of asbestos board was placed between the oil-burner and the furnaces to protect the motors from radiated heat.

b. A trial run of six (6) hours duration was made with a blind installed in the product line to the preheaters. This arrangement allowed maximum heat exchange in the ammonia storage tank in order to increase vaporization. No heat was gained by the incoming ammonia vapor in the preheaters using this flow system (See figure 2).

With burner temperatures between 2000°F and 2150°F and 4000 SCFH product gas flowing, the pressure in the storage tank increased from 90 psig to 210 psig.

It was the opinion of the representatives of the manufacturer and Office of Naval Research that the pressure would continue to rise until the safety valve was overcome, so the test was terminated.

c. To balance the heat supplied to the storage tank, the following changes were proposed by the test personnel, approved by the manufacturer and put into effect (See figure 2).

(1) Remove the pressure regulating valve in the product gas line upstream from the second stage preheater and install it in place of the regulating valve existing in the second stage preheater by-pass line.

(2) Install the valve removed from the preheater by-pass line in place of the cold weather blind in the split gas by-pass line (See figure 3).

(3) Install blinds where pressure regulator was removed from preheater system (See figure 4).

d. A two-week performance test was started and after approximately 165 hours of satisfactory operation No. 1 retort burned out and was removed for inspection. Results of the inspection showed that failure occurred as extensive cracking along the weld at the bottom of the retort (See figure 5). The other two retorts were removed and a decision was made to replace all three torus rings. These rings were fabricated of cold-drawn Incoloy metal.

The new torus rings were cast of Incoloy by the National Bureau of Standards. The retorts were then installed in the plant and operation resumed. After approximately 20 hours operation No. 1 retort again failed. Failure this time occurred as a hole in the side of the torus at the bottom of the retort (See figures 6 and 7). No. 1 retort was removed from the system and No. 2 retort moved to its place.

e. Thermocouples were placed at several locations around the torus of No. 2 and No. 3 retorts, three (3) on the interior and three on the exterior, to check the heat distribution at the bottom of the retorts. Thermocouples were also placed in the furnace stacks, product line, and incoming gas line to compare heat loads in the respective furnaces. Chromel-Alumel thermocouples and a Minneapolis-Honeywell recorder were used to measure and record the temperatures. A layer of refractory brick and also installed in the base of No. 2 furnace to diffuse the burner flame and reduce heat concentration.

f. Operation was restarted and No. 2 retort failed approximately 15 hours afterward. Failure was again due to cracking at the base of the retort (See figure 8).

g. In an effort to reduce the amount of heat delivered to the retorts and to improve warm-up time, several different size nozzles were tried in the oil burner of No. 3 retort. Investigation yielded an optimum nozzle which gave 1.35 GPM at 100 psig fuel pressure. The original nozzle size yielded 1.50 GPM.

h. After consultation with the Navy project engineer and representatives of Battelle Memorial Institute, Columbus, Ohio, thermocouples were again placed at numerous locations on the interior and exterior of No. 3 retort and series of cycling tests, consisting of bringing the retort up to operating temperature and then shutting off the burner and allowing the retort to cool, were made. Temperatures were taken continuously during both the warm-up and cooling periods. The temperature records obtained were forwarded to Battelle Memorial Institute for analysis.

i. A new torus of increased radius and reduced wall thickness and fabricated of cold-drawn Incoloy, was welded to each retort in the USAERDL Machine Shop and the three retorts installed in the plant. A test of three (3) weeks duration was then conducted at a reduced operating temperature of 1800°F. The test was a cyclic operation consisting of bringing the plant up to operating temperature, allowing temperatures to stabilize, and then shutting off the burners and allowing the unit to cool to ambient temperature. Two (2) cycles per day were obtained. After the test was completed the retorts were removed for inspection. No cracks or defects were found.

j. A road test was conducted to study vibration effects on the castable firebox lining. No damage was observed.

III. DISCUSSION

7. Analysis of Results.

a. The plant, as received from the manufacturer, was capable of making a gas product of the required purity, but operation was erratic and required excessive operator attention.

b. The modifications to the flow system made by test personnel eliminated the problem of storage tank pressure regulation. This arrangement removes one preheater from the system completely, and the operation of the pressure regulators by-passes the other preheater when pressure in the storage tank drops below 80 psig. In this way maximum heat transfer can be attained to increase vaporization. The changes were made in such a way as to allow a change to the original flow system under high ambient conditions.

c. Failure of the retorts was due to defective welding and operating temperatures above the safe working temperature of the metal.

d. The original insulation around the firebox was inadequate and the high temperatures caused burning and warpage of the metal container. The lining of castable refractory proved satisfactory in reducing the heat transmitted to an acceptable level and resistant to damage from road shocks. The refractory diffuser in No. 2 retort showed no advantages.

IV. CONCLUSIONS

Operation at the lower temperature (1800°F) and with the new torus rings was satisfactory. Product gas purity well below the specification was attained (See figure 12) and no damage to the equipment was observed.

Based on the results of the tests reported herein, it is concluded that consideration should be given to a complete review of the design and operating characteristics of this plant, with special attention to the following items:

(1) Establishing maximum operating temperature at 1800°F.

(2) Incorporation of the new torus rings on all retorts.

(3) Improved insulation around the fireboxes.

(4) Rearrangement of the flow system and controls in accordance with changes made during these tests.

(5) Provide a larger capacity electric generator set.

(6) Relocation of the furnaces to the rear of the truck, near the exhaust fan, to reduce the high ambient temperatures around the storage tank and electrical control equipment.

(7) Increasing the number of rotameters to one per retort. Spare rotameter tubes should also be carried as replacements.

V APPENDICES

A. AUTHORITY

B. FIGURES

AUTHORITY

Work Order Request from the Military Engineering Department to the Evaluation Engineering Branch, Mechanical Engineering Department

Project Number: FB-79-b-1

Job Order Number: T-58-47

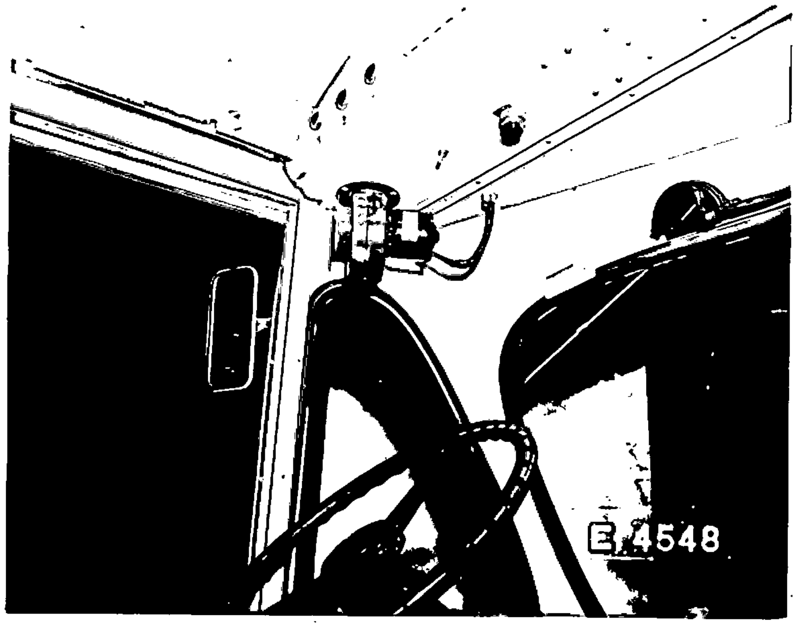
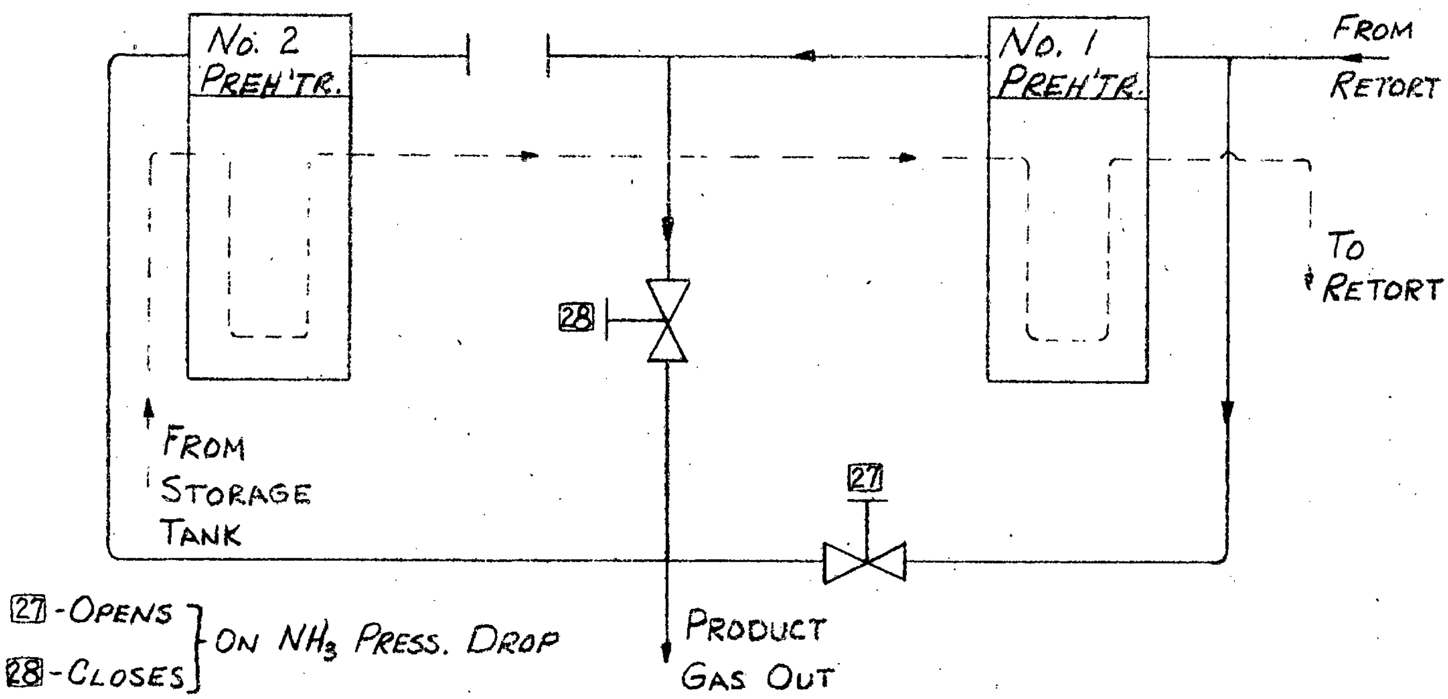


Figure 1. Ventilating fan installed on control cabinet. (E4548)

NORMAL OPERATION



HIGH AMBIENT OPERATION

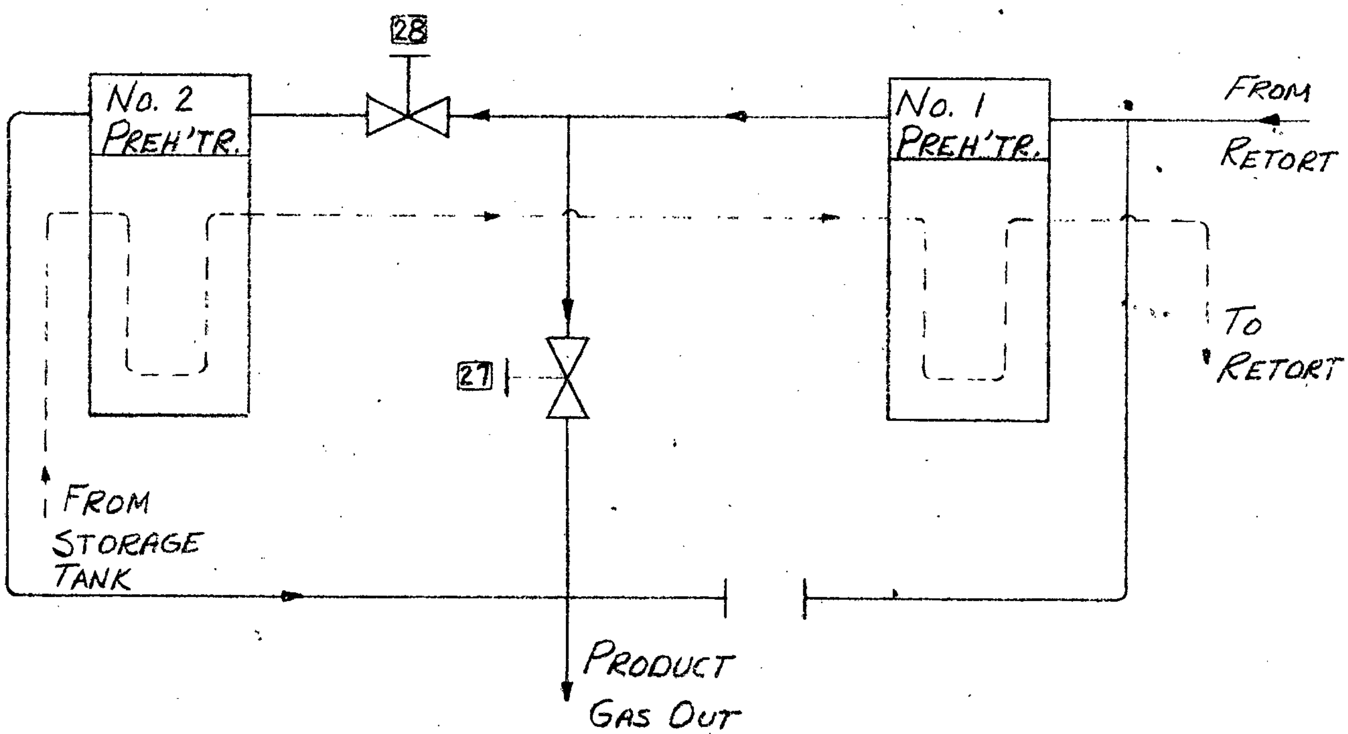


FIG. 2. PIPING REARRANGEMENT

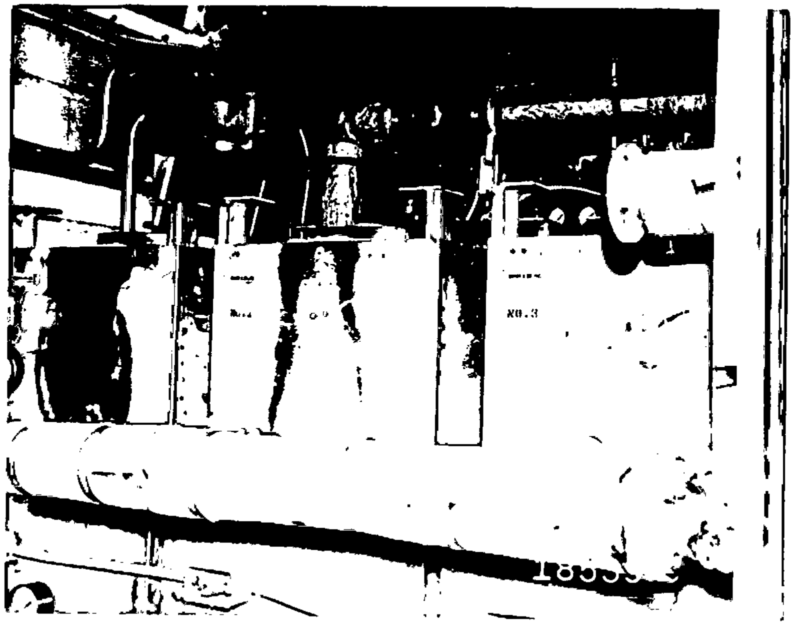


Figure 3. Front view of furnaces and relocated pressure control valve. (18539)

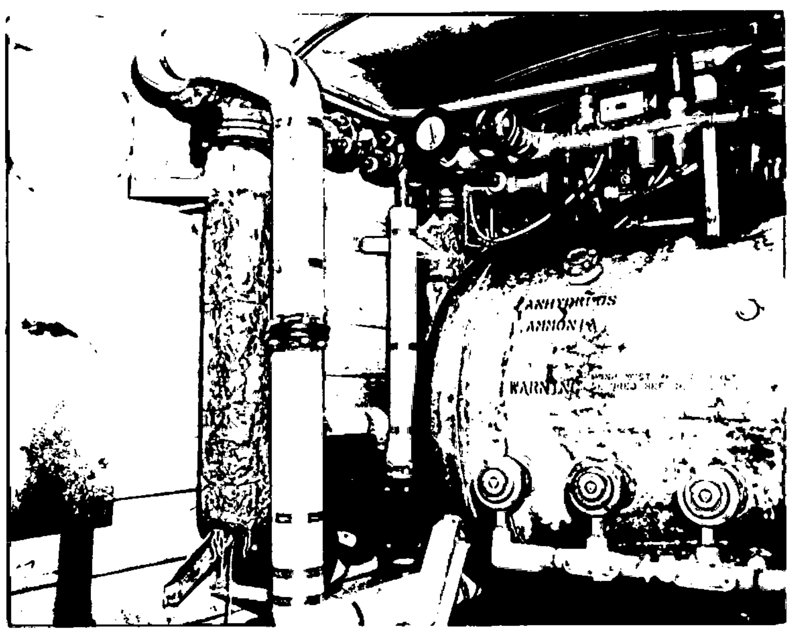


Figure 4. Piping rearrangements. (E4549)

Declassified and Approved For Release 2012/10/25 : CIA-RDP78-03639A001200130001-7

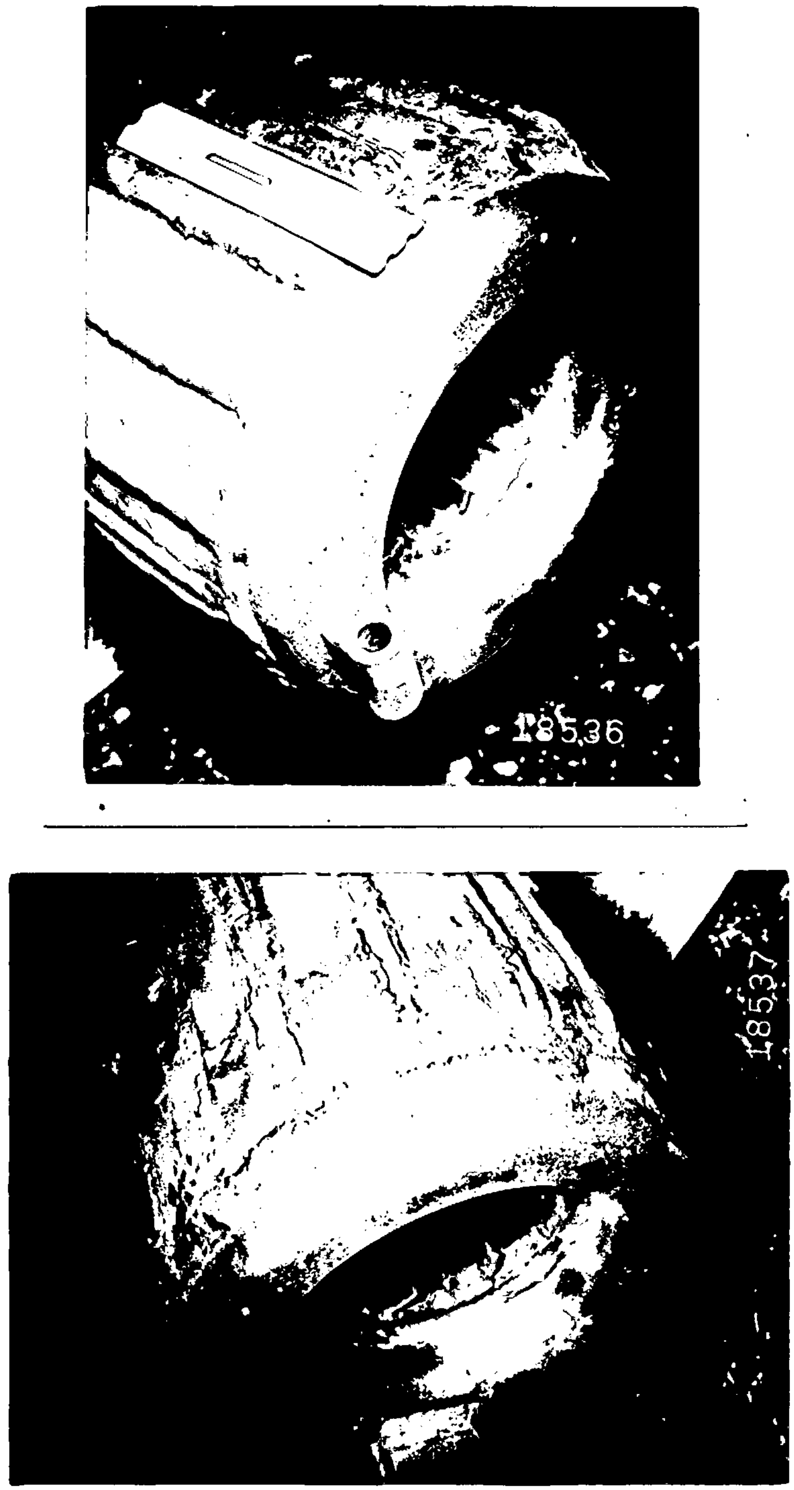


Figure 5. Cracking and distortion of No. 1 retort after 165 hours operation.
(18536-7)

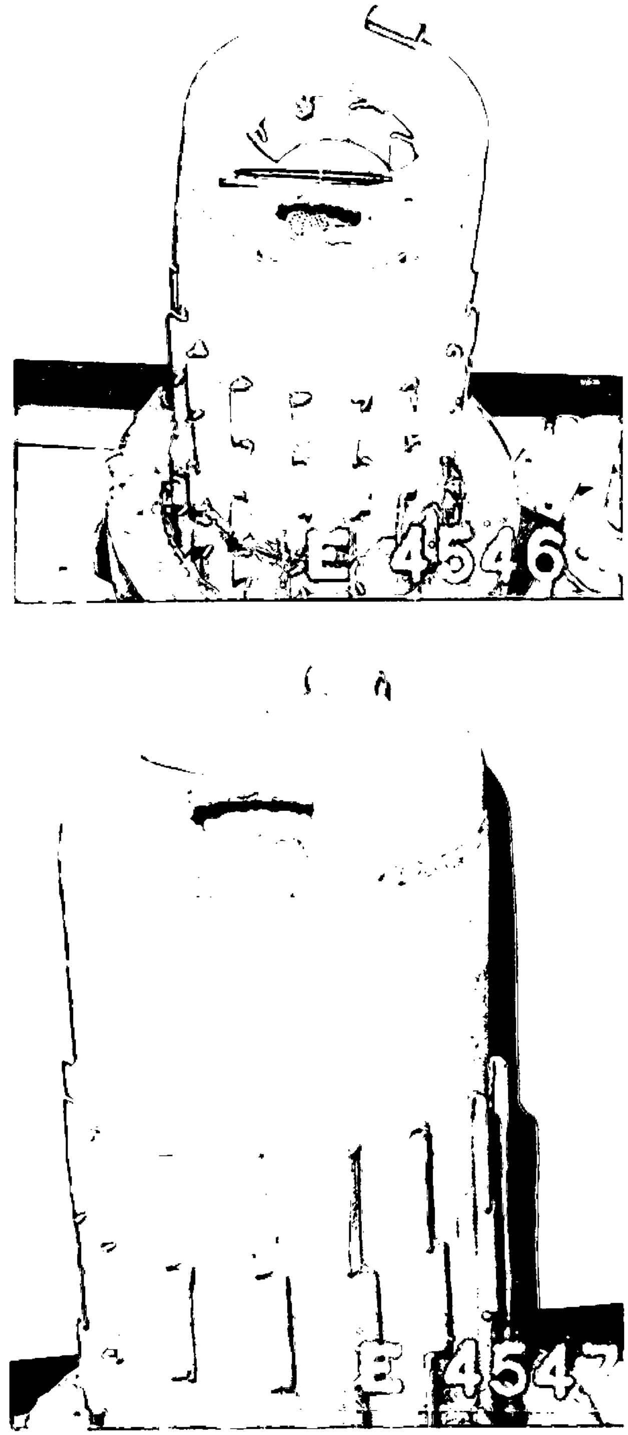


Figure 6. Failure of No. 1 retort. (E4546-7)

Figure 7. Fused metal removed from No. 1 retort. (18538)

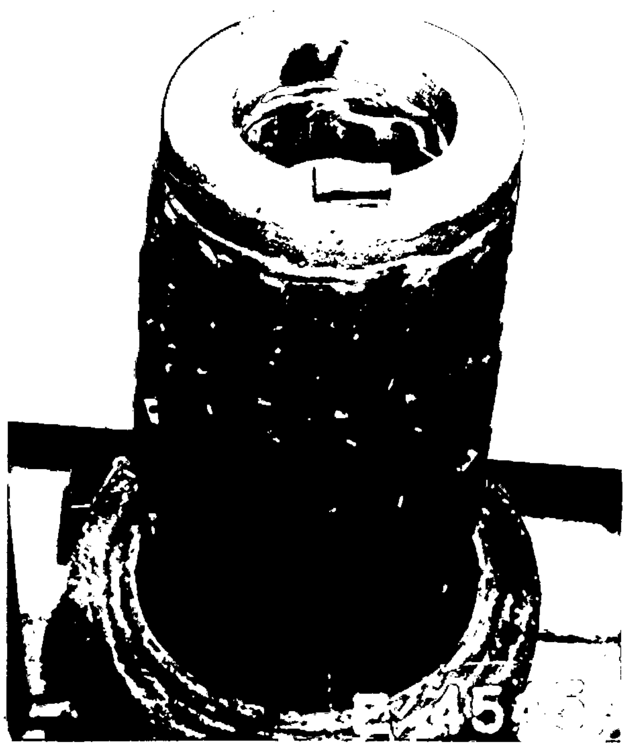


Figure 8. No. 2 retort after removal. (E4545)

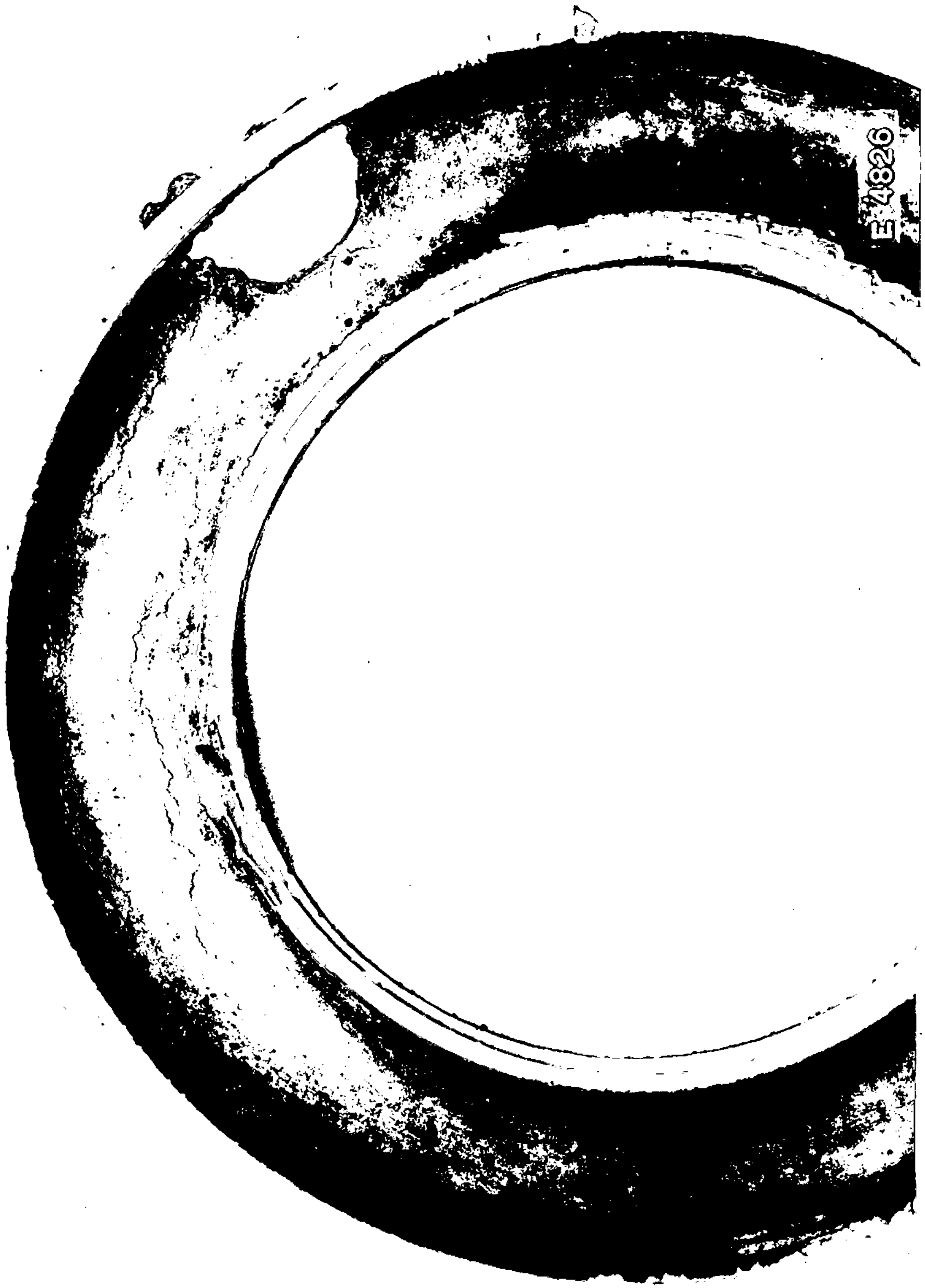


Figure 9. Interior view of torus from No. 1 retort. (E4826)

Declassified and Approved For Release 2012/10/25 : CIA-RDP78-03639A001200130001-7

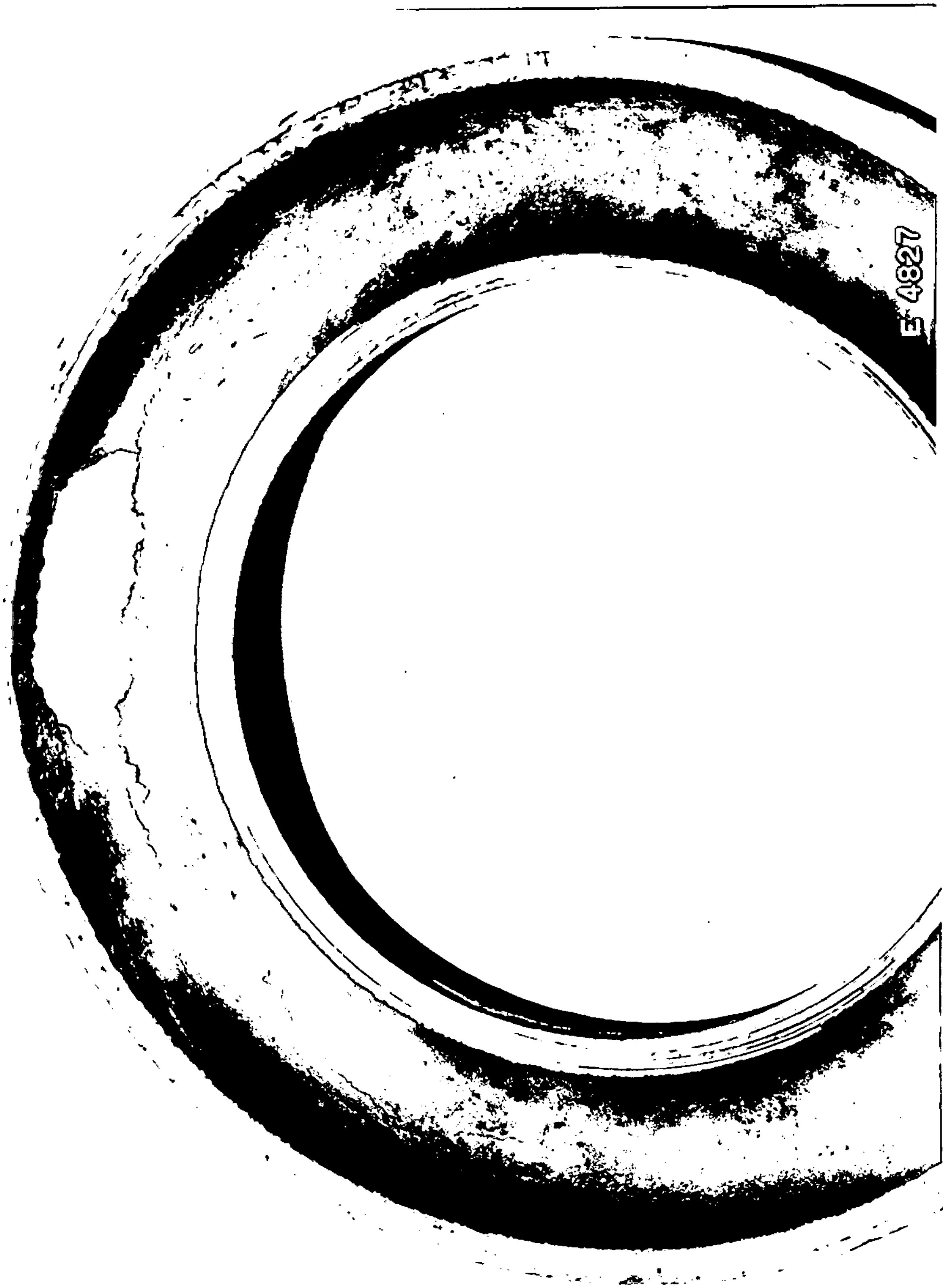


Figure 10. Interior view of torus from No. 2 retort. (E4827)

Declassified and Approved For Release 2012/10/25 : CIA-RDP78-03639A001200130001-7

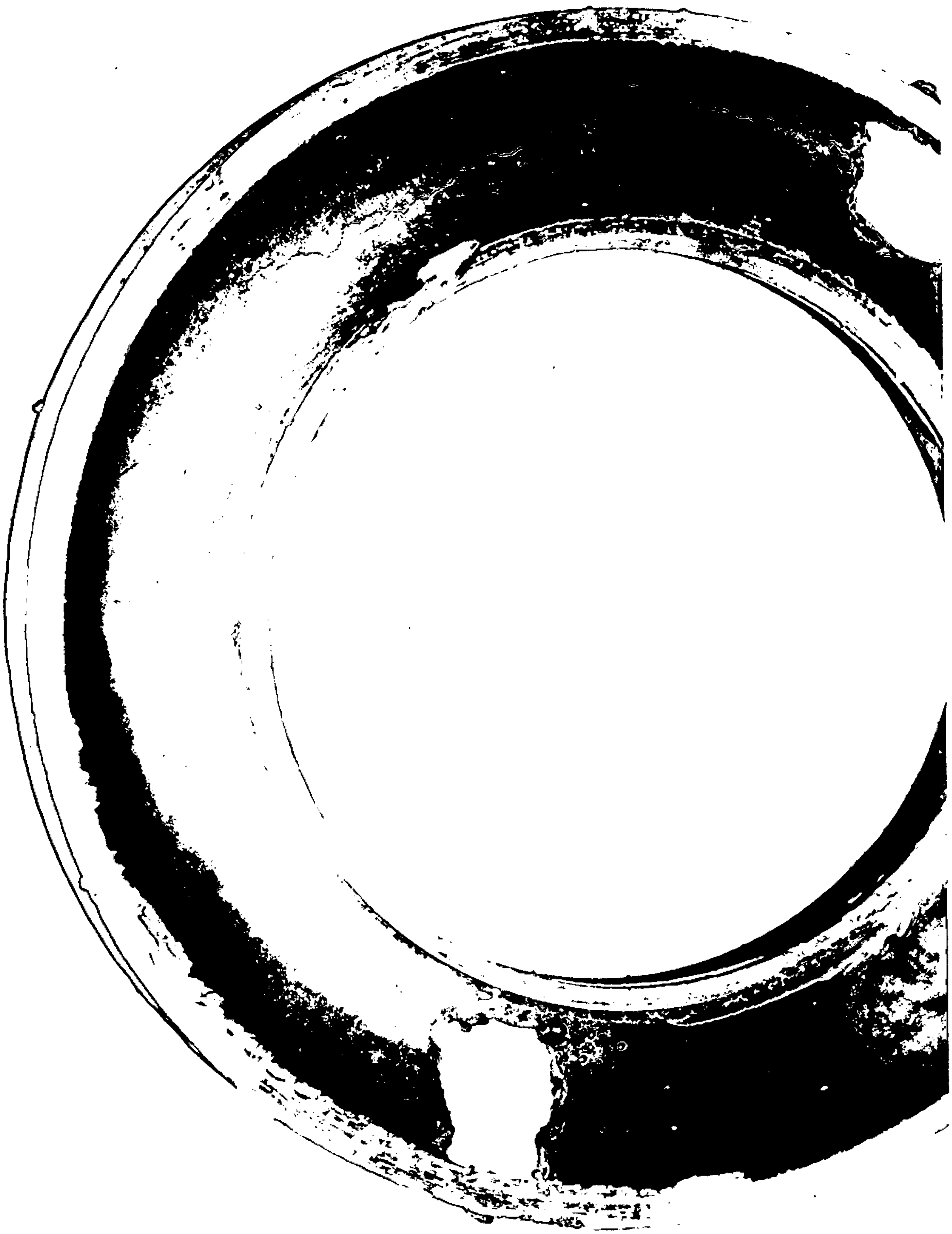


Figure 11. Interior view of torus from No. 3 retort. (E4828)

Declassified and Approved For Release 2012/10/25 : CIA-RDP78-03639A001200130001-7

PERCENT RESIDUE AMMONIA VS REACTOR WALL TEMPERATURE
(BAKER HYDRONEAL GENERATOR)