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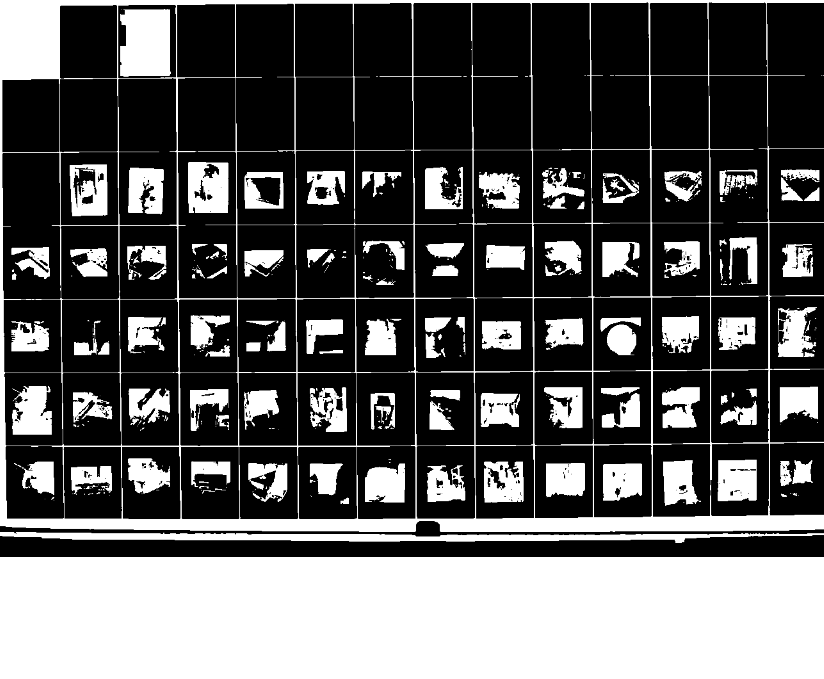

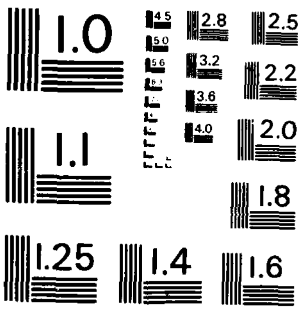

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This report describes vibrational testing and identifies recommended changes to a multifunctional waste incinerator (MFI) intended for use on seagoing vessels as an alternative for overboard discharge of potentially harmful waste. The testing reported completes the third part of Phase II testing, laboratory evaluation of a land-based system. Vibrational testing was completed on both 0° and 90° transverse axes in addition to the vertical axis. The modified MFI operated as required and withstood the vibrational

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20. ABSTRACT (Cont.)

testing environment. Modifications, especially in the use of alumina-chromic oxide plastic refractory in the sewage chamber, proved satisfactory. Some design changes are recommended for easier disassembly and greater structural integrity.

FOREWORD

The work described in this report is the third and final part of Phase II evaluation of a shipboard multifunctional waste incinerator (MFI). Laboratory evaluation of the MFI consisted of testing the unit for 1,200 hr to characterize performance and an additional 250 operational hours to evaluate modifications and the refractory repair materials. This vibrational evaluation, initiated 5 September 1980, was conducted in accordance with the test plan formulated by the Naval Ship Engineering Center, Washington, D.C. and MIL-STD-167-1 (Ships), 1 May 1974, *Mechanical Vibrations of Shipboard Equipment (Type I, Environmental) Department of Defense*.

Released by:

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Weapons Systems Department

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EXECUTIVE SUMMARY

The Navy is currently engaged in a program to develop a multifunctional waste incinerator (MFI) as an alternative to the overboard discharge of pote tially harmful wastes from its seagoing vessels. The laboratory evaluation the MFI consisted of testing the unit for 1,200 operational hours to characterize performance, and testing the unit for 250 operational hours to test refractory repair materials and other modifications. The final laboratory evaluation of the MFI was the vibration test of the unit. This vibrational evaluation, initiated 5 September 1980, was conducted in accordance with the test plan formulated by the Naval Ship Engineering Center, Washington, D.C. and *Mechanical Vibrations of Shipboard Equipment (Type I, Environmental) Department of Defense*, MIL-STD-167-1 (Ships), 1 May 1974.

The MFI successfully completed the vibrational evaluation in all three axes. The unit and the associated structural, refractory, mechanical, electrical, and pneumatic systems withstood the vibration environment with no degradation in the MFI's capability to process waste materials.

Recommendations for certain deficiencies include provisions for relocation of air and fuel oil solenoid valves, gauges, and pressure switches to more accessible and structurally sound locations; a more structurally sound cooling jacket fan mount; an expansion joint in the ductwork connecting the flyash collector to the induced draft fan; redesign of the outer jacket framework and main chamber wall panels to provide better system modularity; and, finally, the use of a plastic alumina-chromic oxide refractory in the main chamber to improve durability. These changes will be performed prior to installation of the MFI on board a naval vessel for shipboard evaluation and approval for service use.

INTRODUCTION

The Navy is currently developing a multifunctional waste incinerator (MFI) to prevent the discharge of potentially harmful wastes from its seagoing vessels. The program encompasses the basic research and development of a central processor capable of handling all shipboard-generated trash, food waste, oil waste, and sewage. The program consists of three phases:

Phase I - Development of a full-scale prototype unit

Phase II - Laboratory evaluation of a land-based system

Phase III - Techeval/Opeval testing of the optimum system on board a Navy ship

Phase I testing was completed at the Dahlgren Laboratory in May 1976.[1] The results of the Phase I testing were used to upgrade the system for the Phase II evaluation.[2] The Phase II evaluation consisted of three parts. The first part was operational testing of the unit at a laboratory for 1,200 hr to characterize performance, reliability, maintainability, habitability, and safety. Figure 1 is an artist's sketch detailing the major components of the MFI. The first part of Phase II testing was completed in December 1978.[3,4]

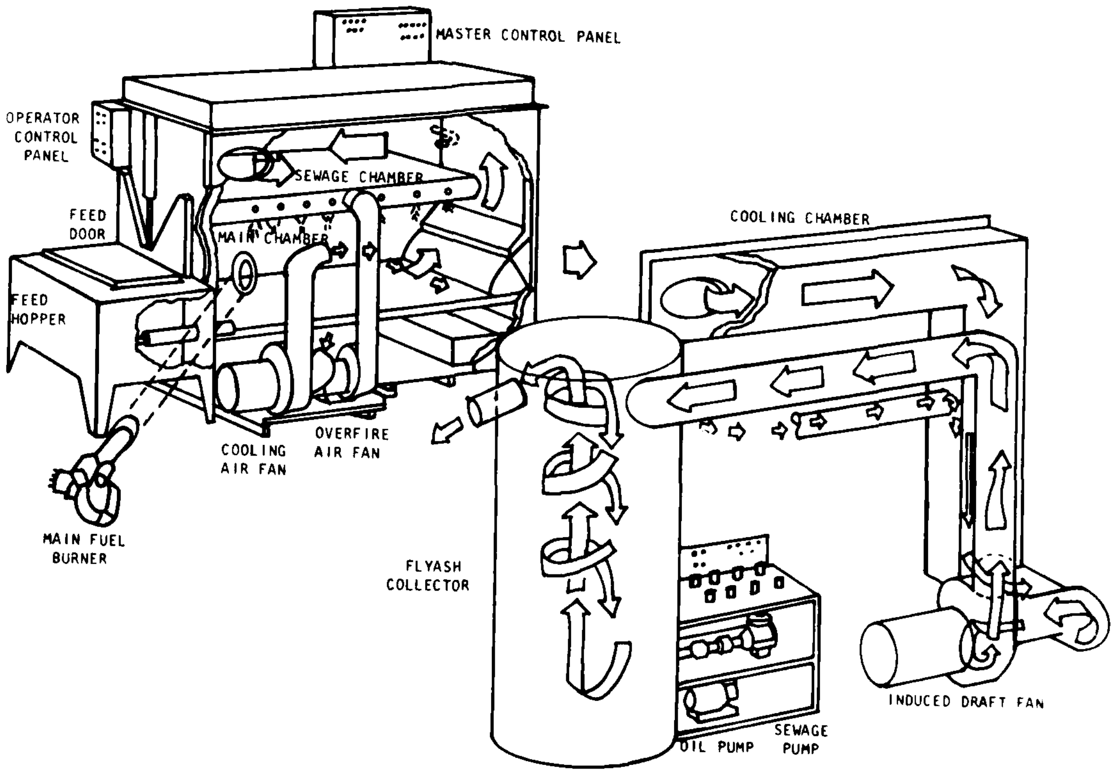

Figure 1. Artist's Sketch of MFI Phase II

Concern for the degradation of the refractory material and several other deficiencies found during the 1,200 hr of testing brought about the second part of the Phase II evaluation. This consisted of performing refractory repairs, correcting other deficiencies, and testing the unit for 300 operational hours. This testing was concluded in June 1979, after 249 of the 300 operational hours, because of irreparable refractory damage to the sewage processing chamber.[5] The refractory material was then changed to a refractory material that was more resistant to corrosion and erosion. This and other modifications were performed prior to the vibration evaluation of the MFI, the third portion of the Phase II evaluation. The vibrational evaluation was initiated 5 September 1980 and completed 23 December 1980.

OBJECTIVE

The objective of the vibrational evaluation was to determine the MFI's ability to withstand vibration as tested in accordance with MIL-STD-167-1 (Ships).[6,7,8]

TEST CONDITIONS AND REQUIREMENTS

TEST CONDITIONS

The MFI was to be operated in its normal operating range of 1,400 to 1,600°F firebox temperature because analyses indicated that the refractory-steel structure was more prone to fail at these temperatures. The MFI was vibrated in the frequency range of 5 to 25 Hz because this range simulated the vibration that would be found on the ship classes where the MFI would be installed. All pneumatic systems were operational; but no sewage, waste oil, or solid waste was to be processed. The main burner fuel was No. 2 distillate fuel oil.

The MFI was vibrated first in the vertical axis, followed by vibration in the transverse 0° axis and the transverse 90° axis concurrently. During the 5-min frequency scan and the 2-hr duration test at each axis, all pneumatic systems were operated at least once per frequency during the scan portion and at least every 10 min during the 2-hr portion. The refractory material and the exterior of the MFI were photographed before and after the vibration test on each test axis. All refractory damage and mechanical problems were photographed or noted in the test record. The test notes are located in the appendix.

Each axis vibration test consisted of three phases. The first phase consisted of a 20- to 30-sec frequency scan from 5 to 25 Hz, at 1-Hz intervals, to determine if a major oscillation occurred at any of the frequencies. The second phase was the variable frequency test, which consisted of vibrating the incinerator at each frequency for 5 min. The third phase was the 2-hr endurance test, which consisted of vibrating the incinerator for 2 hr at any frequency that had produced the most system movement. The system oscillations or movements were observed by test personnel or sensed by accelerometers mounted in various locations on the MFI.

TEST REQUIREMENTS

The test requirements were based on the operational parameters established during approximately 1,449 hr of evaluation. The MFI was required to operate within these parameters reliably and safely, and with a minimum of maintenance. These parameters were that

1. The burner would operate normally at an average firebox temperature of 1,500°F

2. The pneumatic system would function normally, as determined by the test engineer

3. The electrical system would function normally, as determined by the test engineer

4. The refractory materials would not suffer such irreparable deterioration that large portions of the interior metal walls would be exposed

5. The fans would operate in their regular draft regimes without sufficient change to modify the system's overall flow characteristics

6. The mechanical operation of the feeder system, feed door, ash door, chain curtain, and draft damper would not be hindered enough to prevent safe operation of the MFI

MODIFICATION PRIOR TO VIBRATION

During the 1,200 hr of operation and refractory repair evaluations, deficiencies were found in the MFI design and in its refractory materials.[3,4] The system was therefore modified before vibration to correct as many as possible of the following deficiencies:

1. Deteriorated refractory material in the sewage and main chambers, as shown in Figure 2

2. Lack of refractory material in the base of the cooling chamber

3. Deterioration of cooling jacket insulation

4. Poor location of the sewage chamber cleanout/viewing port for adequate cleaning of the ashes

5. Poor air flow in the cooling jacket

6. Poor mounting arrangement of the cooling jacket fan, which made removal and installation difficult

7. Lack of a protective barrier for the operator when stoking the fuel bed

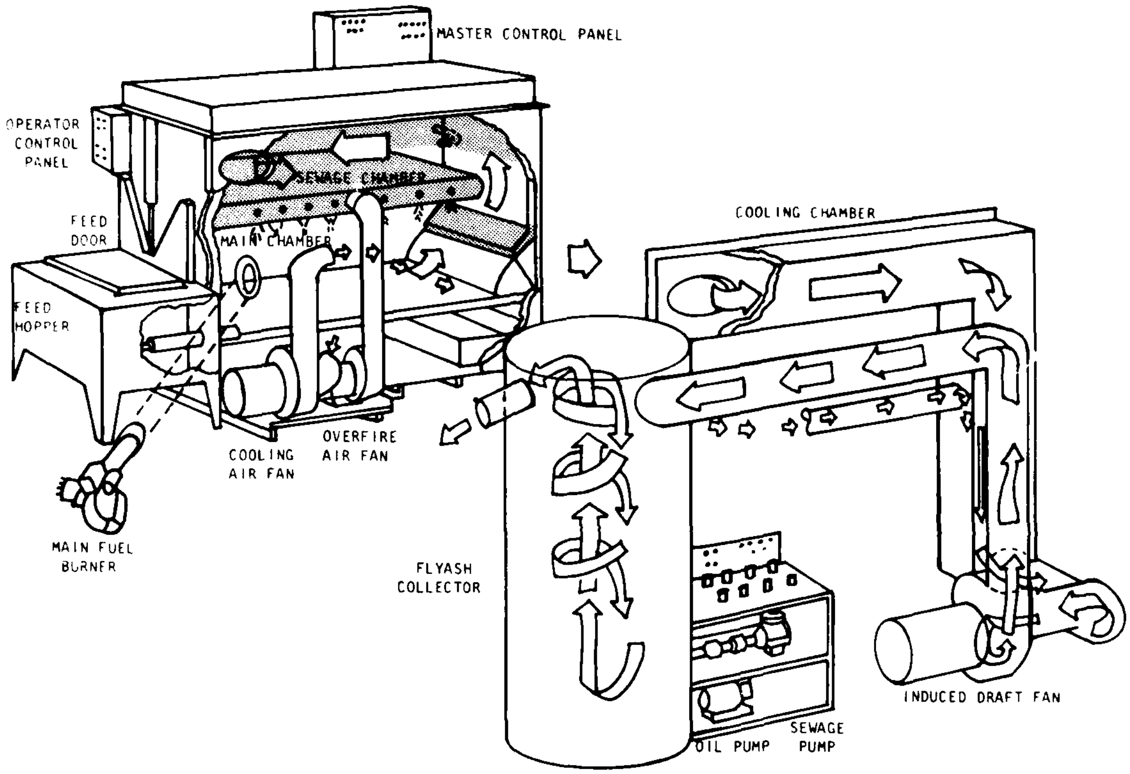

Figure 2. Deteriorated Refractory Sections (Shaded Sections) of MFI Phase II

These deficiencies were dealt with by partially refurbishing the MFI from August through September 1979. This refurbishment began with the careful disassembly and evaluation of the incinerator to determine the condition of all components, especially those accessible only through disassembly.

The disassembly began with the removal of the fans, burner, electrical and pneumatic controls, and electrical conduit. These items were then stored for reuse.

Next, the outer jacket panels were removed and examined. As was expected, the fibrous mineral wool insulation had delaminated in several areas, causing blockages to the cooling jacket fan. The incinerator walls were now exposed as shown in Figures 3, 4, and 5. The framework and ports of the outer jacket and incinerator's main structure are also shown. Figure 3 shows the front of the incinerator; the large, square opening is the solid waste feed port. One can also see the firebox and grates. Notice the corroded portion on the left side of the feed opening. This corrosion was caused by sewage leaking past the refractory lining during sewaꞡ ꞡ. Figure 4 is a view of the ash cleanout side and the rear of the incinerator. Figure 5 is a view of the right side of the incinerator, the cooling chamber, and the various burner and fan ports.

After the outer jacket framework was removed, the disassembly of the main structure began. The cooling chamber was removed first, followed by the roof section of the sewage chamber. Figure 6 is a view of the roof showing the condition of the refractory material. Figure 7 is a view of the sewage chamber and the top of the partition. The port at top center is for the sewage nozzle. The port at top left is the cleanout/viewing port. The port at bottom right is the flue exhaust. The sewage chamber wall was then removed. Removing the partition was difficult.

The MFI's main chamber is composed of four 1/4-in. steel sheets flanged on the four edges of each wall. The bottom flange of each wall is bolted to the base frame. The walls are connected with four 1/4-in. thick steel connecting straps as shown in Figure 3.

It was difficult to remove the partition for two reasons. First, the top flange of the main chamber walls made it necessary to remove one of the side walls to provide clearance for lifting the partition. The second problem occurred when, in trying to remove the connecting strap, the bolts could not be removed because they were corroded; the nuts were hidden behind 8 in. of corner (grout) refractory. The refractory was removed so that the bolts could be accessed. This caused collateral damage to the side wall, as shown at the top left and bottom left of Figure 8.

Figure 9 shows a bottom view of the removed partition. The damage shown was caused during testing. It is believed that the sodium chloride component of the sewage chemically attacked the alumina refractory bonds, causing the refractory to crumble. This deterioration exposed an overfire air manifold pipe, which was, in turn, destroyed by contact with the burner flames and solid waste flames. As shown in Figure 8, the rear ash door overhead structure refractory sustained damage during stoking operations.

The refractory that was used in this test unit is a 97 percent tabular alumina castable (hydraulic setting) material. The material is mixed with water to a cement-like consistency and then poured into a form. It sets hydraulically after 24 hr and at that time has sufficient strength to be transported without exterior support. The material is then cured by slowly increasing the refractory temperature at a rate of 50° to 100°F per hour to 1,800°F.

The refractory material of the sewage chamber, partition, and ash door overhead was removed as shown in Figures 10 and 11. The condition of the metal structures is shown in Figures 12, 13, and 14. Figure 12 shows the sewage roof metal structure. Figure 13 is a front view of the sewage chamber wall metal structure. The partition's metal structure, shown in Figure 14, was repaired by replacing the destroyed air manifold pipe. The location of that pipe was also changed, so that an increased thickness of refractory material protected the pipe. All metal structures were then sandblasted and painted with a zinc/silicone high-temperature primer and a coat of high-temperature aluminum paint.

These metal structures were readied for the emplacement of the plastic refractory. This moldable (hence plastic) material requires no water for preparation. The material is rammed into place with a pneumatic rammer. The plastic refractory does not set hydraulically and must be supported externally until cured. The material also absorbs excess water and, hence, must be protected with an impermeable covering. The advantages of the chromic oxide-alumina plastic refractory (88 percent alumina) include a substantial increase in crushing strength and service temperature, as well as a much greater resistance to abrasion and chemical interference than castable refractories have.

Figures 15, 16, and 17 show the anchors, wire ties, and insulation installed in the sewage chamber roof section and sewage chamber walls, respectively. The insulation is a pressed mineral wool, 2 in. thick. The wire ties, connected to the anchors, were used to support an external sheet of expanded metal. The anchors are made of 5/16-in. thick stainless steel rod, V-shaped, with S-curves at the tips. The expanded metal prevented the plastic refractory from losing the molded shape or moving prior to curing.

Figure 18 illustrates how the material is rammed into the supporting structure. Once a sufficient amount was in place, a sharp metal strap was drawn across the refractory to level the surface. Since refractories are cured to remove moisture and "set" refractory bonds, the surface of a new refractory is left as rough as possible to allow moisture to exit easily while the material is curing. Dense plastic refractories also need additional holes, spaced 4 to 6 in. apart over the surface to provide additional routes for water vapor to escape. The holes were 1-1/2 in. deep, which was half the refractory depth. The total refractory and insulation thickness is 5 in. (2-in. thick insulation and 3-in. thick plastic refractory). The anchor height from the metal structure is 3 1/2 in.

The front wall of the incinerator was refurbished with a castable insulating refractory, KAST-O-LITE 30®, because there were extensive cracks in the wall. The finished wall is shown in Figure 19. Note the V-shaped expansion etches, which were supposed to relieve expansion/contraction stresses. Such stresses can cause large cracks in the refractory.

Two of the plastic refractory structures are shown n Figures 20 and 21. The roof section has the expanded metal in place; note the wire ties. The tack welds around the periphery of the expanded metal were ground away before installation. The ash door overhead structure is shown prior to removal of the forms or installation of the expanded metal.

The walls of the sewage chamber were rammed <u>in situ</u>, as requested by the manufacturer, A. P. Green Co. This method of ramming a vertical wall against the horizontal roof and the partition section was found to be very difficult. Dimensional control of the wall thickness was difficult, because the material tended to flow down the wall, thus requiring additional bracing by the installers and slowing the installation considerably.

Finally, the refractory units were reassembled to be cured. Curing required was approximately 80 continuous hours, and was accomplished by assembling the main refractory structure and installing a temporary burner port and exhaust port. The other openings were filled with an insulation material to provide a heat-resistant seal.

Figure 22 shows the structure after curing. The lower left circular opening was used as the burner port, and the upper right opening was attached to the exhaust flue. Figure 23 is a view of the main chamber after curing. The ash door overhead and the bottom of the partition are shown. The repaired portion of the side wall in the upper left appears as a bright white area surrounding the thermocouple shield.

The sewage chamber view with the expanded metal in place is shown in Figure 24. The expanded metal tended to soften and pull away from the refractory, but the refractory was sufficiently strong to maintain the initial dimensions. The refractory was heated up to 2,000°F over 80 hr, and then allowed to cool slowly over 2 days before the unit was inspected and photographed.

The next part of the refurbishment was the addition of insulating refractory to the base of the vertical portion of the cooling chamber, as shown in Figure 25. The refractory in the cooling chamber is a dense, high-alumina castable that is 2 in. thick and backed by 1 in. of castable insulation. Although this is a durable combination of refractories, its total insulating value could be improved. Therefore, KAST-O-LITE 30®, a castable refractory with improved insulating properties, was chosen and cast to a depth of 3 in. into the areas shown in Figures 25 and 26. The anchors shown in Figure 26 are an example of the two types of anchors that were present in the MFI. The larger-diameter, V-shaped rod anchors with the hoop base are type SS 310 stainless steel A. P. Green Co. anchors. The diameter of the rod is 5/16 in. The V-shaped anchors to the right, with no hoop base, have a 3/16 in. diameter. The A. P. Green Co. anchors proved superior to the V-shaped anchors in restraining the refractory because of their curved ends and greater stiffness. The A. P. Green Co. anchors were welded to the walls with 1/8-in. diameter type 316 stainless steel welding rod. This refractory insulation proved very durable during testing.

The curing of the chamber is shown in Figure 27, with the vertical portion of the cooling chamber as the section being cured. Figure 28 shows the cured refractory. The layer that has broken away from the refractory was caused by the casting mold, which left a smooth surface that did not allow the moisture to escape. Consequently, the refractory layer was removed with steam pressure, until a rough surface was exposed that allowed the steam to escape easily. The solution to the problem of curing the refractory is to cast the wall horizontally, to allow the face exposed to the heat to be uncovered and hence roughened during setting.

The third portion of the refurbishment involved the cooling jacket insulation. This insulation consisted of a mineral fiber blanket, 1/4 in. thick, with an aluminum foil backing. The aluminum foil side of the insulation was glued to the outer jacket panel, exposing the blanket insulation to the air flow. Consequently, portions of this insulation were drawn into the cooling jacket fan, causing blockage of the fan and loss of cooling air. This type of insulation was replaced by fiberglass insulation, 3/4 in. thick and bonded to fiberglass cloth; it was held in place with capped studs. The fiberglass cloth side faced the air flow to prevent insulation loss.

The fourth task of refurbishment was the addition of another access port in the sewage chamber to allow access to the sewage flow impingement area. This access will make the cleanout of ashes from this area much easier. Unlike the after sewage access hatch, this hatch does not penetrate the cooling jacket and, therefore, has an access plate. The new sewage chamber hatches were made of Jade-Pak 88-P refractory to offer the same strength and corrosion resistance as the wall structure. The drawback to the new hatches is the density, which makes the hatches heavy and awkward. Since the material must be rammed, forms must be very durable to maintain tolerances.

The fifth deficiency in the original MFI was the occurrence of hot areas on the rear wall of the cooling jacket. These areas regularly exceeded 140°F during operation and after shutdown, whereas the front wall of the cooling jacket was always near ambient temperature. The front wall had approximately 4 in. of clearance, while the rear wall had approximately 1 in. of clearance. Baffles were installed to limit the front air flow and to direct the flow toward known hot spots.

The sixth problem area was the mounting arrangement of the cooling jacket fan. The fan is mounted at three points: the intake, the exhaust, and the overhead frame. Since the fan is mounted under the cooling chamber, as shown in Figure 29, and weighs more than 150 lb, an improved mounting system was devised to make removal and installation easier. The angle frame that mounts to the cooling chamber was slotted, so that the fan could be lifted to its mounting height clear of the overhang, attached to two outside bolts, and slid into place to complete the mounting.

The seventh problem was one of safety to the operator during stoking. During each hour that the MFI burns, the operator must manually rake the solid fuel bed to ensure proper combustion. A determination was made from ship incinerator operations and from the NSWC MFI laboratory evaluation that if aerosol cans or sealed bottles were accidentally put into the incinerator, they might burst. This would be an obvious danger to the operator, especially during stoking. Design studies were conducted by NSWC and the MFI contractor, Vento-O-Matic Incinerator Corporation (VOM), to determine the most feasible system to make stoking safer. The system chosen was one that used a pneumatically operated lever arm with a high-temperature chain curtain attached. Small-link chain curtains are used by industry to cover high-temperature furnace openings to decrease radiant heat, and, to a degree, contain splattered metal in the furnace. The MFI system has an arm that rotates 90° from the vertical/stowed position into the solid waste feeder, with the chain forming a barrier between the operator and fuel bed.

MODIFICATIONS TO TEST SITE

The MFI had the distinction of being the largest (9x9x8 ft) and heaviest (10 ton) device vibrated at NSWC. The test site modifications required for the task were:

1. 480 V, three-phase, 30-A electrical supply

2. additional 100-psi air supply piping

3. exhaust flue

4. fuel oil supply

5. test fixture

Electricity was diverted from the electrical supply panel in Building 9462 to an exterior disconnect box. From there, the power line went to the MFI control panel. A multiwire umbilical provided the MFI's power while it was on the test fixture, as shown in Figure 30. A flexible rubber air hose supplied 100-psi air to the pneumatic control system from the additional outlet that was provided.

The exhaust flue structure consisted of 22-gauge galvanized 12-in.-diameter stovepipe, held in place by supporting columns on the interior, as shown in Figure 30. The white section nearest to the fly ash collector (FAC) was an insulated outer blanket over the expansion joint. The expansion joint consisted of a 10-in.-diameter pipe, covered with a mineral wool blanket, that was tightly fitted into the 12-in. duct. The seams were covered with a high-temperature silicone rubber to complete the seal and provide some flexibility.

Figure 31 shows the exterior portion of the flue and its supporting framework. Note the 90° bend required to direct the gases away from the building. The fuel oil supply was provided by an above ground 275-gal tank with the required flexible copper piping to the floor-mounted fuel pump. High-pressure, flexible, and hydrocarbon-resistant hydraulic lines with quick-disconnect fittings were used to transfer the fuel from the pump to the MFI burner.

The test fixture was a 9- by 9-ft floorlike structure constructed of 8-in. wide flange H-beam framework covered with metal plate. The entire MFI and fixture were supported with air springs at various points around the base. The air springs were important because the weight of the MFI was not supported by the vibrator. The details of these structures are shown in Figure 30. The MFI and text fixture weight supported by these springs was approximately 10 T.

TEST RESULTS

VERTICAL AXIS

After installation of the incinerator for the vertical axis, as seen in Figure 30, the refractory portion was photographed to record the "before" condition of the surfaces. These views are shown in Figures 32 through 39. Figure 32 is a view from the feed door, detailing the back and side walls and the partition structure. Figure 33 shows the left rear corner grout and the main chamber thermocouple. The feed door and viewing port walls are shown in Figure 34, while the burner port and front wall are shown in Figure 35. The front wall cracks (caused by curing) are prominent in this latter view. Notice that the V-shaped scoring on the wall did not crack to prevent the center-line crack, as had been expected.

Figure 36 is a view of the burner wall detailing the condition of the refractory (white areas) and the coating mortar (darker areas). It was expected that the coating would be removed during vibration, because some areas showed poor adhesion to the base refractory. This problem is also revealed in Figure 37, a view of the right rear corner of the main chamber. Figure 38 is a view of the sewage impingement wall. The right-hand port is the additional (forward) clean-out hatch; the opening on the left is the exhaust port. The flaked, gray material is the remains of the oxidized expanded metal. The wire ties are clearly visible at the lower right of the picture. The white refractory material on the left below the exhaust port is the excess refractory that fell into the sewage chamber when the cooling and sewage chamber joint was cast. Figure 39 is a more detailed picture of the exhaust port and joint area, showing the fillet at the joining of the sewage chamber walls and partition.

The vertical axis testing began on 5 September 1980. While the incinerator was brought to an operating temperature of 1,500°F, the pneumatic and fan systems were checked and found operational. The tests consisted of vibrating the unit at the following frequencies and amplitudes:

1. 5 to 15 Hz, at 0.06 in. amplitude

2. 16 to 25 Hz, at 0.04 in. amplitude

The first phase consisted of vibrating the unit at each frequency for 15 to 30 sec, at an amplitude of 0.02 in., to try to discover any system-damaging resonance frequencies. None were found, and the 5-min variable frequency test began. The data are presented in the appendix and in Reference 9.

The third phase was the 2-hr duration test. Three frequencies, 14, 15, and 22 Hz, were selected. The first two, 14 and 15 Hz, were selected because some equipment showed movement at these frequencies, and the blade rate frequency of the prospective ship where the MFI will be installed is between these frequencies. The third frequency, 22 Hz, was chosen for duration testing because of the equipment oscillation seen at this frequency.

The MFI was vibrated at 14 Hz for 60 min., and at 15 and 22 Hz for 30 min. each. All pneumatic systems were actuated several times during the test and checked for proper operation. No operational problems occurred during this portion of the testing, and all draft measurements were within the tolerances established during laboratory testing. Sheet metal screws from the aluminum jacket of the FAC and one bolt from the ram feeder loosened during the test. The air cylinder universal joint was easily modified to prevent any further loosening through the installation of a set screw. Toward the end of the test, white dust began coming out of the flue, indicating some degradation of the castable refractory; but there was no noticeable change in the air flow through the MFI. Thus, the MFI successfully completed the vertical axis test.

The MFI's refractory material needs at least 48 hr to cool down to where personnel can thoroughly inspect the interior. The MFI cooled over the 6th and 7th of September, and it was moved from its fixture supports on September 8th. This movement was required so that the fixture supports could be reoriented for the transverse 0° axis testing.

Inspecting the MFI refractory was not practical on the 6th and 7th, and was scheduled to be performed after the MFI and fixture were placed on the floor during the support change. Unfortunately, the supporting spreader bar that was used to lift the MFI and fixture broke, dropping the MFI and the attached fixture onto the vibrator and causing considerable damage to both the MFI and the vibrator. This event and its attendant damage are shown in Figures 41 through 51. Figure 41 is a view of the MFI prior to the move. Figures 42, 43, and 44 are the front, side, and rear views of the MFI, respectively, as it rested after falling approximately 2 ft onto the vibrator and transverse table. The broken spreader bar is shown in Figures 42 (lower right), 45, and 46; Figure 45 shows the fractured metal.

Figures 47 through 51 are a pictorial damage assessment of the MFI. Figure 47 is a view of the front of the MFI with the cooling chamber hatch removed; the damage is very apparent. Figure 48 gives a closer view of the damage in the cooling chamber. Figure 49 is a view of the cooling chamber exhaust port. The pieces of broken refractory blocked the air flow path through the chamber; this blocking would have caused a significant change in the main chamber draft had it occurred during the testing. This damage was assumed to have been a result of the fall rather than because of the vibration testing. Vibration may have cracked or weakened the structure to an extent where the damage from the fall was excessive, but no record could be obtained to prove this. Figure 50 shows the refractory that entered the fan plenum, and Figure 52 illustrates some of the damage to the outer jacket. The main and sewage chambers suffered very minor damage, as shown in Figures 52 through 58.

Comparing Figures 52 and 32, the most notable damage is to the left wall where (as shown in Fig. 52) approximately a 1/2-in. thick layer (shown as a slightly raised section in Fig. 32) has fallen from the wall. The opposite wall lost only a minor portion of its mortar coating. A closeup view of the left wall refractory loss is shown in Figures 33 and 53. Figure 54 shows no appreciable change from Figure 34. The burner wall lost a very small layer of refractory from the crack above the burner port, as shown by Figures 55 and

36. There was no assessable change in the right rear corner of the main chamber, as viewed in Figures 56 and 37. A comparison of Figures 57 and 58 with Figures 38 and 39, also shows no noticeable damage. The mechanical, pneumatic, and electrical systems, with the exception of a loose universal joint and some loose screws, suffered no damage. The loose screws were coated with thread-locking compound and replaced. The universal joint was modified by adding a set screw in the outer collar to prevent loosening.

COOLING CHAMBER REFURBISHMENT

The horizontal section of the cooling chamber had its two refractory side walls competely destroyed. There was no possibility of repairing them with patches. The vertical section showed all of the refractory walls above the refractory that had been added by NSWC stripped of the original refractory. As in the horizontal section, bare metal walls were exposed over such a large area that only complete recasting of the walls completely would repair them.

To further complicate matters, this cooling chamber was the original Phase II MFI construction. This construction consisted of 10-gauge sheet steel supporting walls with 3/16-in. V-shaped wire anchors. This type of construction was found inadequate for the larger sewage and main chambers and was replaced with 1/4-in. steel plate walls with 5/16-in. rod A. P. Green Co. anchors. The cooling chamber has a refractory thickness of 3 in., versus a refractory thickness of 5 in. in the main and sewage chambers. When testing began, the consensus was that because of the smaller cross-sectional area and the smaller thickness of refractory, the cooling chamber might pass the vibrational test. The results do indicate that the chamber, at least, suffered cracked walls. The evidence of powdered refractory in the cooling chamber and the emission of refractory dust is a strong indication of refractory deterioration during the duration test. Well-cured alumina refractories will generally crack and break into pieces rather than forming a powder. The powder was probably generated by a cracked wall that allowed independent motion between the cracked sections, causing a grinding motion to create the powdered refractory. The poor anchor design and the steel walls could not restrain the refractory properly for vibration loading or, unfortunately, the shock loading.

The MFI was moved from the test site to the environmental test area, where it was completely disassembed. An assessment of the MFI generated three refurbishment options:

1. Recast the cooling chamber as is, and revibrate on the vertical axis to determine positively what caused the wall failure.

2. Reinforce the thin metal walls with steel angle, add 5/16-in. rod anchors in lieu of the wire anchors, and recast the structure. The vibration testing would continue with the next two axes.

3. Entirely redesign and rebuild the structure, using 1/4-in. steel plate, bolted rod anchors, and a stronger castable alumina refractory. This design would be identical to that of the sewage chamber, except for

the type of refractory used. The vibration testing would continue with the next two axes.

After studying the options presented by NSWC, the Naval Sea Systems Command, Code 0534, decided that the third option was the most viable. Because the sewage chamber showed no deterioration, and the new castable refractory was only slightly weaker than the plastic, it was believed that the design was sufficiently proven and the risks were fewer than those associated with the other two options.

The cooling chamber was redesigned and rebuilt in two sections, as shown in Figures 59 through 62. Figure 59 shows the horizontal section of the cooling chamber with the two side walls cast and the forms in place. Figure 60 is a view of the bottom of the horizontal section, detailing the circular access port and the rectangular section exhaust. Figure 61 is a photograph of the vertical section showing the exhaust port and the metal form that provided a smooth transition from refractory to metal. Figure 62 is a view of the top portion of the vertical section. The large rectangular opening is the portion that mates with the horizontal section. The smaller, flanged opening is for the exhaust from the cooling jacket fan. The angled form is used with metal vanes to redirect the air flow into the main stream passing through the section. The metal forms were liberally greased to prevent the refractory from adhering. Using this method also provides much better "set" refractory tolerances than would be achieved using wood forms.

The two sections were mated and inverted. A burner was installed in the access port, and the refractory was cured to 1,800°F. As Figure 63 shows, the cure was successful. The unit was mated to the sewage chamber and base frame, as shown in Figure 64, and moved back to the vibration test site.

TRANSVERSE 0° AXIS TEST

The MFI was installed on the vibrator on December 15th and 16th, and the unit was vibrated on December 17th. The transverse 0° axis arrangement is shown in Figures 65 and 66. Figure 65 is a front view of the MFI and fixture; springs supporting the fixture are clearly visible. Figure 66 is a rear view of the MFI showing the vibrator and transverse table assembly.

As in the previous test, a 15- to 30-sec scan was performed at each frequency. No system problems were encountered. The 5-min scan at each frequency was performed next. The notable occurrences were the loss of a bolt from the cover of the ram feeder, which caused high "g" readings to occur, as well as considerable cover movement. A temporary clamp was installed to prevent movement of the cover.

The internal mechanism of the ram feeder has large tolerances, so the ram can move freely in the housing after it has been heated by exposure to main-chamber temperatures. The ram was vibrated sufficiently to cause it to strike the interior of the housing, which did no damage, but caused considerable noise. The oil burner also showed considerable vibration over the frequencies from 14 to 17 Hz. However, other than the loosening of two screws, there were no major problems. From this scan, 14 and 23 Hz were chosen for the 2-hr endurance test.

The 14-Hz test lasted 1 hr and produced no problems from the vibration. The burner did fail to fire on command, but that problem was traced to a malfunctioning control panel. The malfunctioning control panel was not being vibrated; in its case, the cabinet had been open and exposed to dusty conditions. The dirty relay was cleaned and the cabinet was sealed, which solved the problem. The endurance test at 23 Hz caused no system problems other than the loosening of the sheet metal screws holding the insulation on the FAC.

The unit was allowed to cool only 24 hr before it was moved so that the mount supports could be changed for the transverse 90° axis. A photographic inspection of the refractory was made, but due to scheduling difficulties, it was a limited one. This documentation is shown in Figures 67 through 71. Figures 67 and 68 are views of the main chamber. There was some additional peeling of the protective mortar, but there was no significant damage. Figures 69 and 70 show the sewage chamber. Figure 69 is a view of the exhaust port. The white material is excess refractory that was dropped into the sewage chamber when the joint between the sewage and cooling chambers was made. Figure 70 shows the sewage nozzle port at the left and a single vertical crack in the opposite wall. This crack is considered very minor and would not affect MFI operation. Figure 71 is a view of the cooling chamber. No visible change could be seen in the refractory. From this assessment, the MFI met all requirements for normal operation while enduring the tranverse 0° axis vibrational environment.

TRANSVERSE 90° AXIS

The MFI was reinstalled on the vibration table on December 22nd and the transverse 90° axis testing began on December 23rd. The transverse 90° axis arrangement is shown in Figures 72 and 73. Figure 72 is a view of the front of the MFI. The vibrator is arranged to vibrate on an axis perpendicular to the left (viewing port/ash door) wall. Figure 73 shows the right side of the MFI and placement of the exhaust ductwork.

The 15- to 30-sec frequency scan was not performed because of time constraints, and the vibration test personnel felt that the scan performed during the transverse 0° axis provided sufficient information. The 5-min scan at each frequency was the next performed. The FAC displayed a rocking motion in the 5- to 7-Hz frequency range, caused by the flexing of the 1/8-in. steel deck. A more rigid steel deck that is 1/4 in. thick or more would prevent this movement.

No significant movements or problems occurred from 8 to 14 Hz. At 15 Hz, the feed door showed movement when fully open, but this movement did not affect the feed door operation. From 16 to 20 Hz, no system problems or movements were noted. At 21 Hz, the cooling jacket fan showed some movement. The cooling jacket and induced draft fans had definite movement at 22 Hz. The movement of the fans decreased at 23 Hz and was negligible at 24 Hz. There were no major subsystem motions or problems at 25 Hz. For the 2-hr duration test, 22 Hz was selected because the only major subsystem motions were displayed at this frequency, and all other subsystems functioned well during the frequency scan.

The duration test had only one incident: The ductwork between the FAC and the induced draft (ID) fan lost two bolts from the flange nearest the ID fan. These bolts were sheared off by the movement. The remaining ten bolts did not loosen, and the joint did not leak. The transverse 90° vibration test of the MFI was completed without any further problems.

Figures 74 through 83 are the photographs of the refractory after the third axis vibration test. Figure 74 is the view from the feed door of the main chamber. Some additional loss of an approximately 1/2-in. layer of mortar and refractory can be seen on both side walls. This loss would not affect the solid waste process rates. Figure 75 details loss of the refractory layer in the lower right corner of the figure, with the viewing port shown in the upper left corner of the figure. Figure 76 shows that no additional cracking occurred in the front wall. The loss of a small, thin section of the burner is shown in Figure 77; and, again, this refractory loss is very minor. The ash door overhead structure and the rear grout are shown in Figure 78. The right rear grout has been damaged. This damage, though easily repaired, would not affect the MFI's operation, since the castable insulating refractory behind the grout refractory would protect the metal wall. Figures 79 and 80 are views of the sewage chamber from the ash cleanout hatches. As shown, no visible changes or damage could be detected. Figures 81 and 82 are views of the sewage chamber from the sewage nozzle port, and again, there were no discernable changes in the refractory. Figure 83 shows the cooling chamber. Other than the heavy layer of soot, there was no damage to the chamber. Thus the MFI, with only minor refractory damage, successfully passed the transverse 90° axis vibration test. The MFI subsystems functioned as required and were capable of incinerating waste materials.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The modified shipboard MFI, Phase II, operated as required and withstood the vibrational environment, as tested, in accordance with MIL-STD-167(1), Ships. The mechanical, pneumatic, and electrical systems functioned reliably throughout the test. The refractory materials were not irreparably damaged by the vibration test. The minor damage sustained would not have prevented the MFI from processing waste materials. The modifications to the MFI proved successful, especially the use of alumina-chromic oxide plastic refractory in the sewage chamber.

RECOMMENDATIONS

In the oil burner, it is necessary to relocate all solenoid valves, gauges, and pressure switches to areas where the items are easily accessible and firmly mounted, such as on the framework below the burner. The cooling jacket fan requires a more sturdy frame of 1 by 1 by 1/8-in. angle, in lieu of the 16-gauge sheet steel box frame being used. An expansion joint is required in the duct between the ID fan and FAC to allow for movement caused by vibration and thermal expansion. The outer panel framework needs to be changed to a design that does not require portions of the frame to be welded to the main support frames of the MFI. This change would allow easy disassembly of the unit. The metal walls of the main chamber should be redesigned to provide a totally modular construction that does not require grouting in the corners. The use of self-tapping screws should be eliminated. Standard screws with thread-locking compounds and lock washers should be used instead of the self-tapping variety. Finally, the main chamber refractory should be changed to the alumina-chromic oxide plastic refractory, with its proven durability.[10] These changes will produce a shipboard incinerator that is structurally sound, reliable, and maintainable for shipboard use.

Figure 3. Front View of MFI with Cooling Jacket and Feed Door Removed

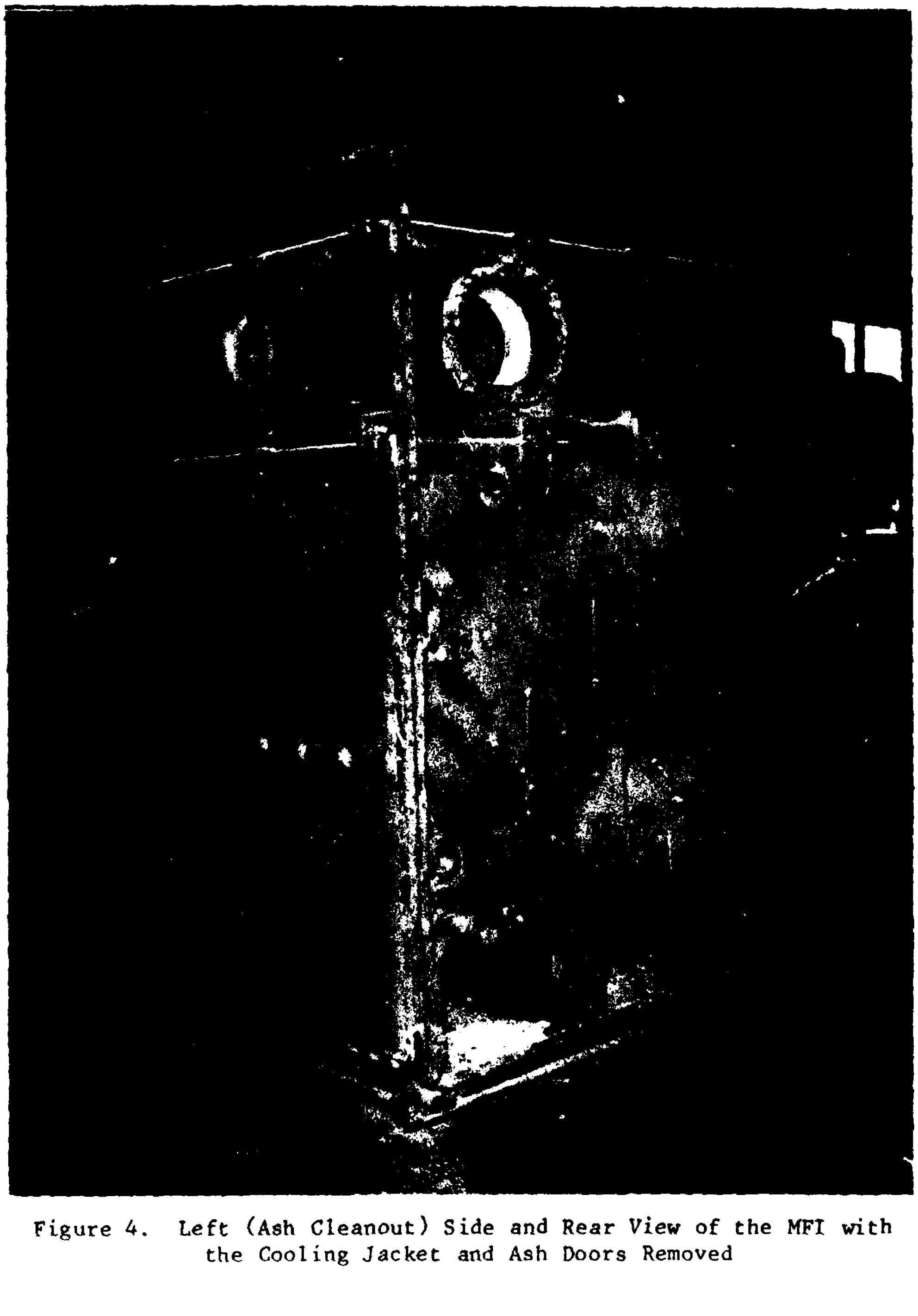

Figure 4. Left (Ash Cleanout) Side and Rear View of the MFI with the Cooling Jacket and Ash Doors Removed

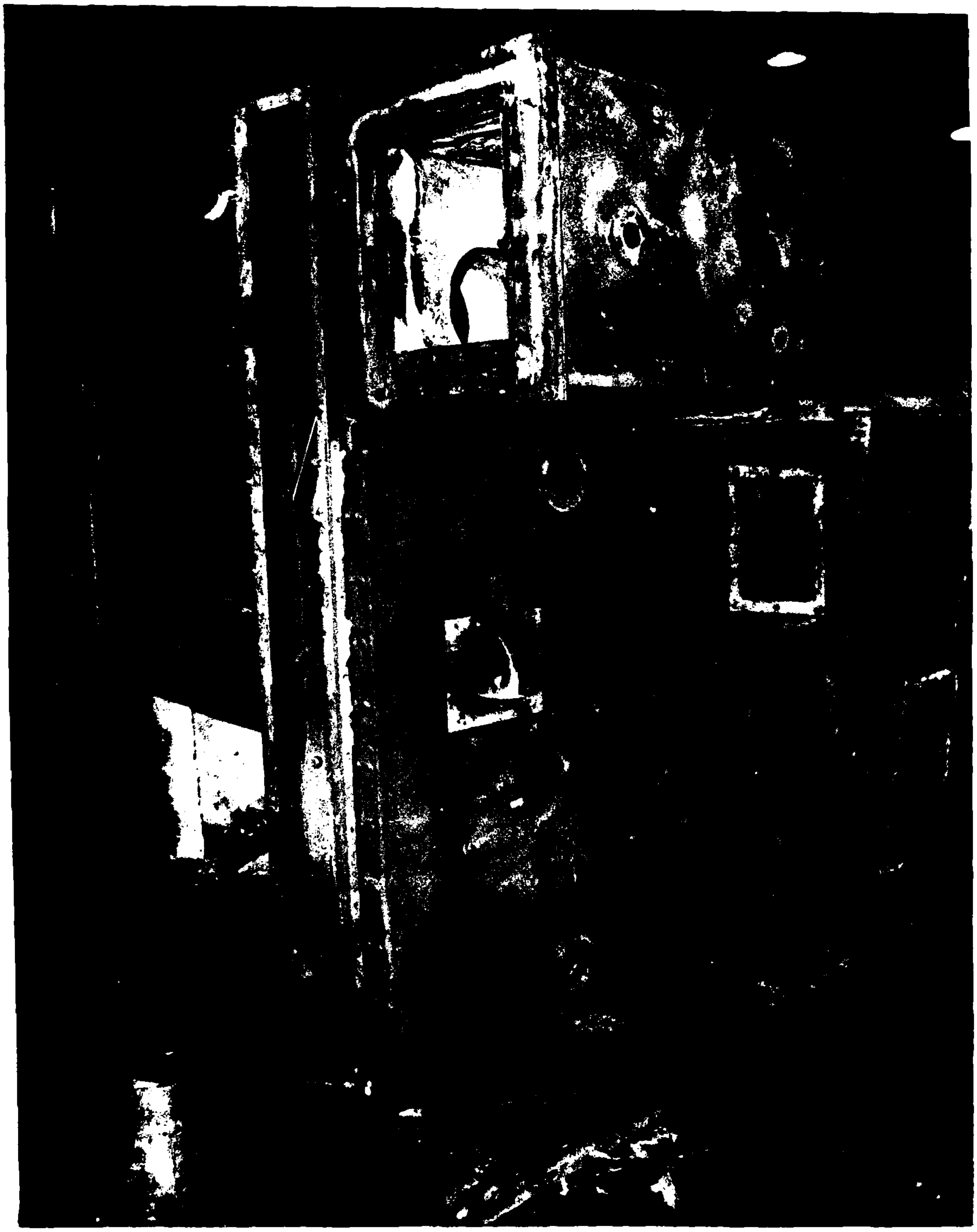

Figure 5. Right (Burner and Fan Pan) and Front View of the MFI with the Cooling Jacket Removed

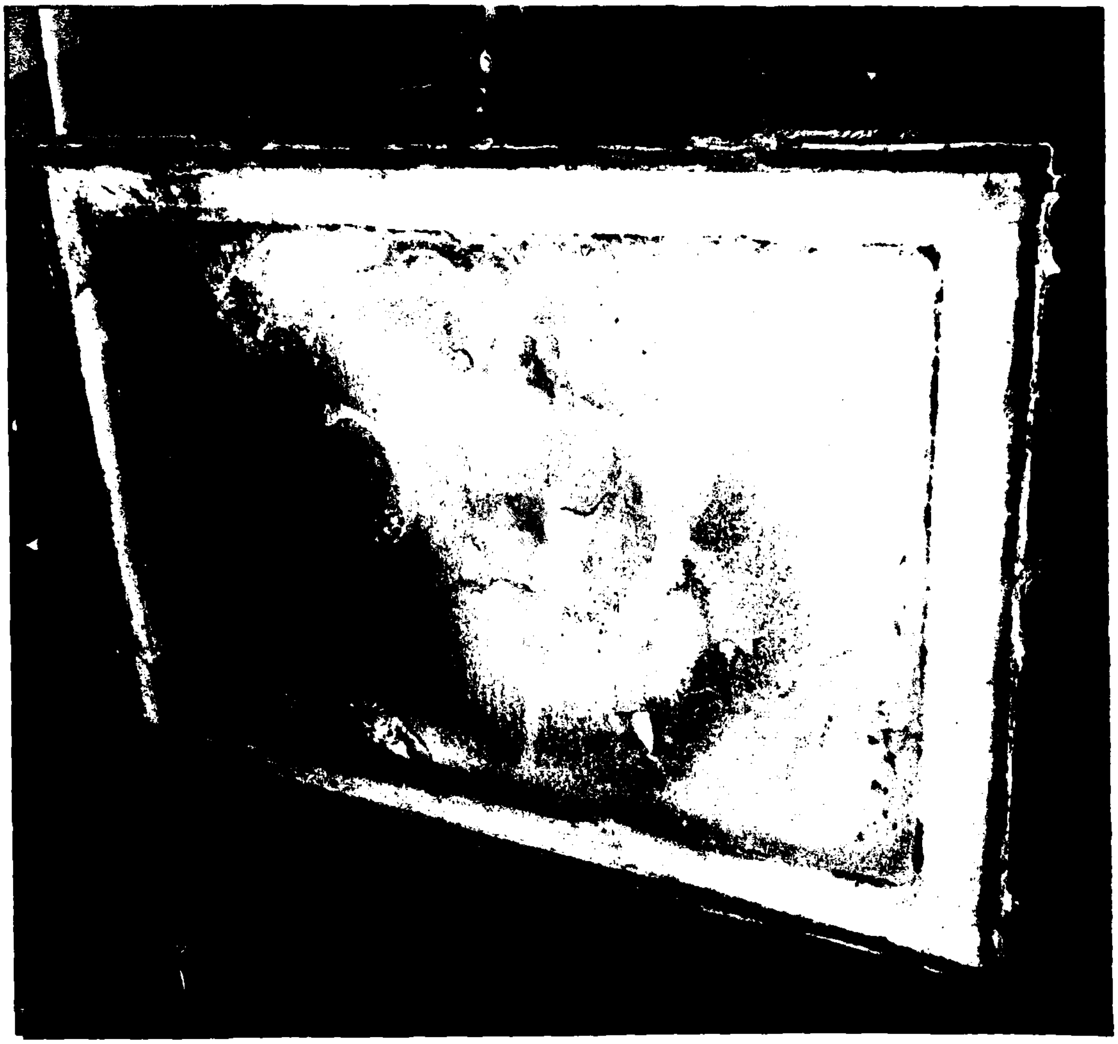

Figure 6. Sewage Chamber Roof Structure

Figure 7. Overhead View of the Sewage Chamber

Figure 8. Overhead View of the Main Chamber

Figure 9. Bottom View of Partition Structure with the Refractory and Metal Pipe Damage

Figure 10. An Electric Hammer was Required to Remove the Refractory from the Sewage Chamber Roof

Figure 11. Refractory Removal from the Sewage Chamber

Figure 12. The Sewage Chamber Roof Metal Structure After the Refractory was Removed

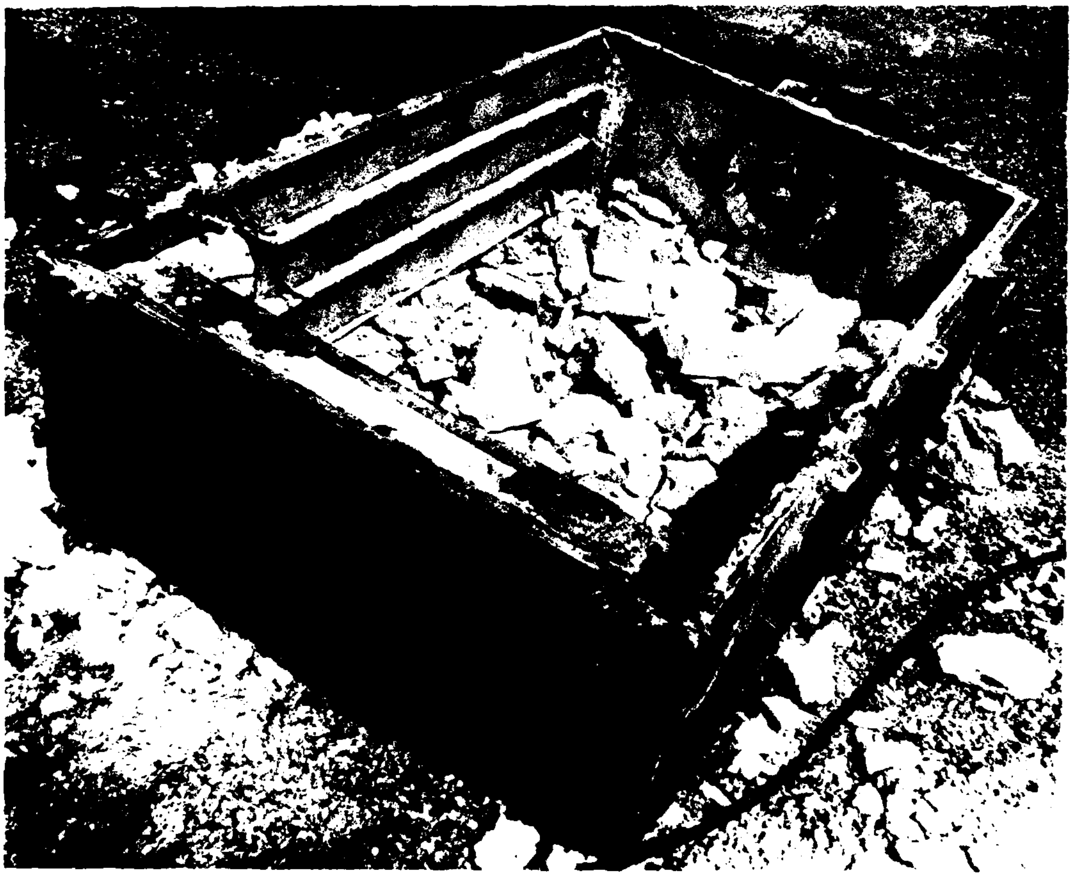

Figure 13. The Sewage Chamber Metal Walls After Refractory Removal

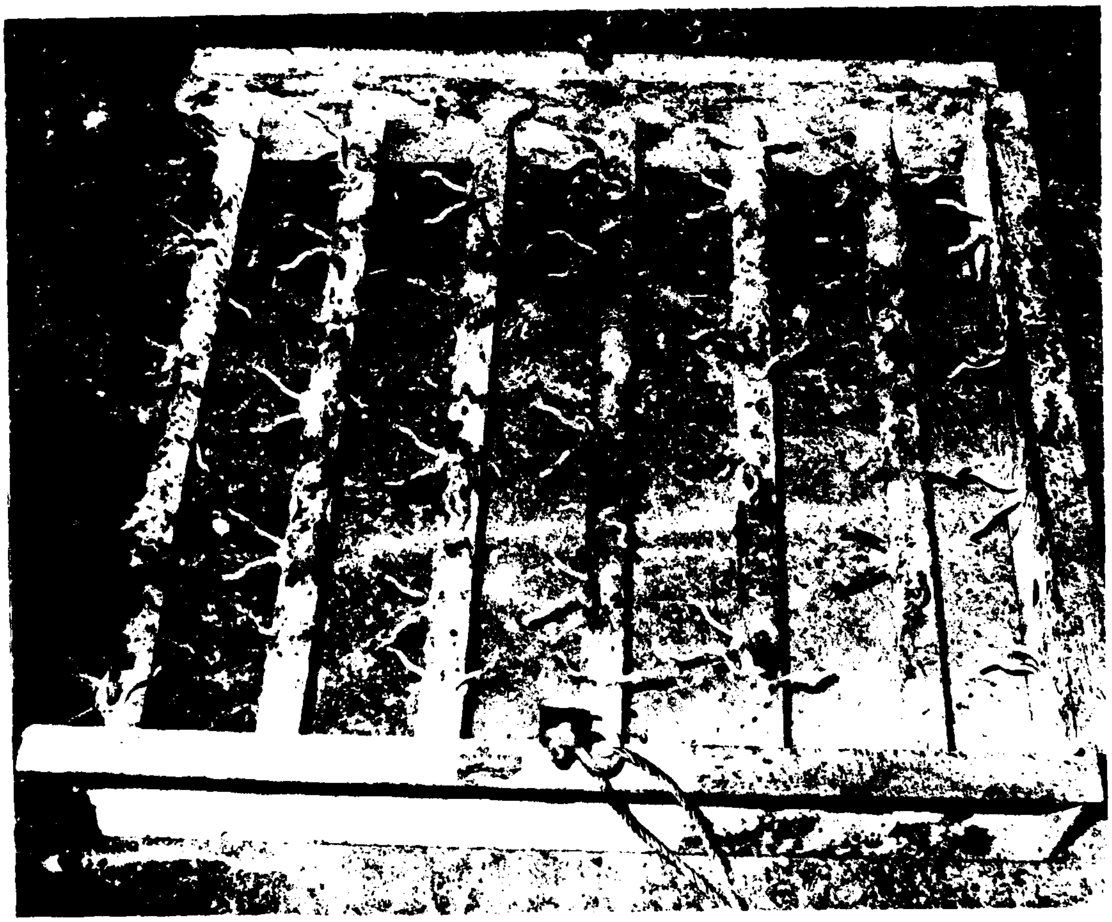

Figure 14. The Air Manifold Pipes and Channel of the Partition Structure

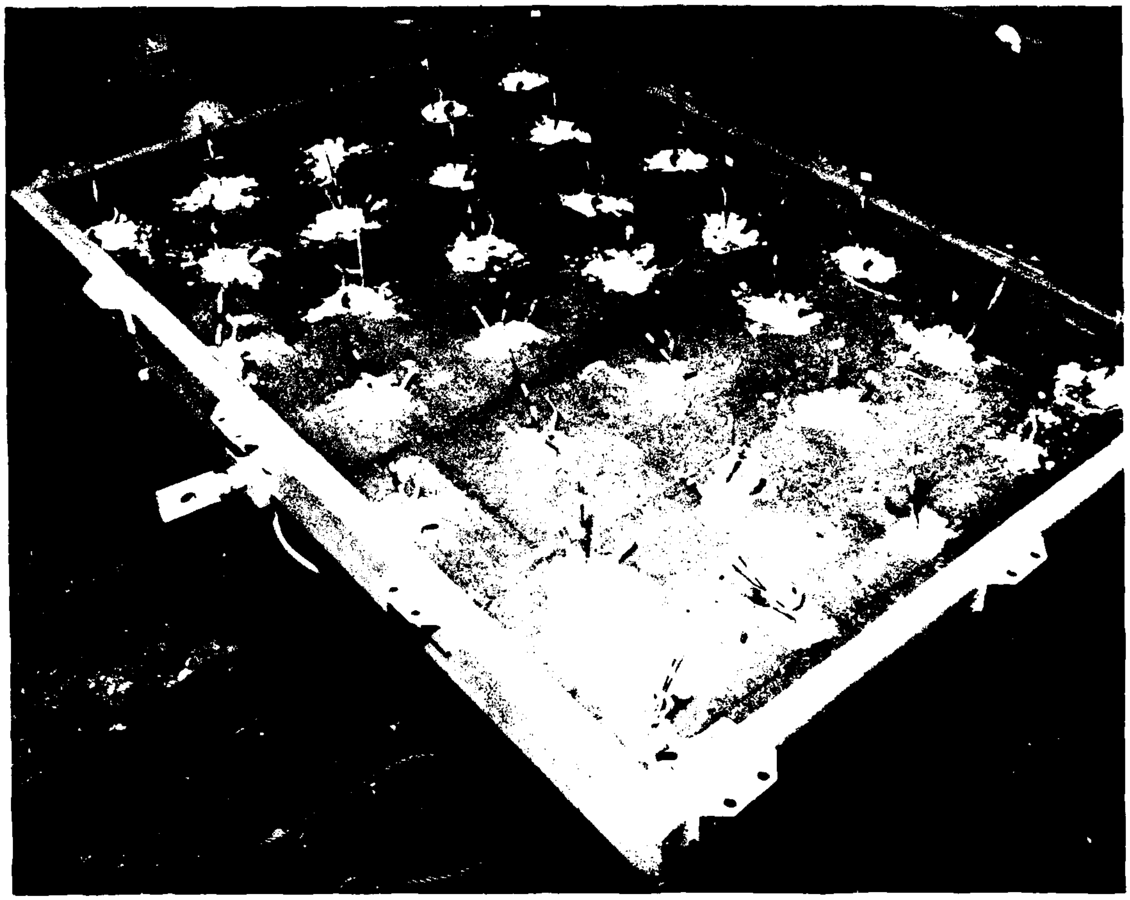

Figure 15. The Sewage Chamber Roof Structure with the Insulation, Anchors, and Wires in Place

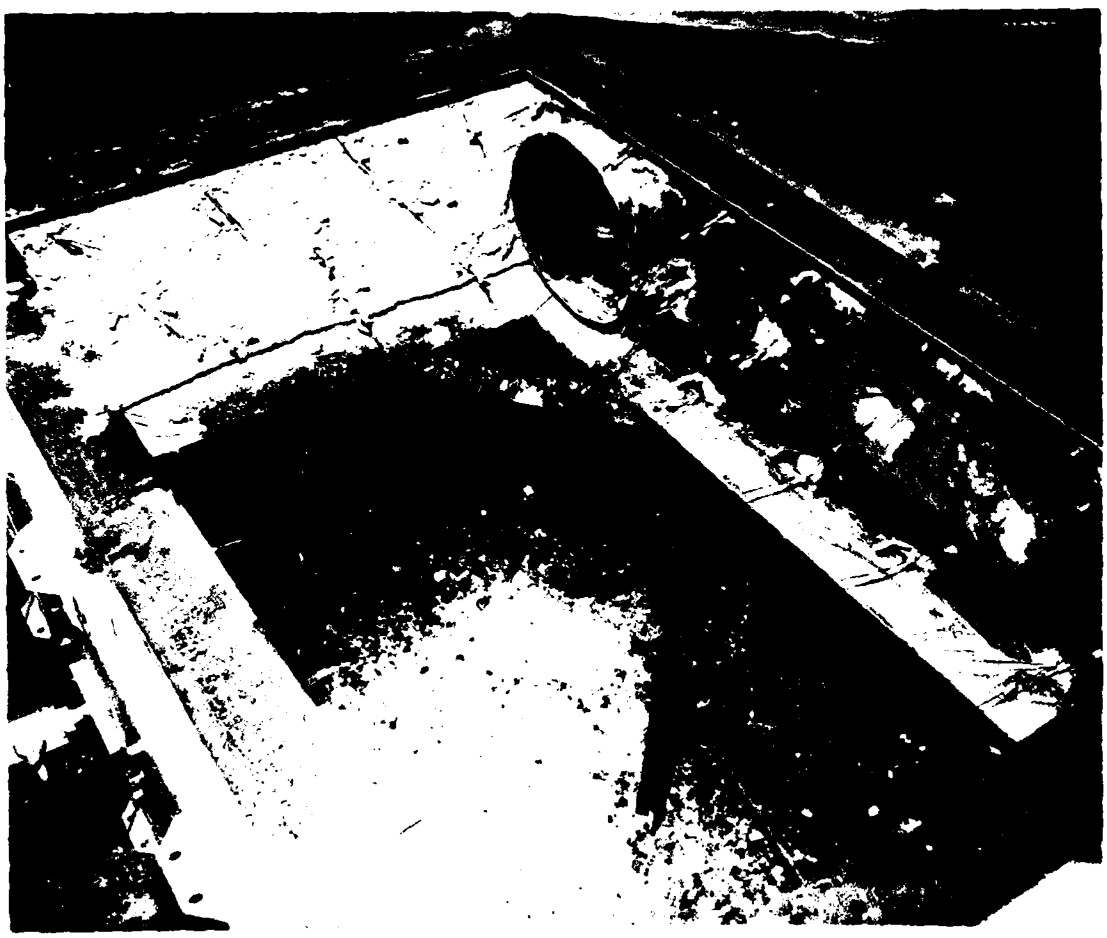

Figure 16. The Sewage Chamber Impingement and Exhaust Port Walls, with Insulation, Anchors, and Wires in Place

Figure 17. The Nozzle Port and Ash Cleanout Walls in the Sewage Chamber with the Insulation, Anchors, and Wires in Place

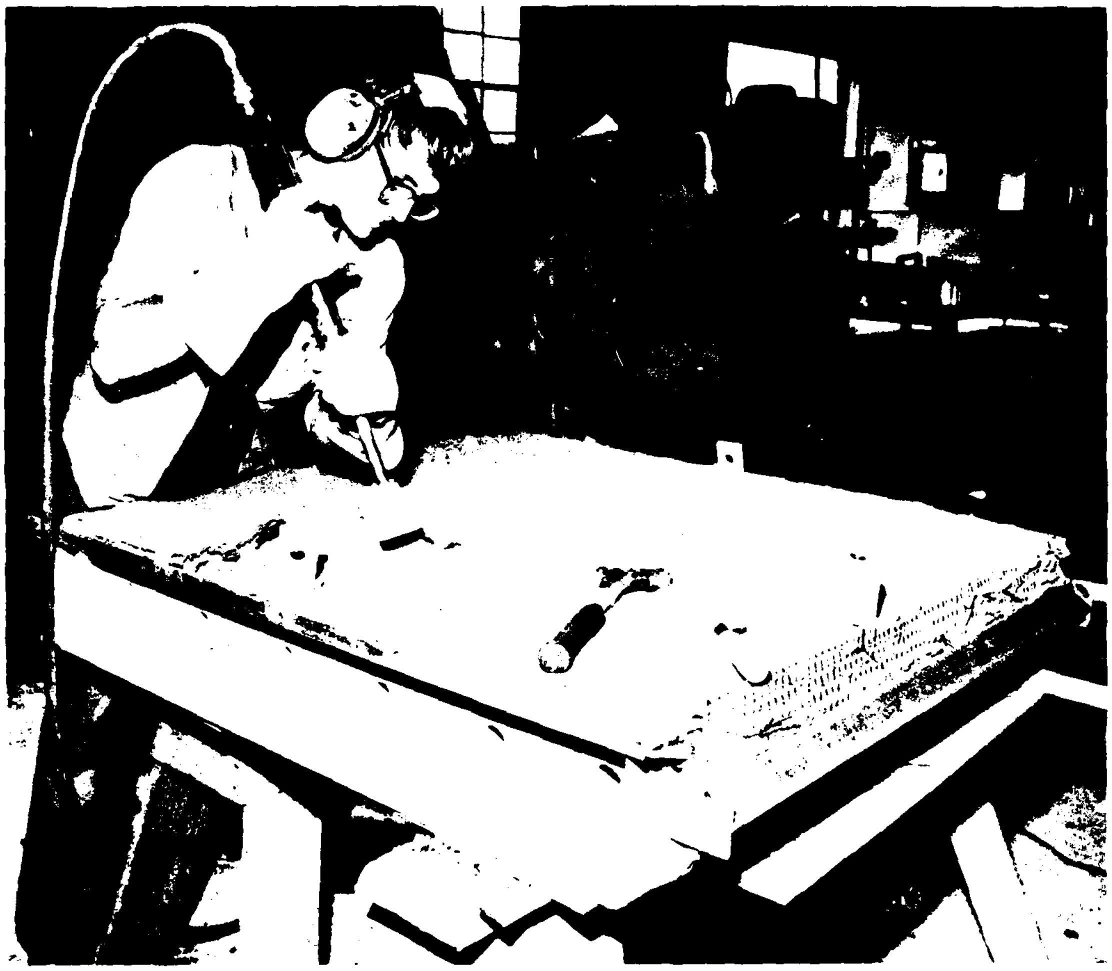

Figure 18. The Partition Structure with the Plastic Refractory Being Rammed into Place

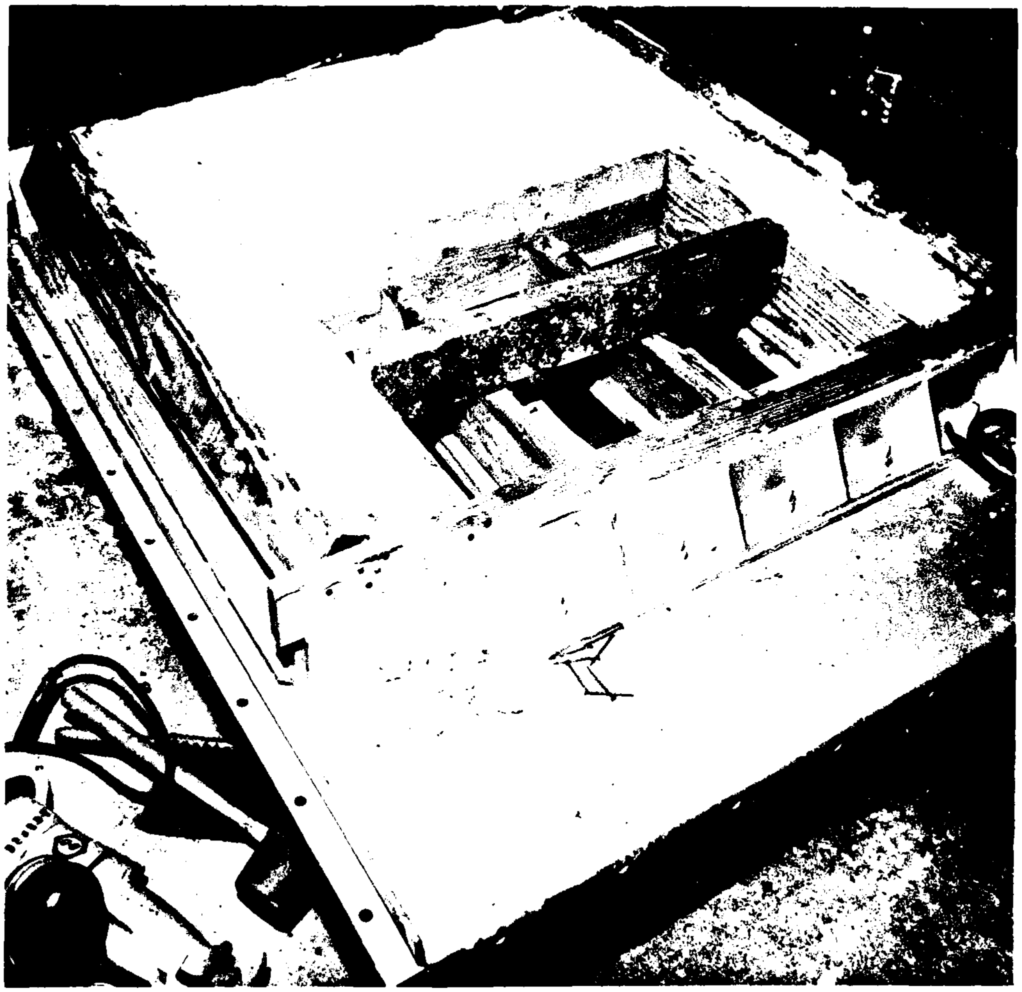

Figure 19. The Front Wall After Casting with the Form in Place

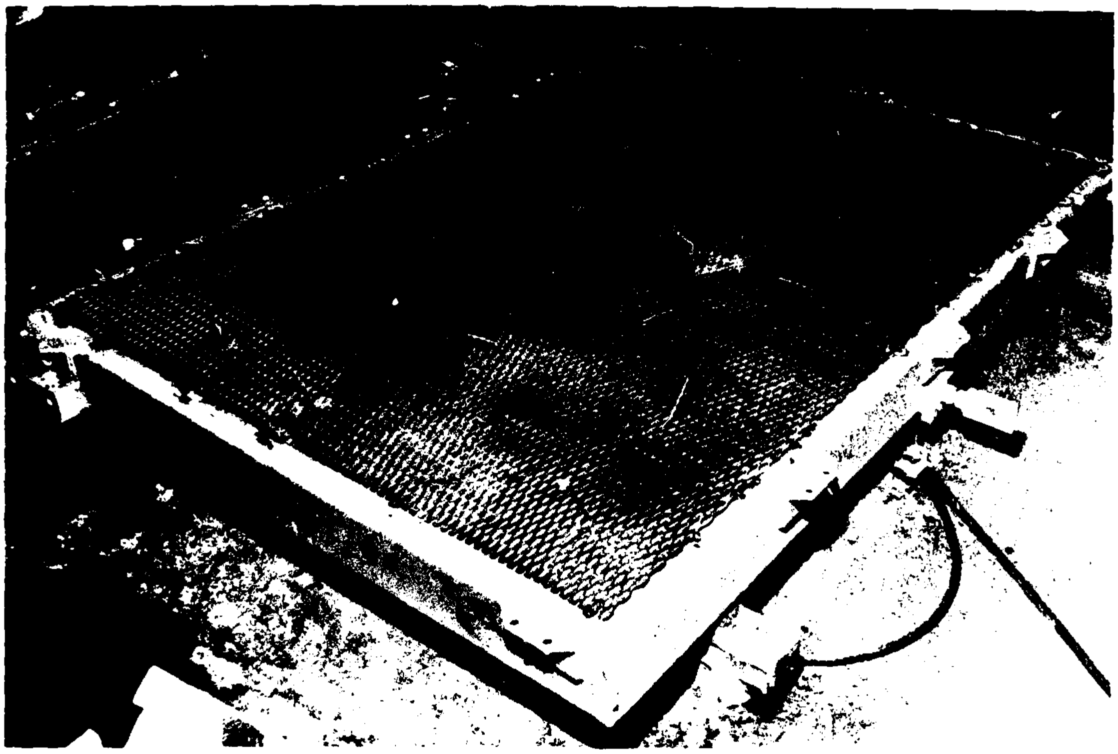

Figure 20. The Sewage Chamber Roof with the Expanded Metal Ties in Place and the Unit Ready for Assembly

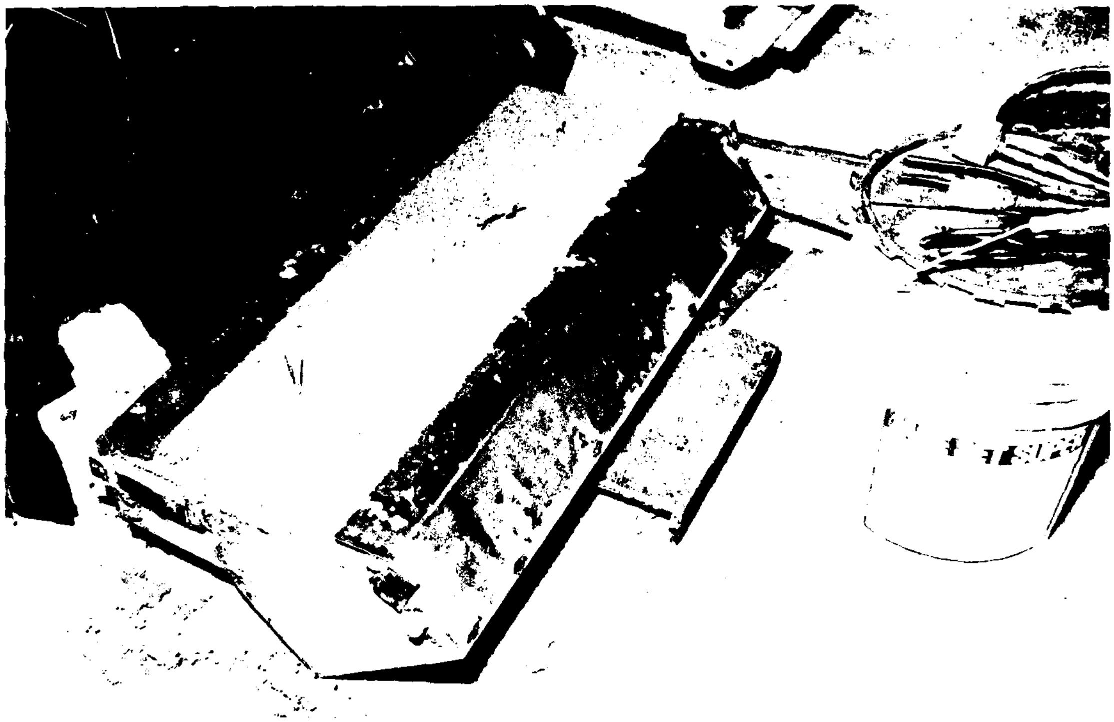

Figure 21. The Ash Door Overhead Structure After Ramming, Prior to Removal of the Forms and Installation of the Expanded Metal

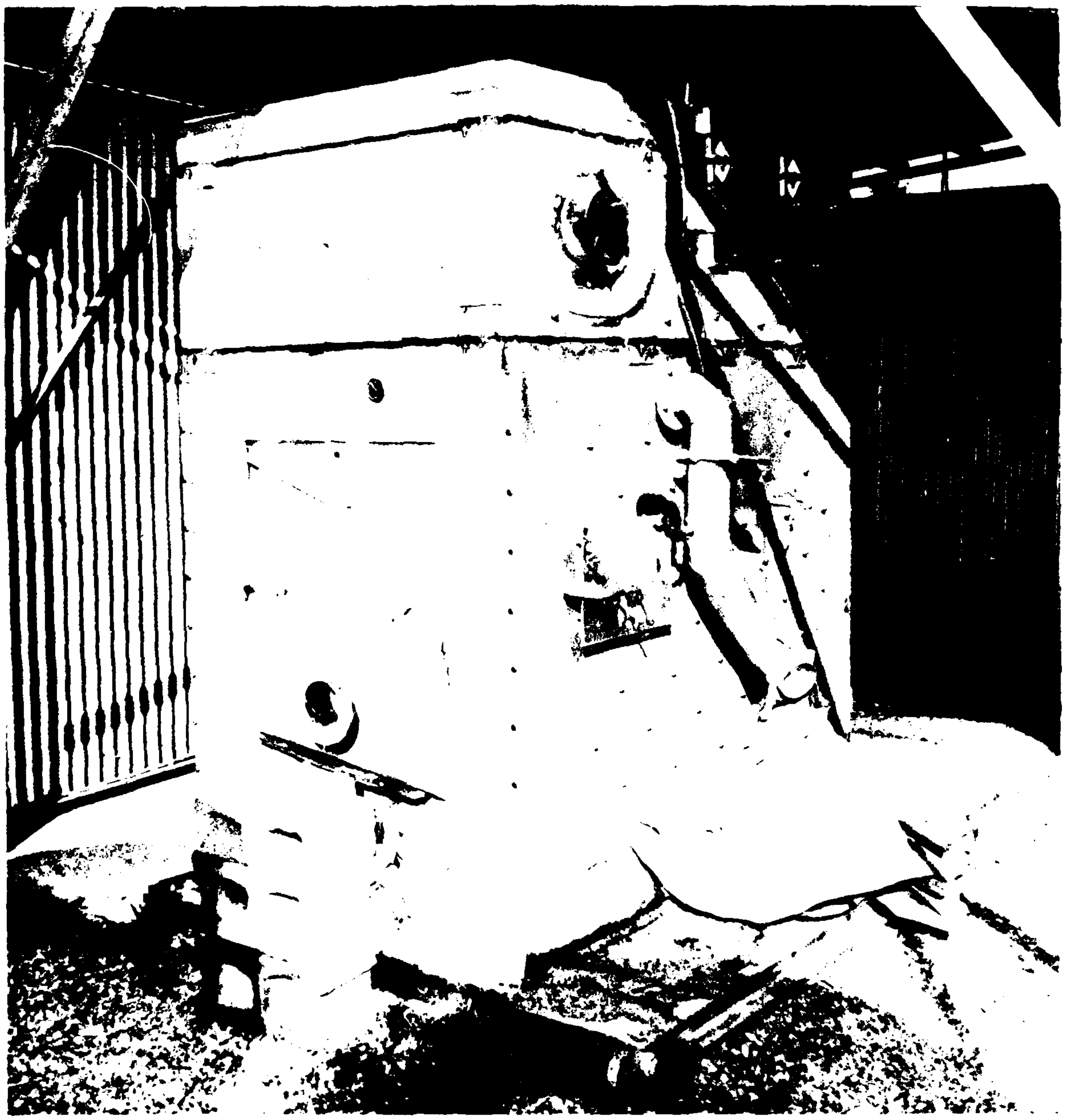

Figure 22. The Main and Sewage Chambers Assembled for Curing

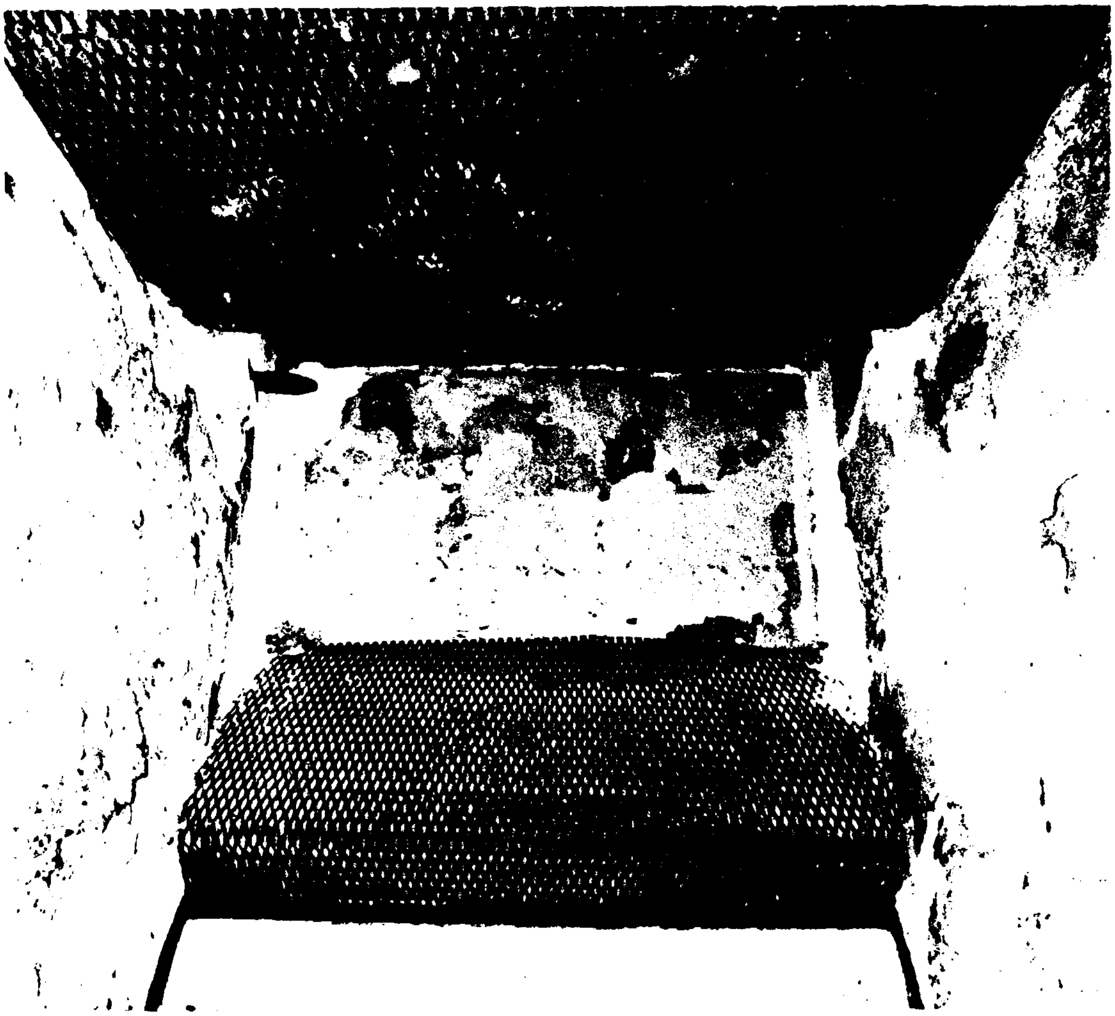

Figure 23. The Side and Back Walls in the Main Chamber

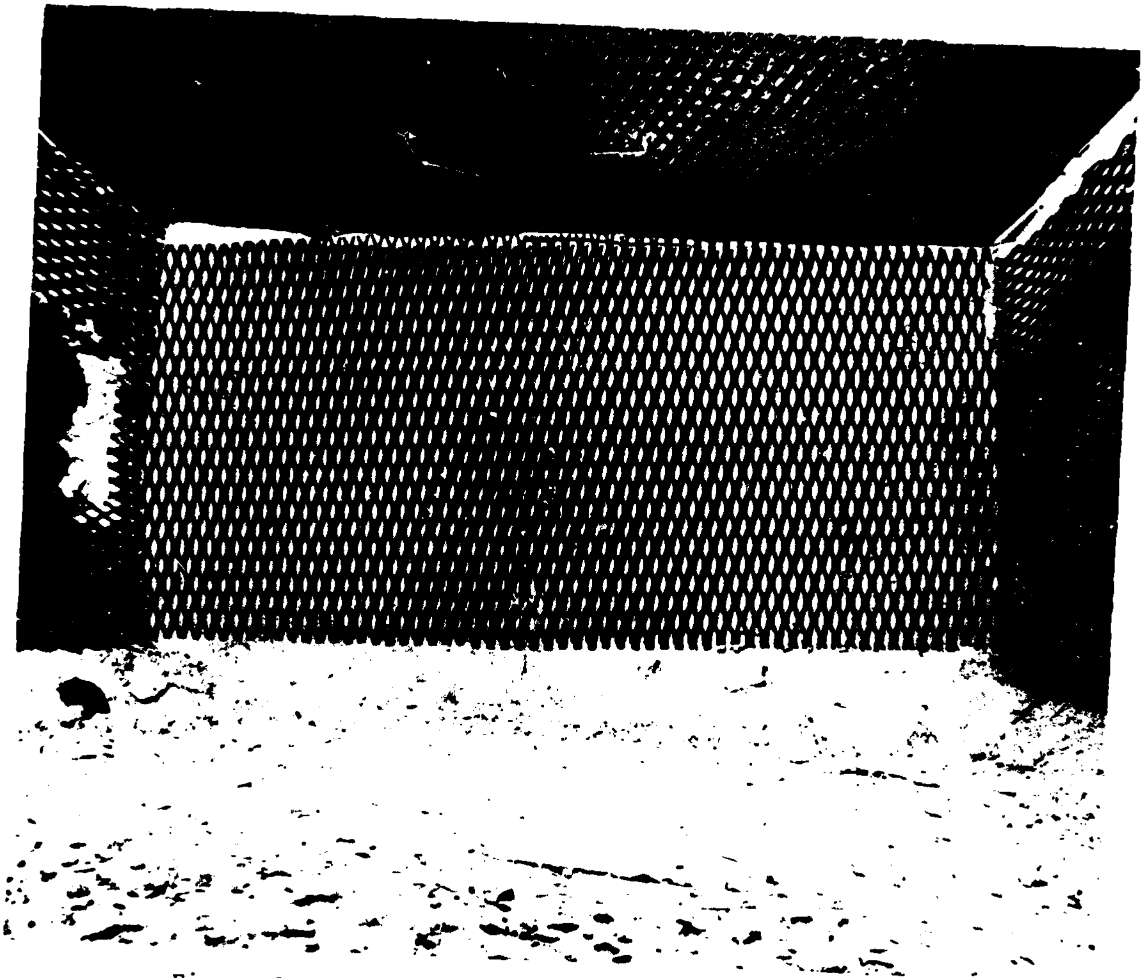

Figure 24. The Impingement Wall in the Sewage Chamber

Figure 25. The Side and Exhaust Port Walls of the Cooling Chamber Base with the SS 310 Anchors in Place

Figure 26. The Opposite Cooling Chamber Wall, with Both Types of Anchors

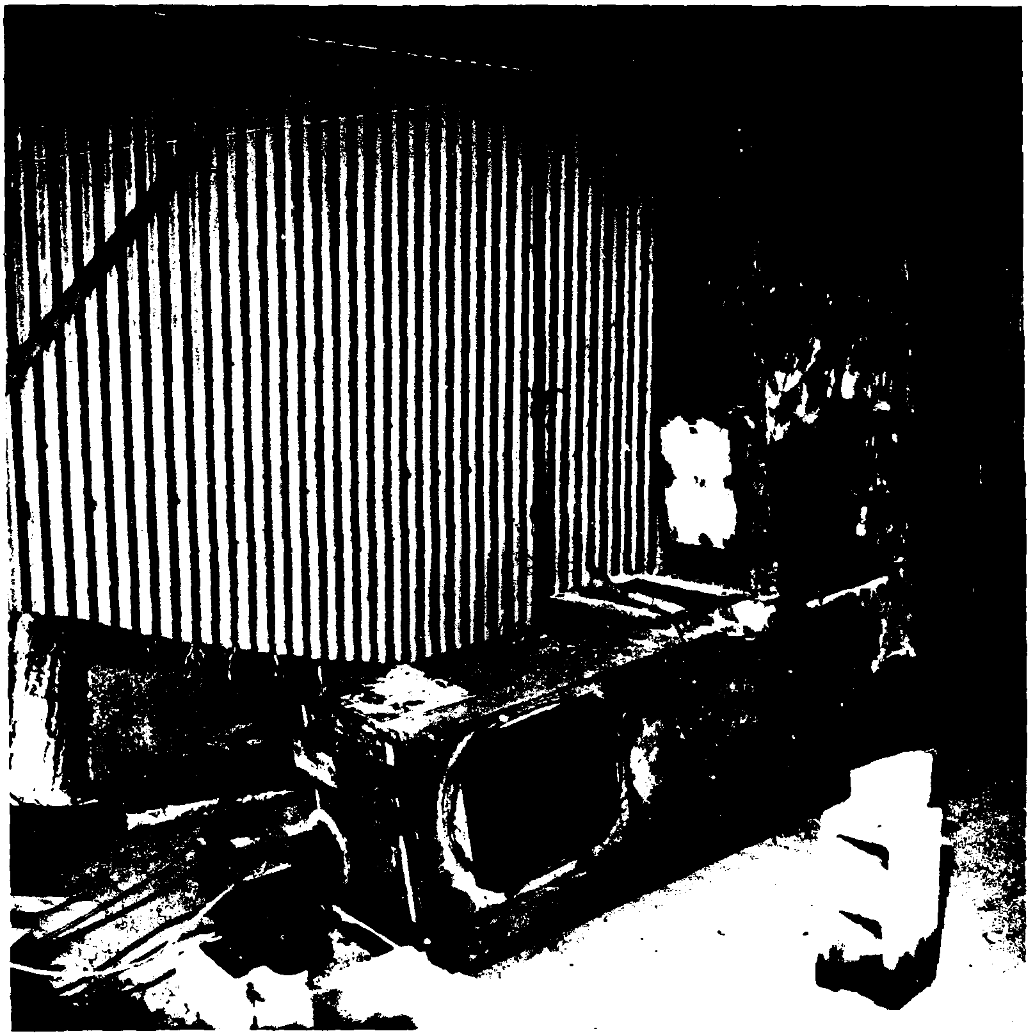

Figure 27. The Inverted Cooling Chamber, Set Up for the Curing Process

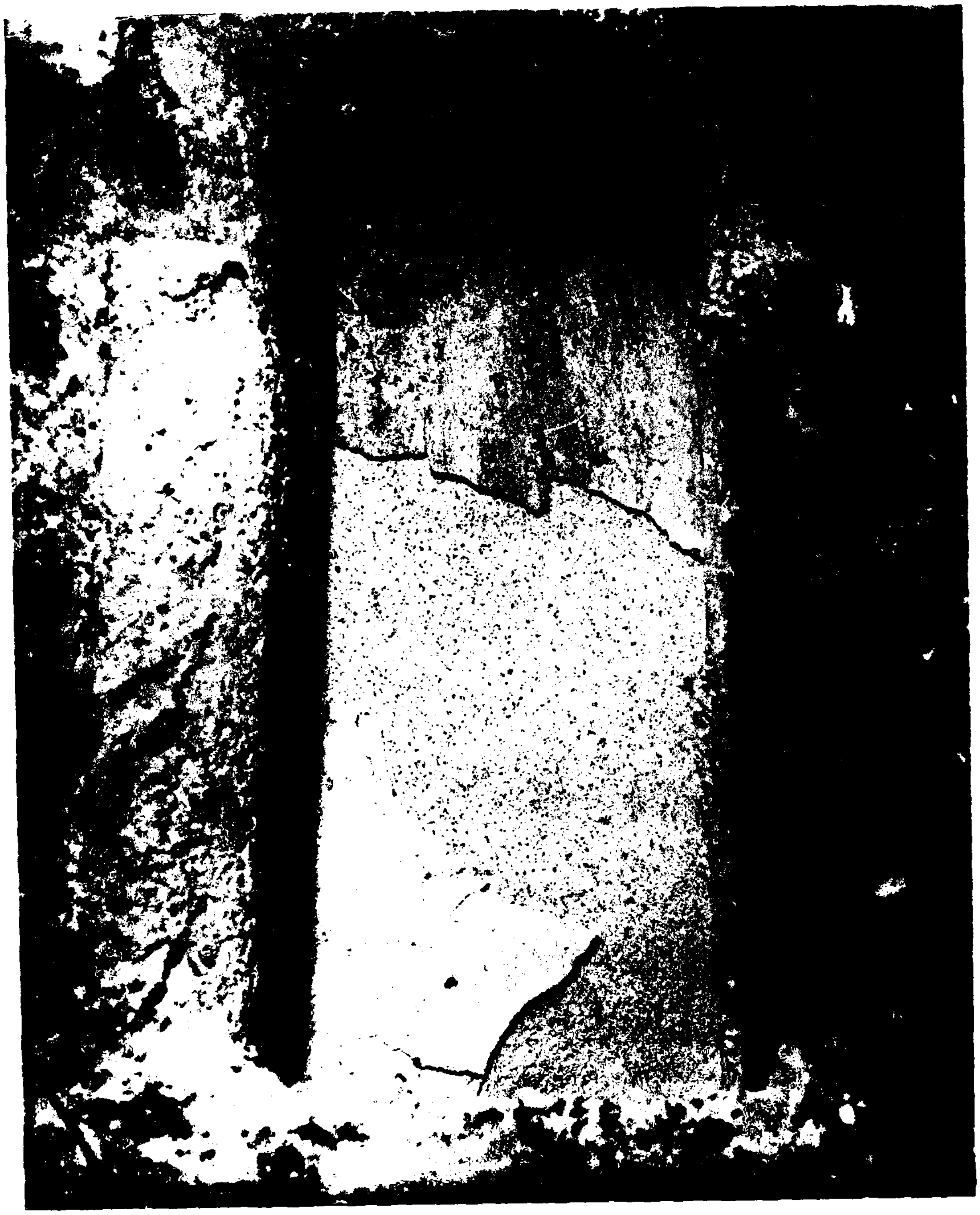

Figure 28. The Cooling Chamber Base Refractory After Curing

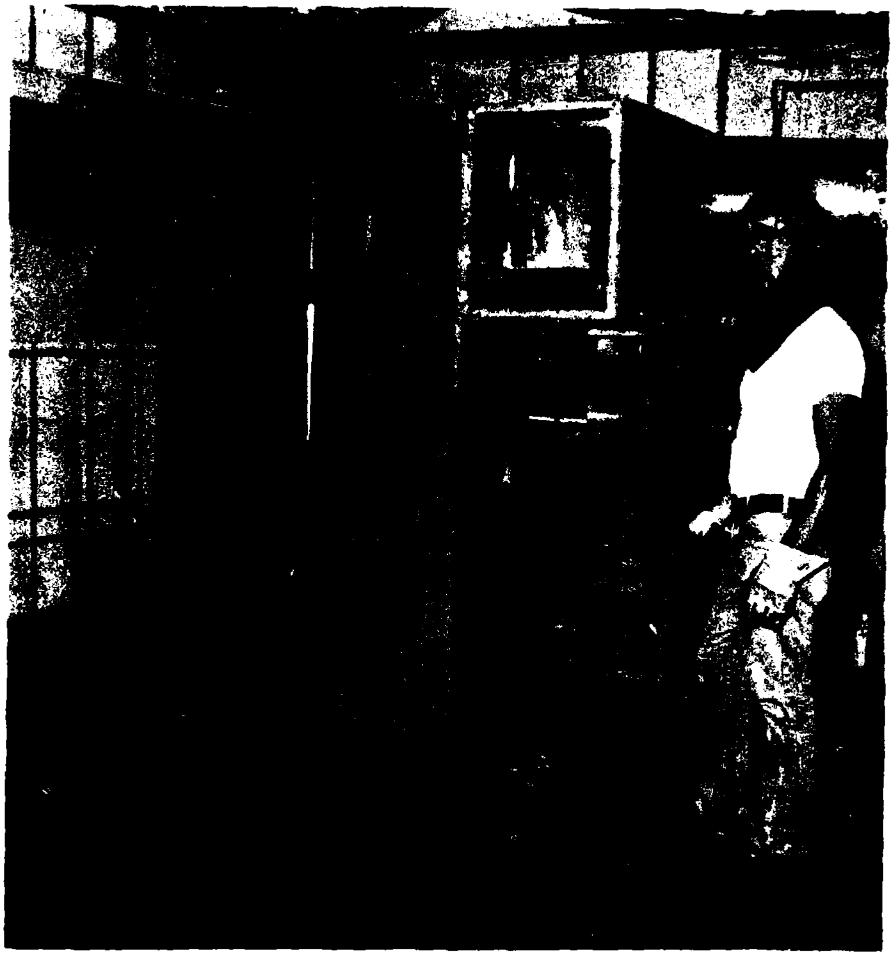

Figure 29. The MFI Being Removed from the Test Area for Shipment to the Vibration Test Site. Cooling Jacket Fan Indicated by Arrows

Figure 30. The MFI and Fixture Mounted Above the Vibrator for the Vertical Axis Test

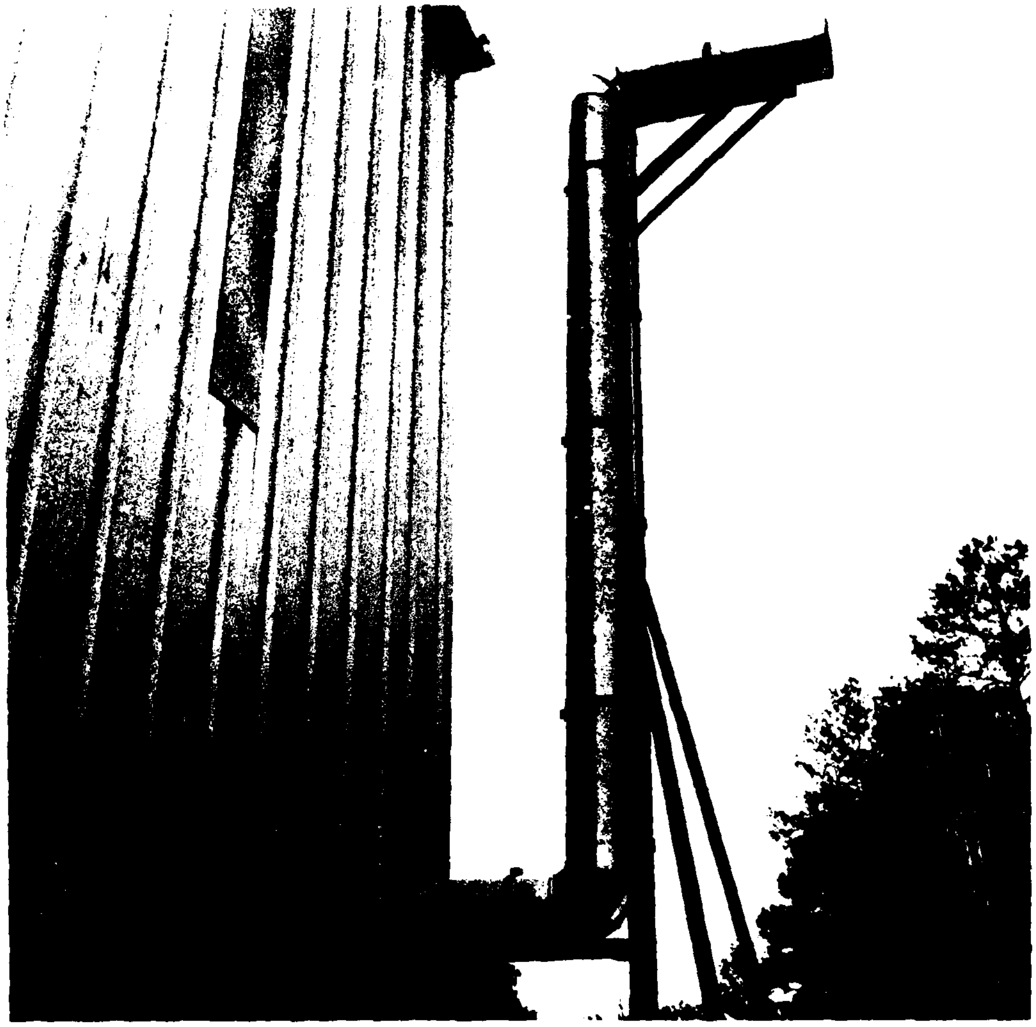

Figure 31. The Exterior Portion of the MFI Exhaust Ducting

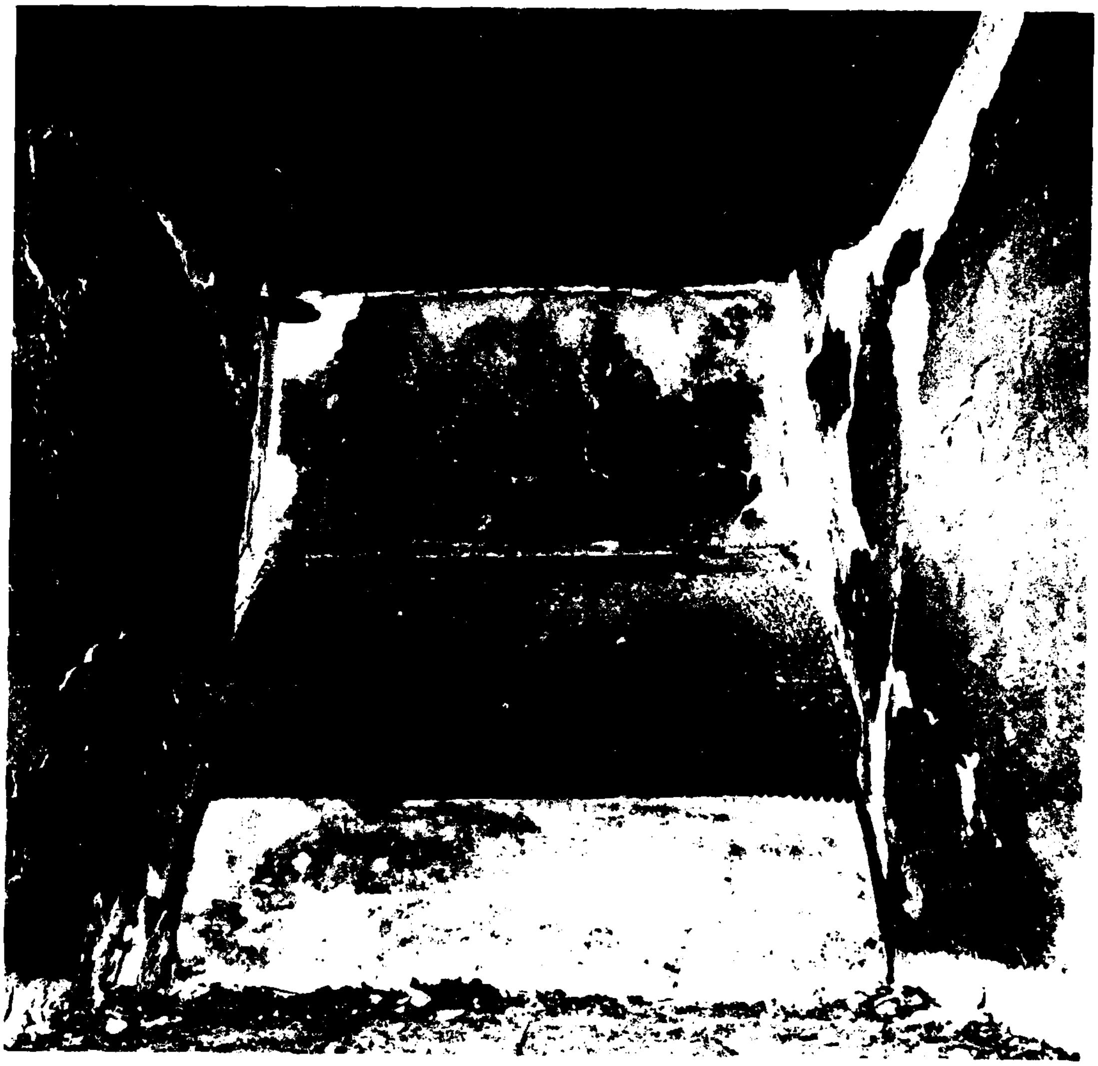

Figure 32. The Side and Back Walls in the Main Chamber

Figure 33. The Left Rear Corner in the Main Chamber

Figure 34. The Front Wall and View Port in the Main Chamber

Figure 35. The Burner Port (Far Left Center) and Front Wall in the Main Chamber

Figure 36. The Right Wall and Burner Port in the Main Chamber

Figure 37. The Rear Portion of the Right Wall in the Main Chamber

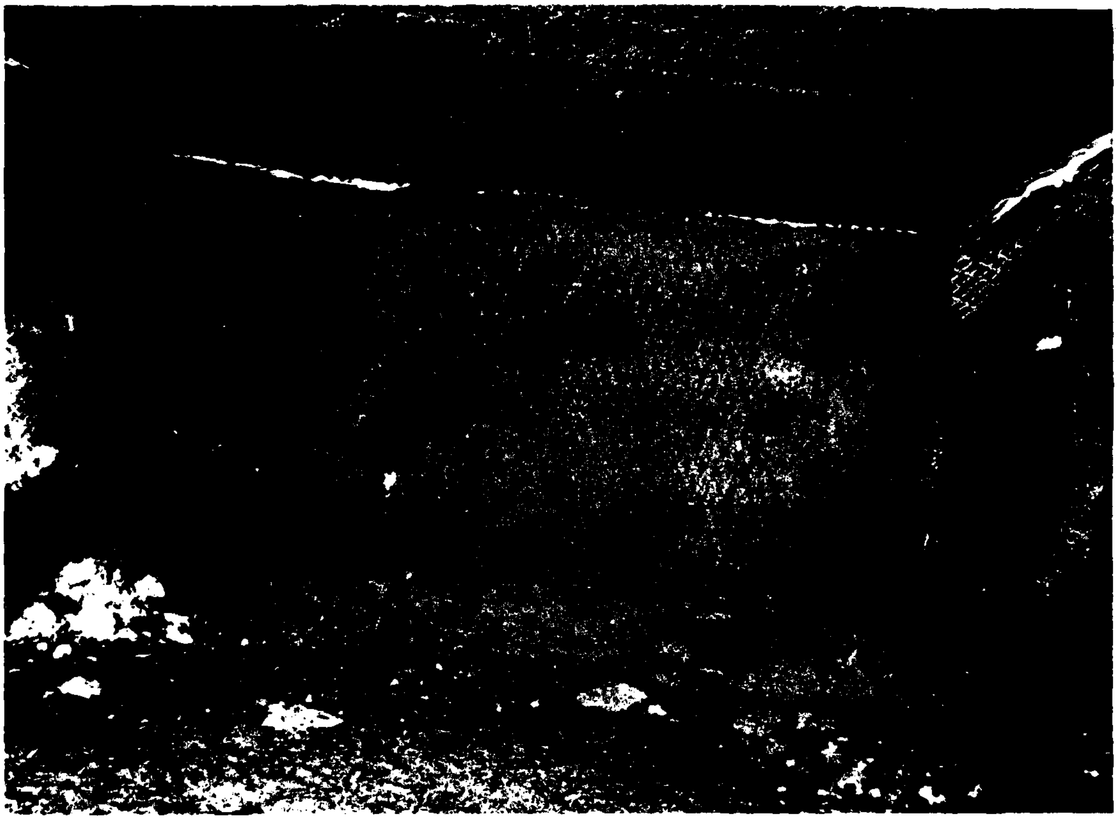

Figure 38. The Sewage Impingement (Front) Wall

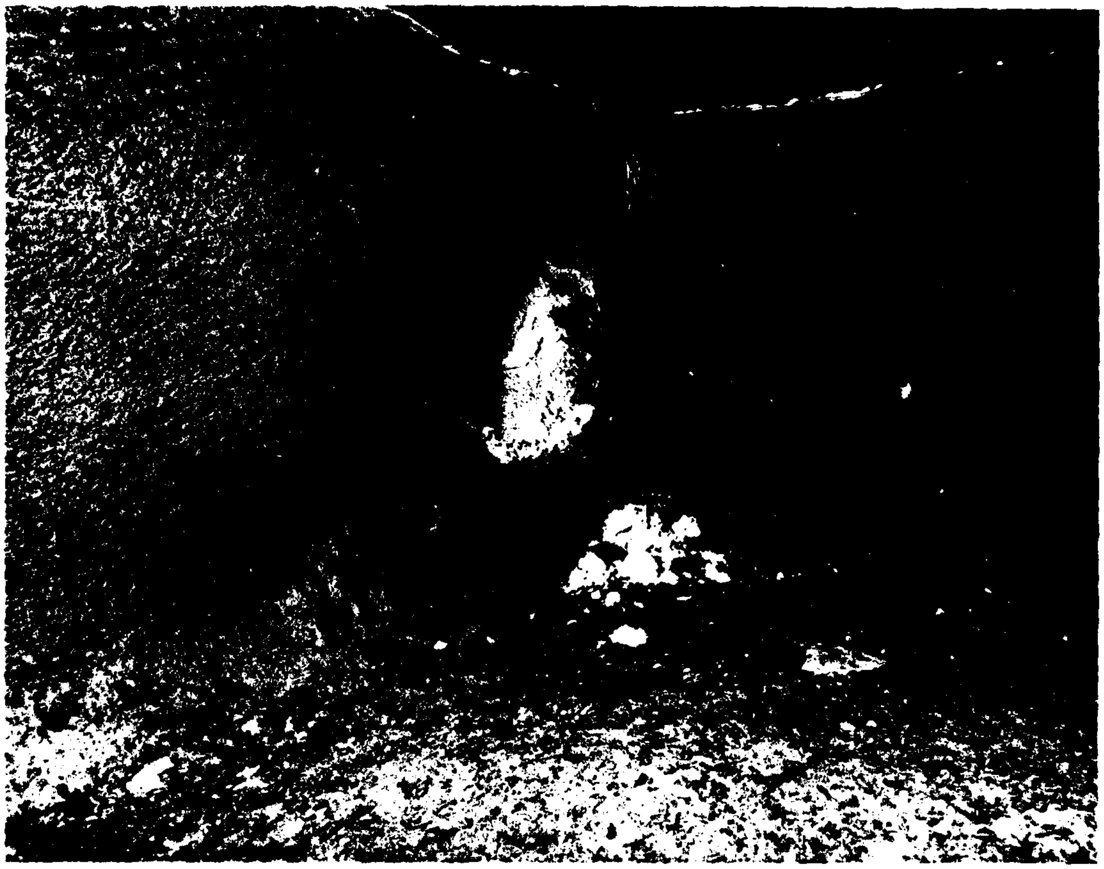

Figure 39. Sewage Chamber Exhaust Port and the Cast Joint (White Material in the Port) which Mates this Chamber to the Cooling Chamber

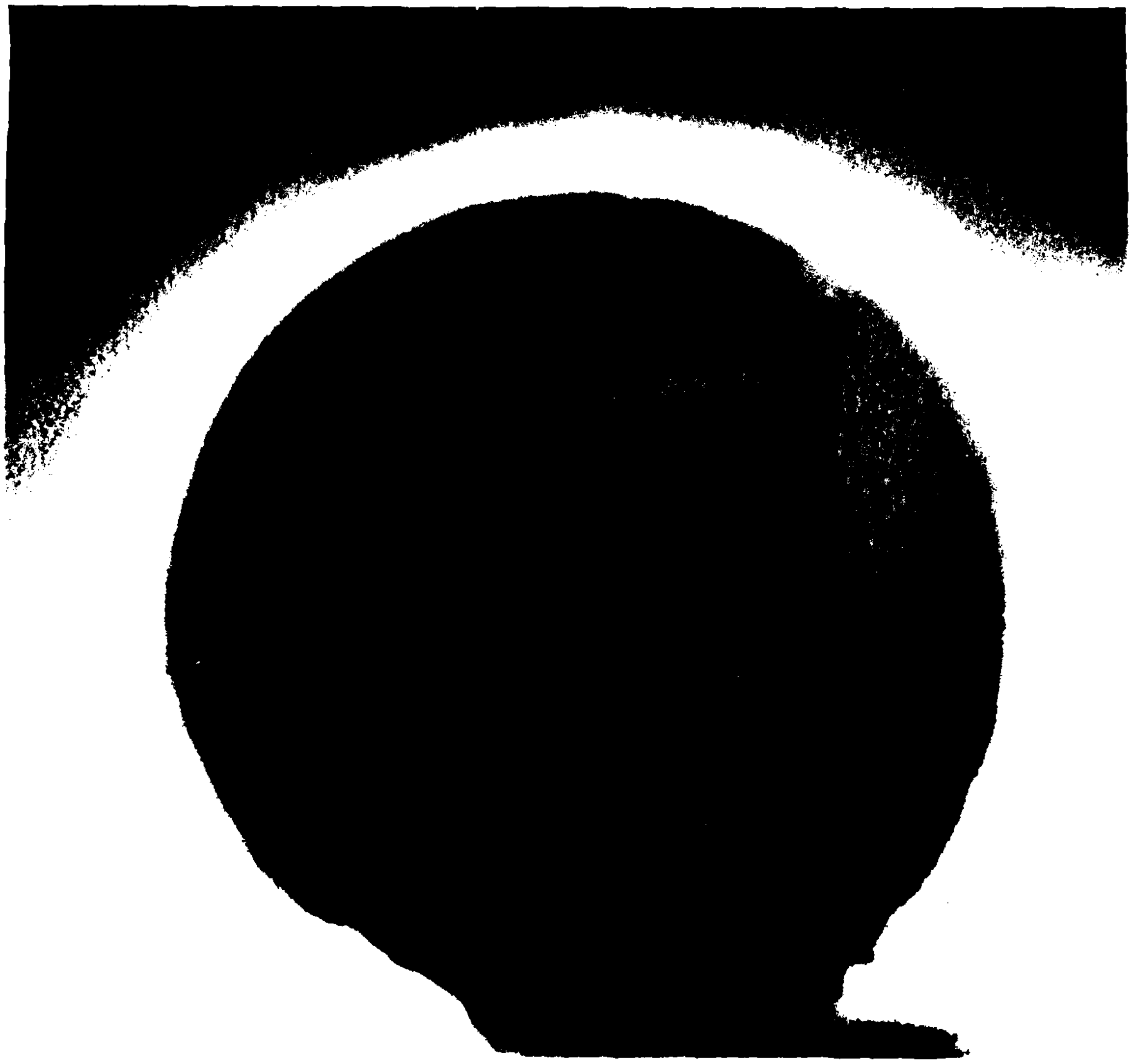

Figure 40. View of the Cooling Chamber from the View Port

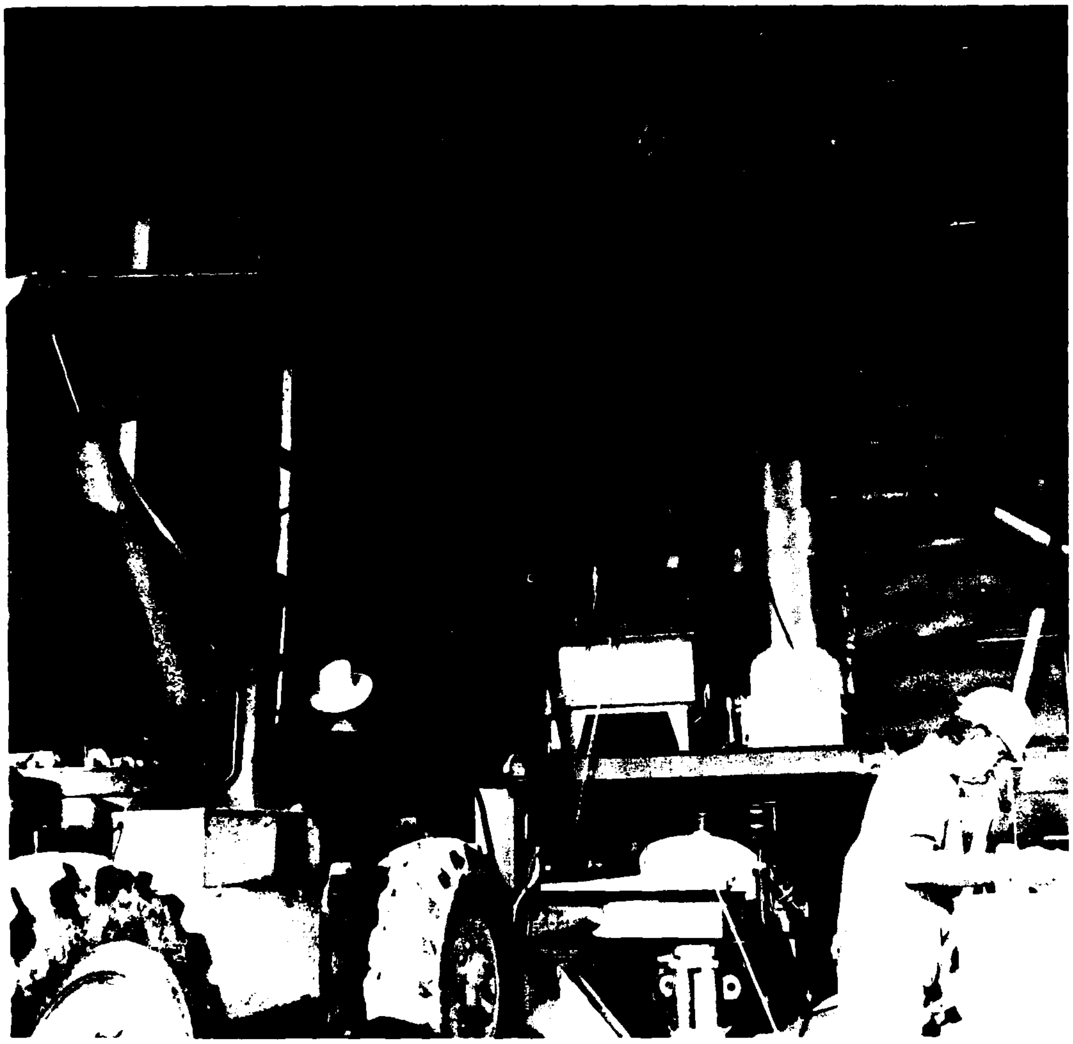

Figure 41. The MFI and Fixture Prior to Removal from the Vibrator and Support Structure

Figure 42. The MFI and Fixture After Being Dropped

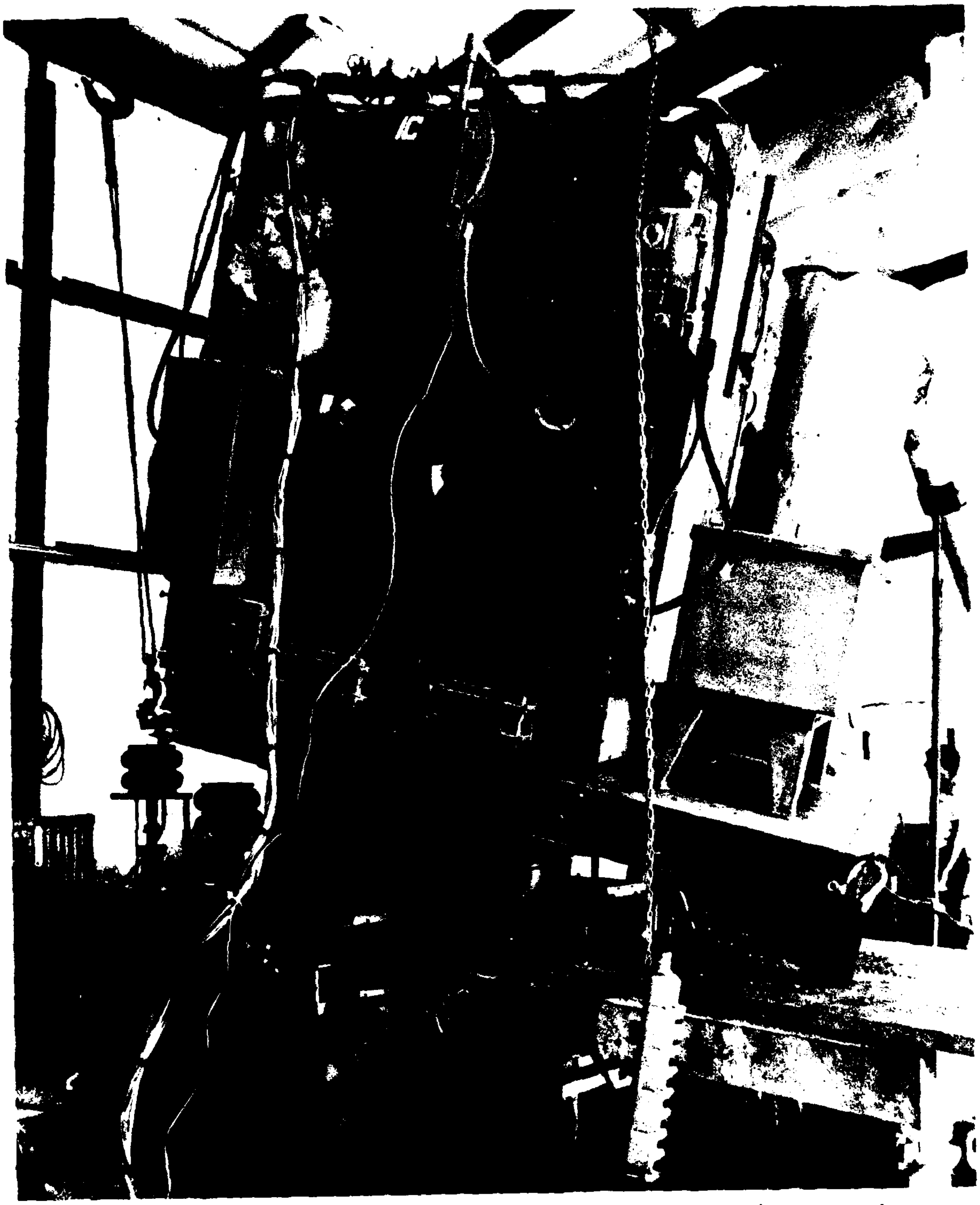

Figure 43. Side View of the MFI and Fixture After Being Dropped

Figure 44. Rear View of the MFI with the Rear Portion of the Broken Spreader Bar Lying in the Foreground

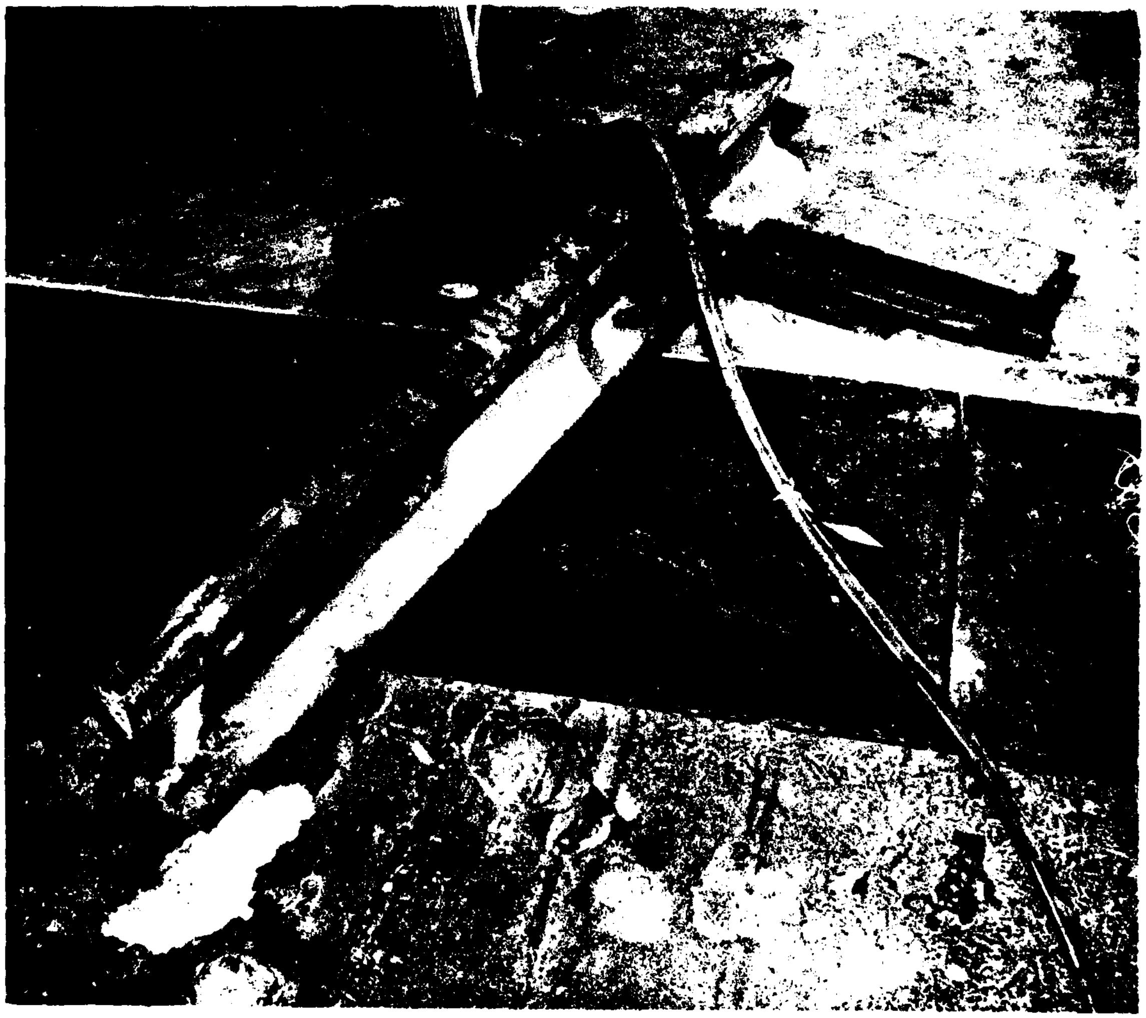

Figure 45. The Front Portion of the Broken Spreader Bar

Figure 46. Closeup View of the Spreader Bar Fracture

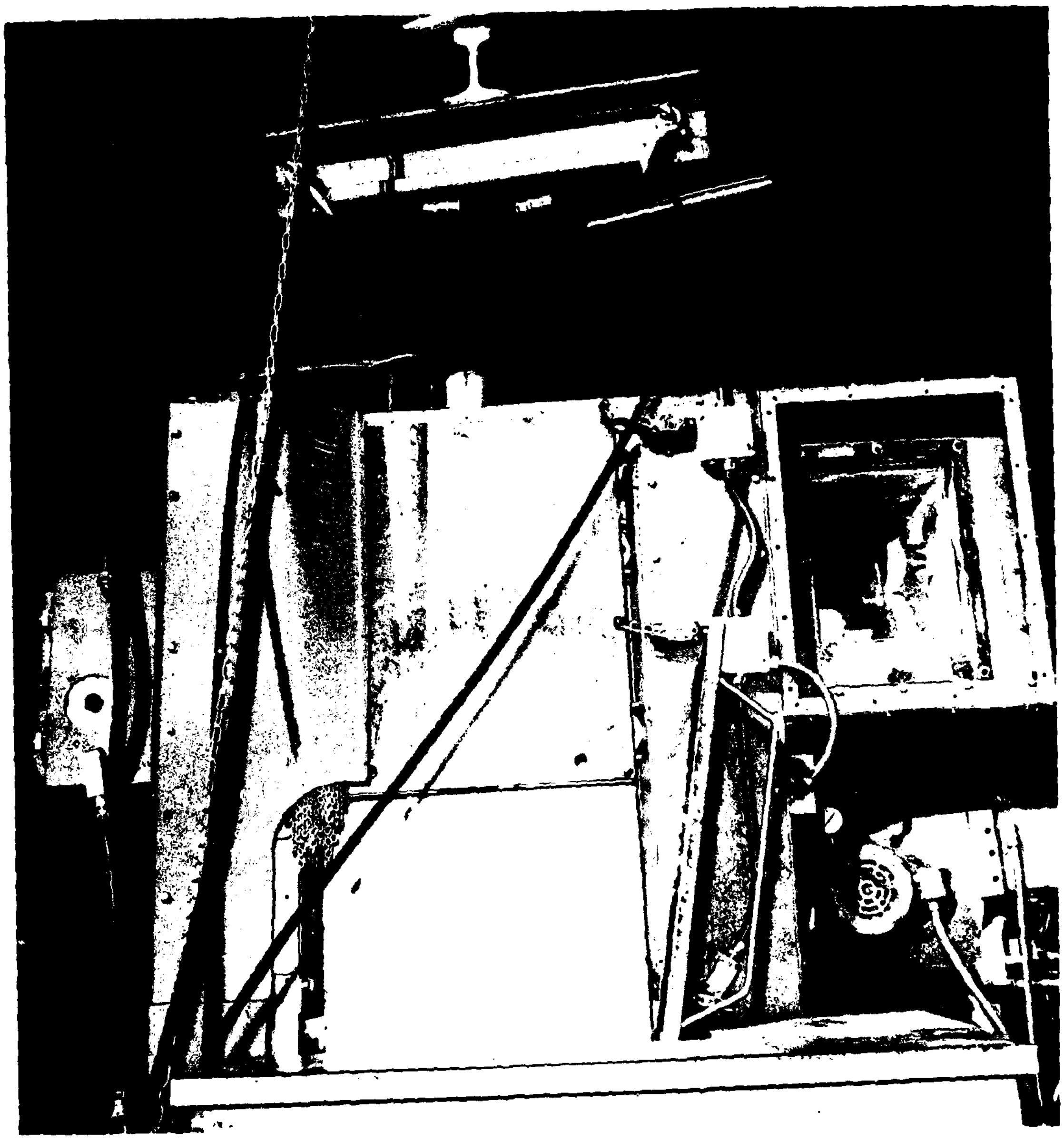

Figure 47. The Cooling Chamber and Chain Curtain Guard Damage

Figure 48. Horizontal Cooling Chamber Damage

Figure 49. Lodged Refractory Pieces in the Vertical Cooling Chamber at the Exhaust Port

Figure 50. Refractory in the ID Fan Plenum

Figure 51. Damaged Cooling Jacket Roof Panel

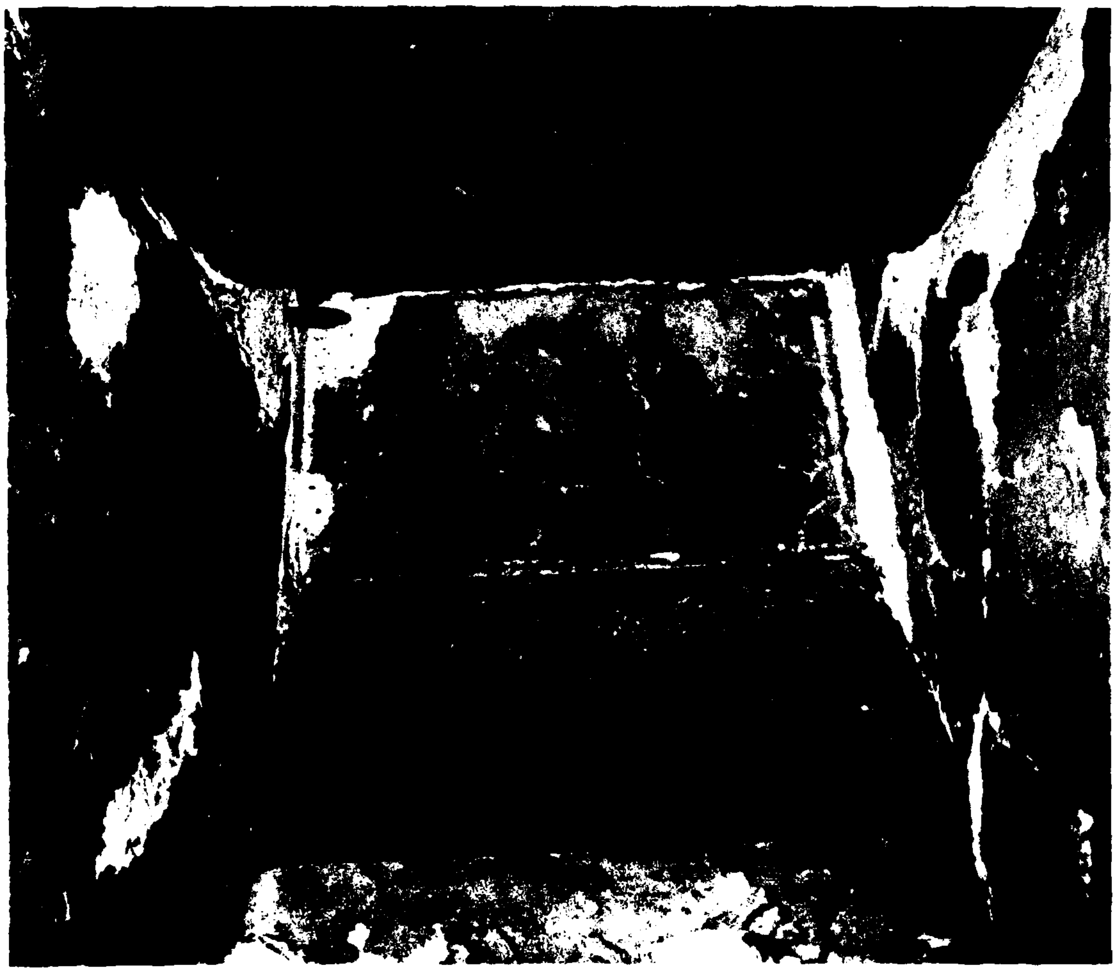

Figure 52. Side and Rear Walls in the Main Chamber

Figure 53. Left Rear Corner in the Main Chamber, with the Refractory Loss at Bottom Center

Figure 54. The View Port (Left Side) Wall and the Feed Door Opening in the Main Chamber

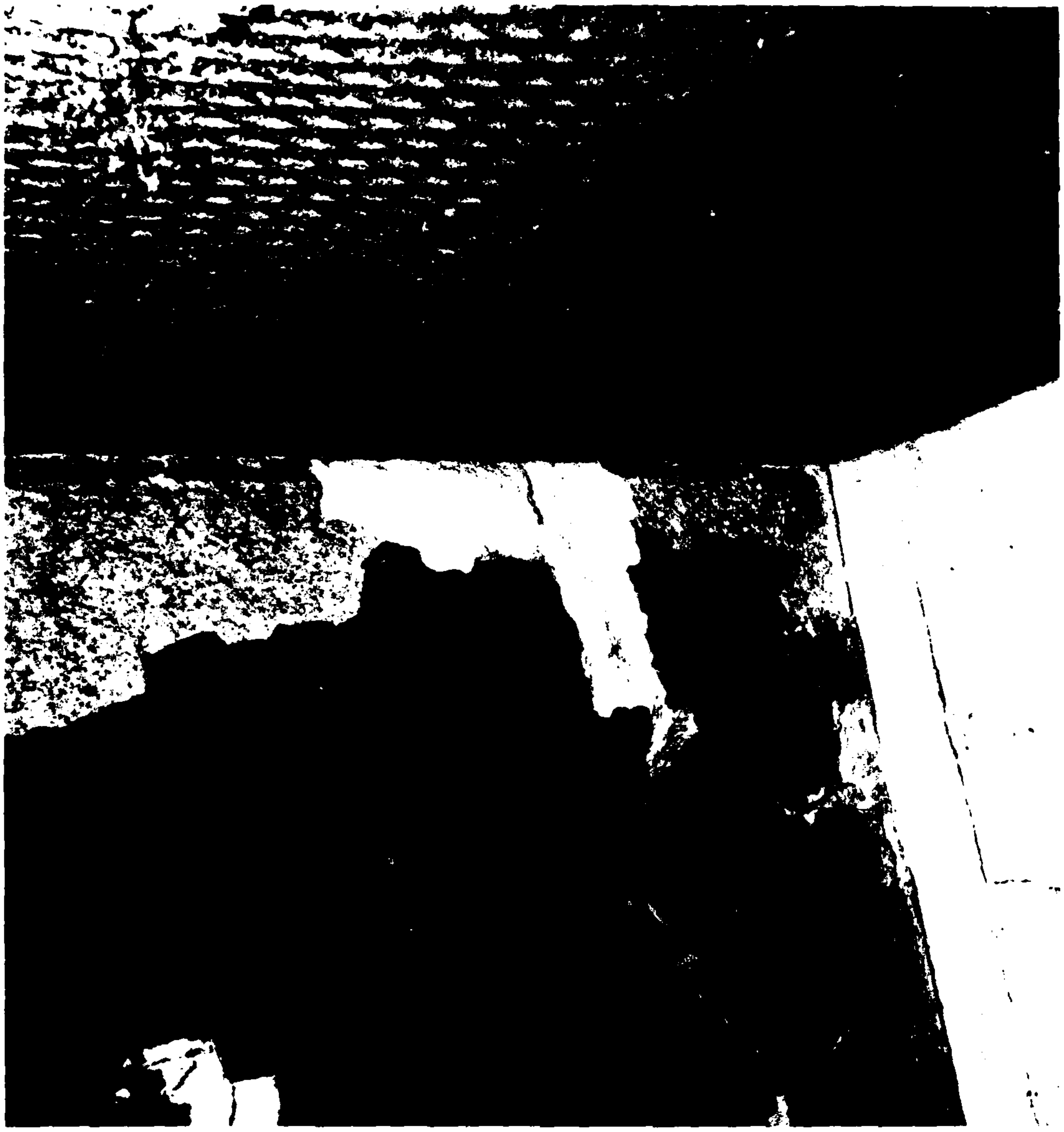

Figure 55. The Oil Burner and Surrounding (Right) Wall Structure in the Main Chamber

Figure 56. The Right Rear Corner in the Main Chamber

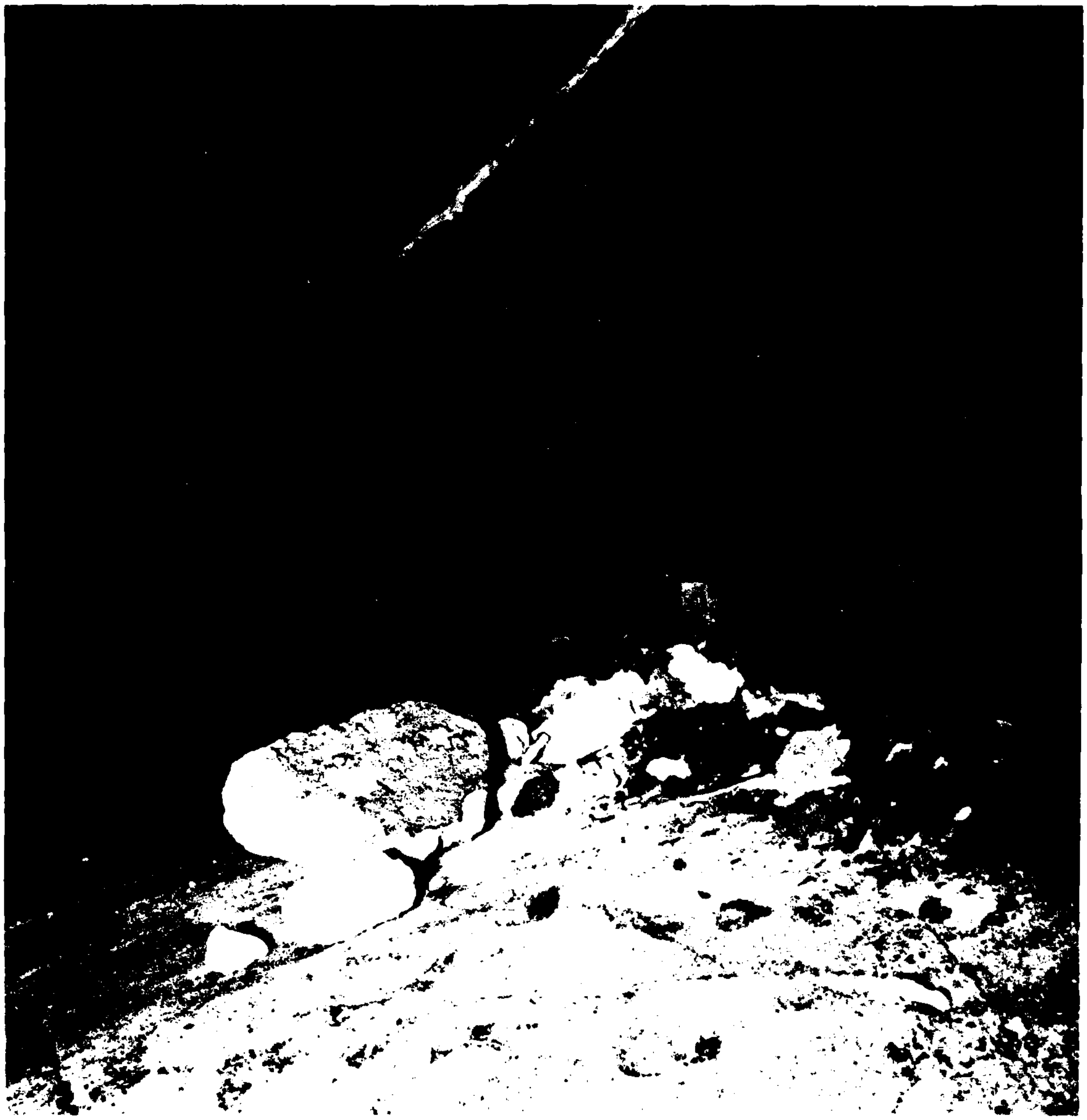

Figure 57. The Right Corner in the Sewage Chamber, with the Cleanout Ash Port Shown

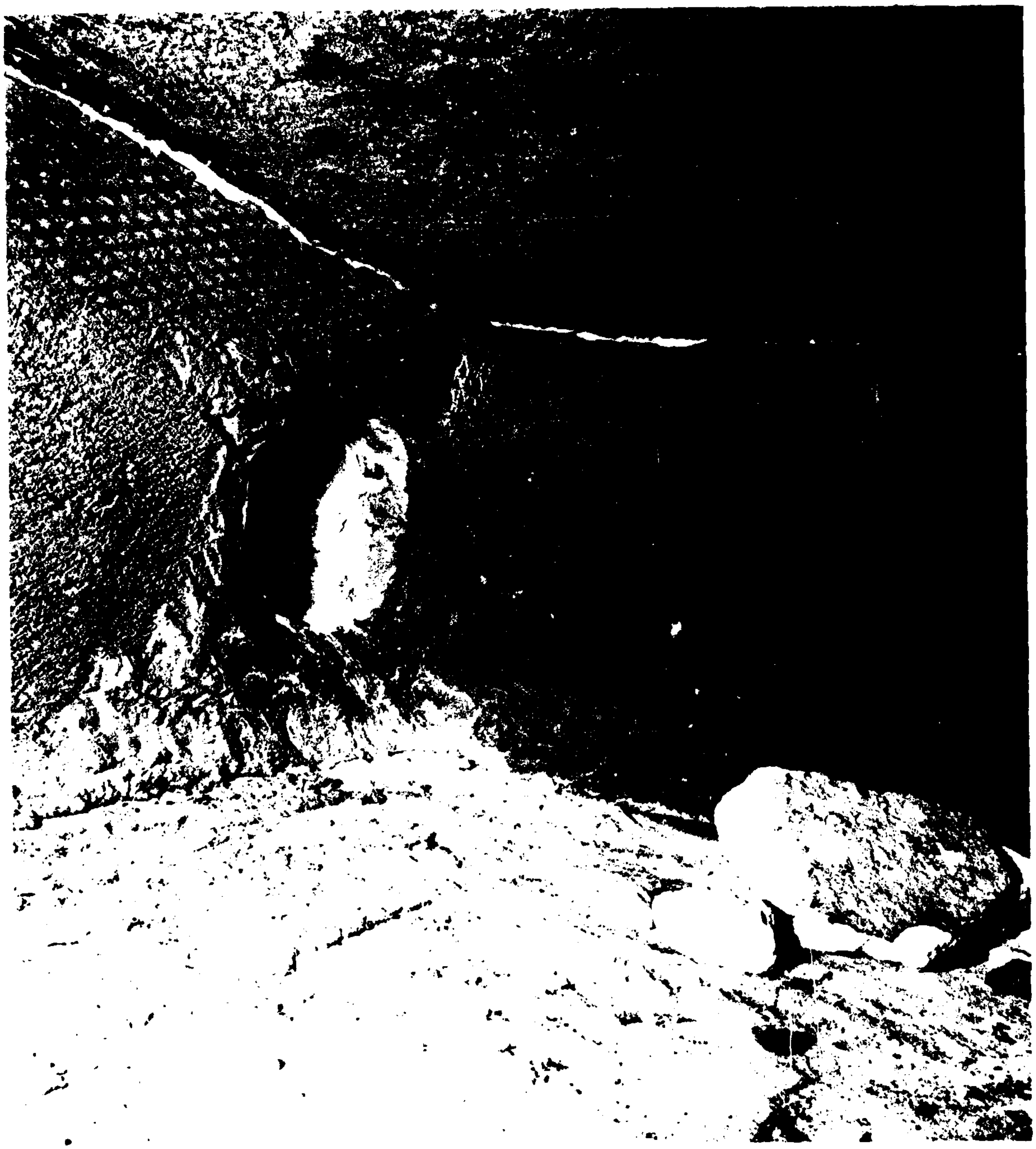

Figure 58. The Exhaust Port and Left Front Corner in the Sewage Chamber

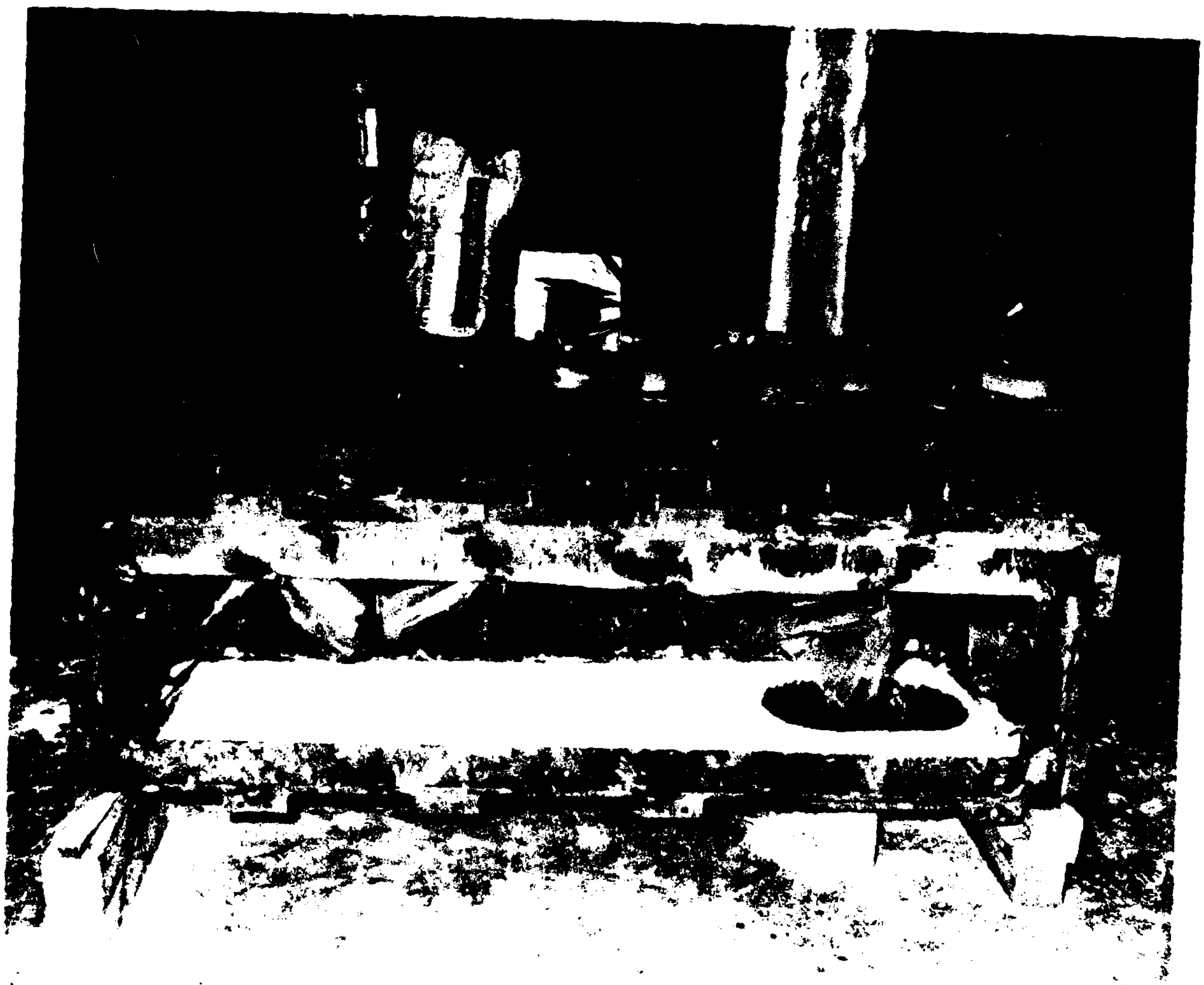

Figure 59. Left Wall of Horizontal Cooling Chamber After Casting, as Viewed Through the Top of the Structure

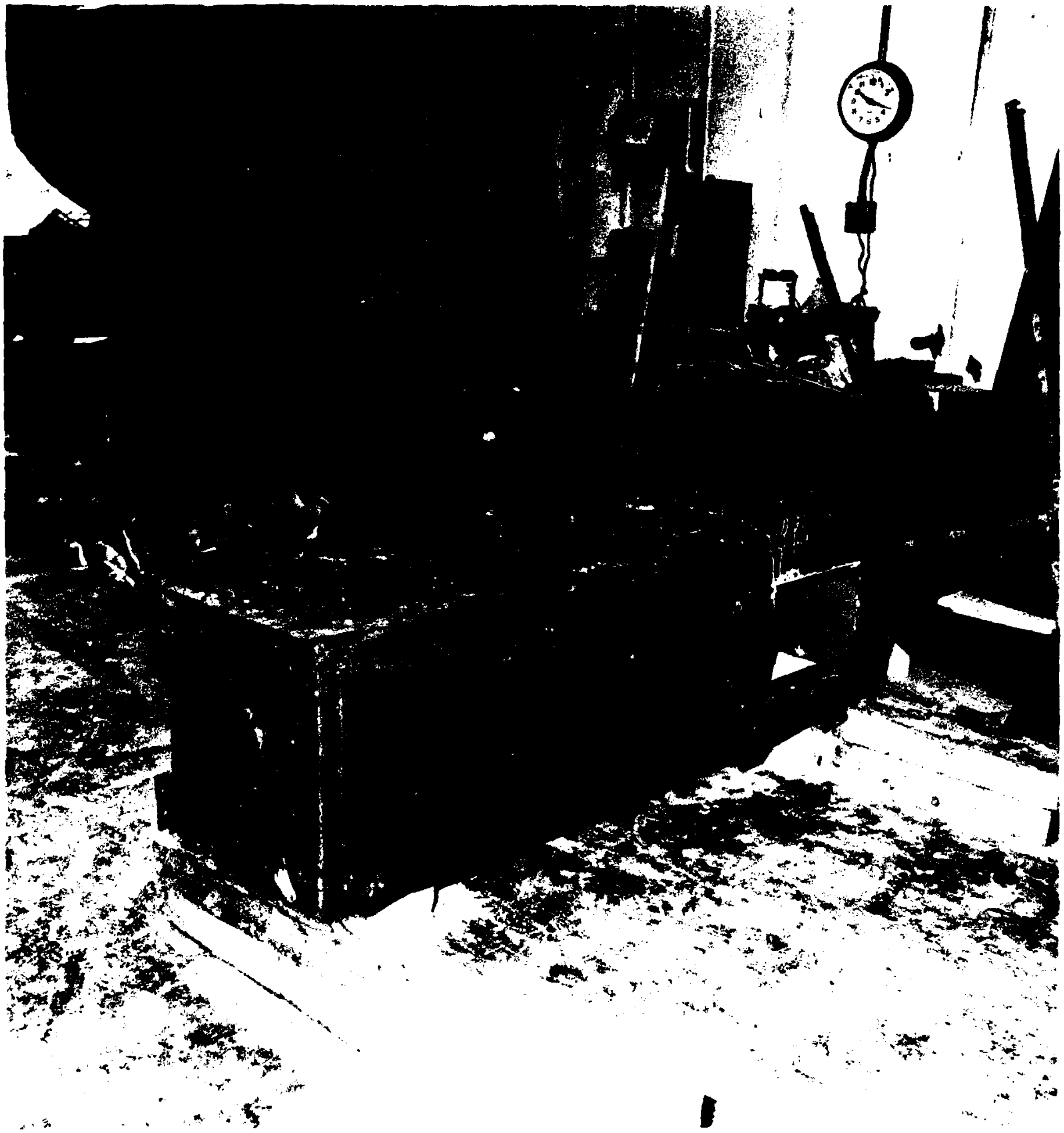

Figure 60. Bottom View of the Horizontal Section of the Cooling Chamber

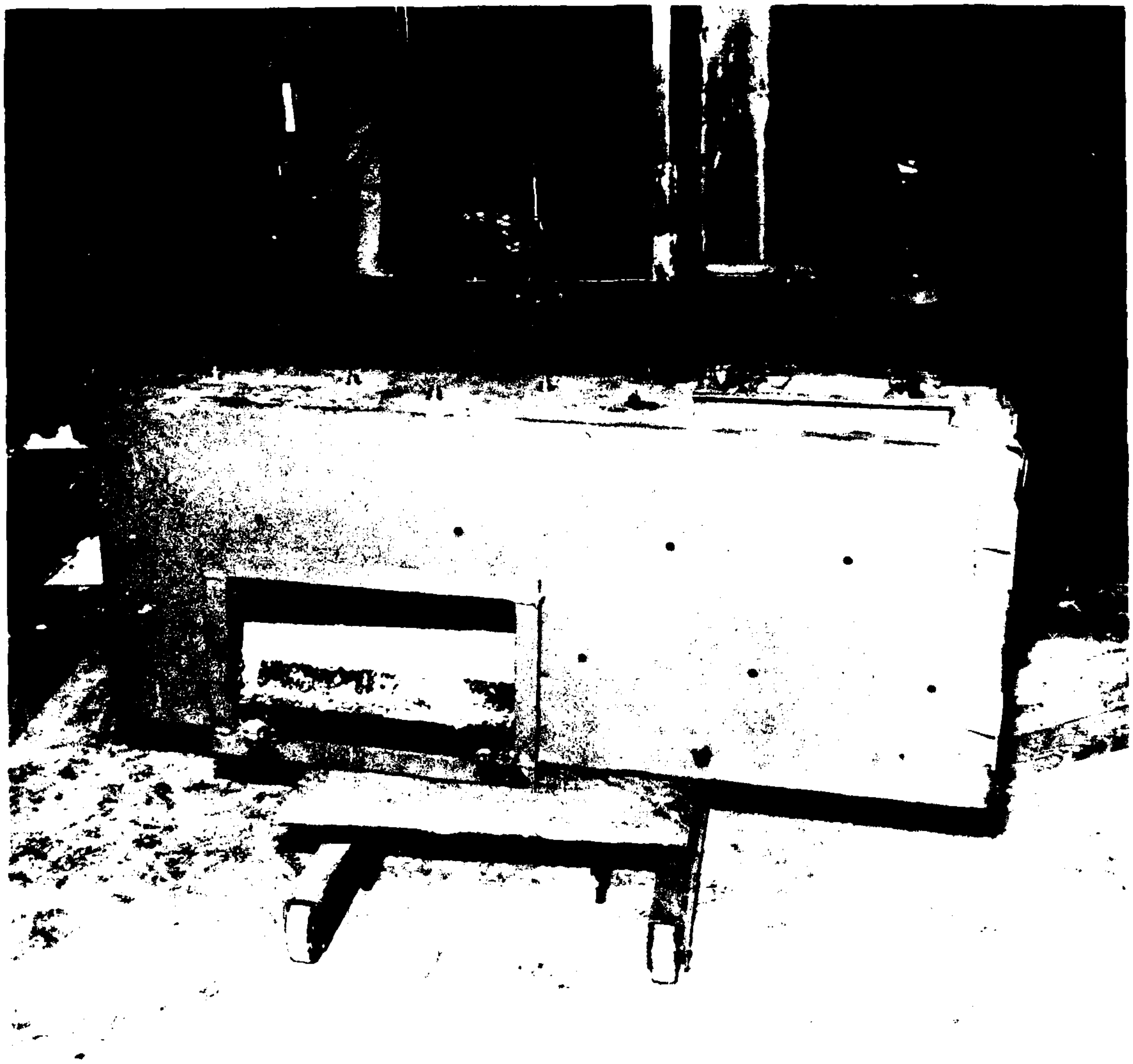

Figure 61. Vertical Section of Cooling Chamber, with the Exhaust Port at the Lower Left and Cooling Fan Port at the Upper Right

Figure 62. Vertical Section of the Cooling Chamber, Viewed from the Intake Port

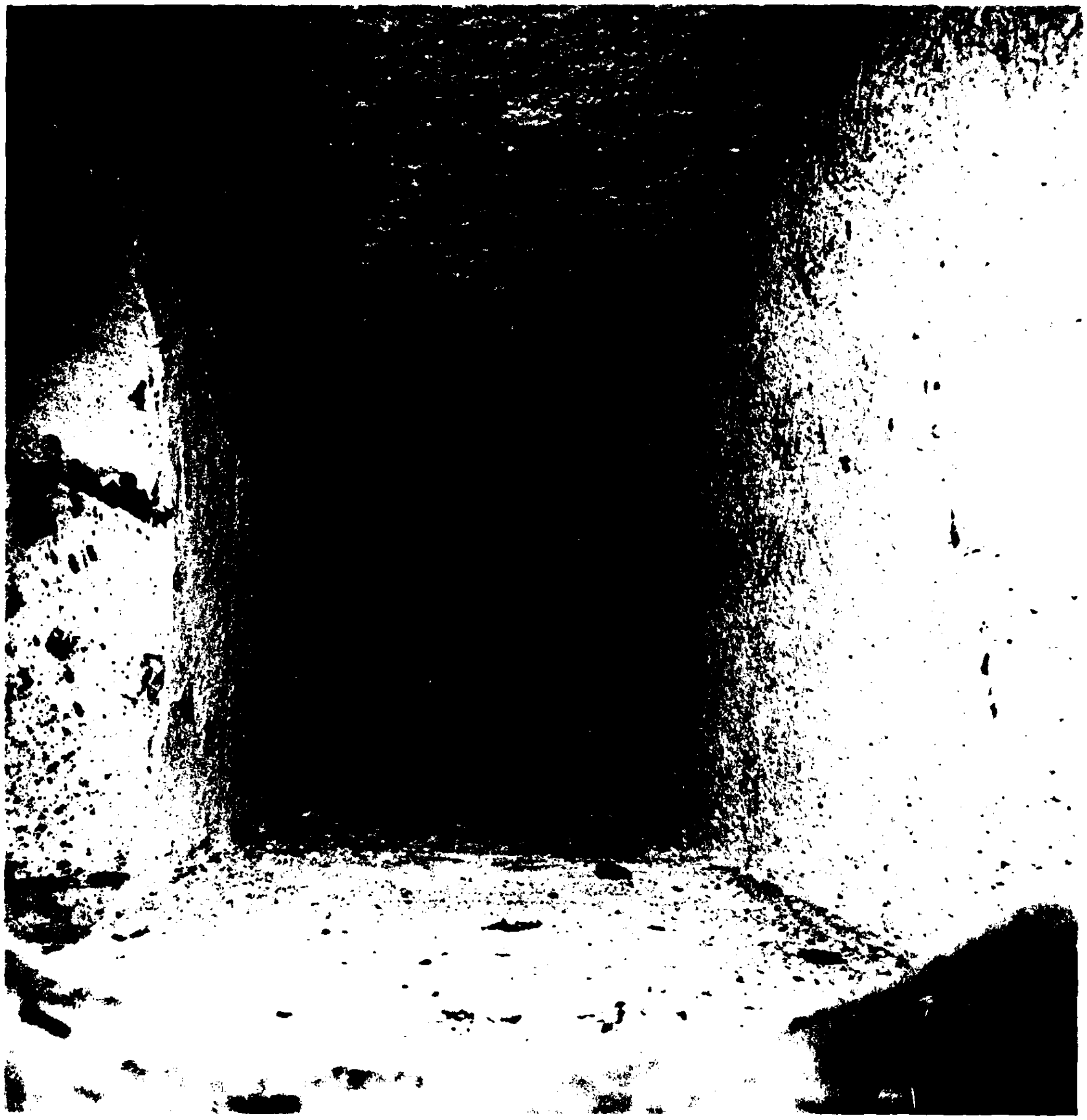

Figure 63. The Cooling Chamber Horizontal Section, with Cured Refractory

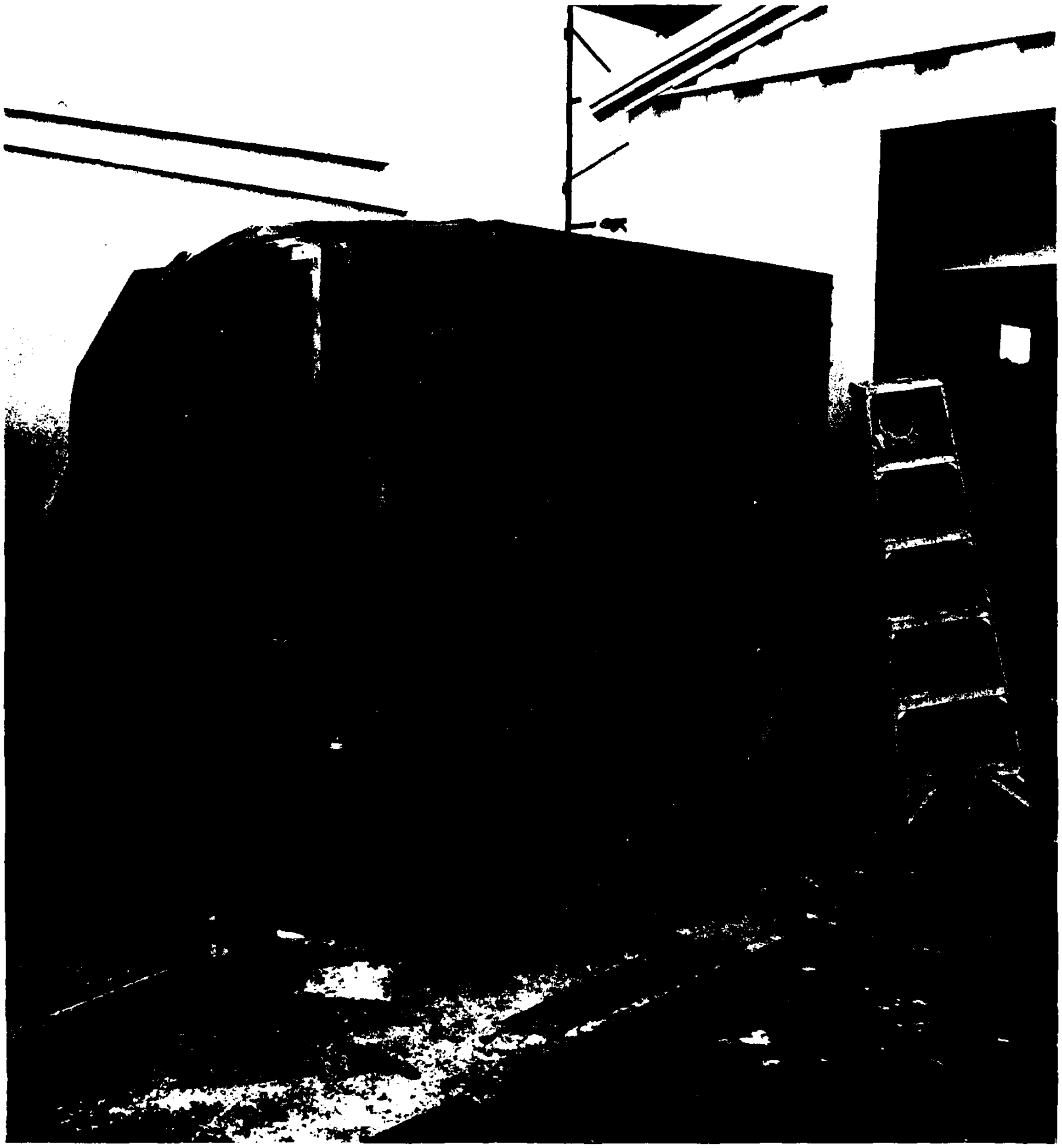

Figure 64. Rebuilt Cooling Chamber Mated to the MFI

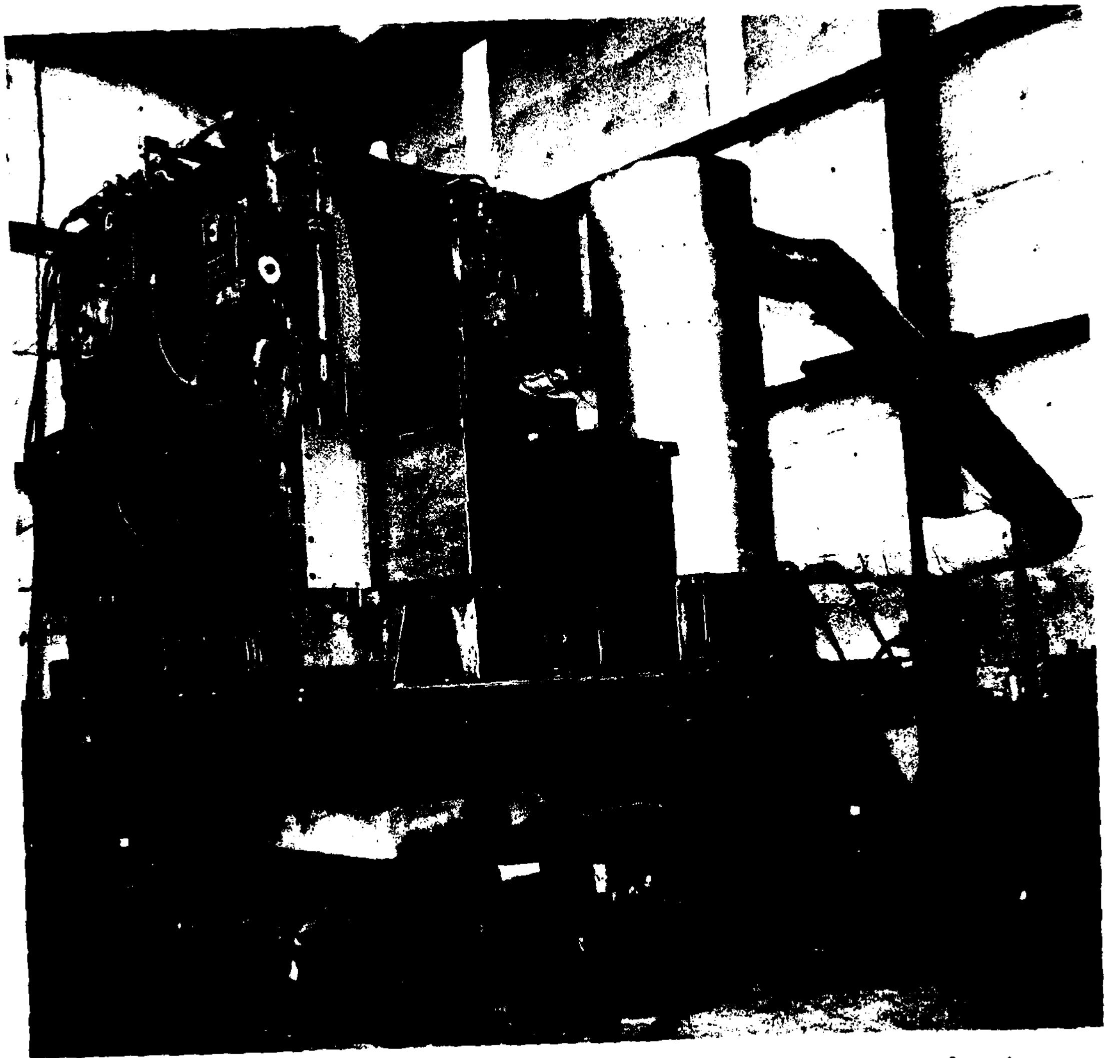

Figure 65. MFI and Fixture in Place Prior to Transverse 0° Axis Vibration Test

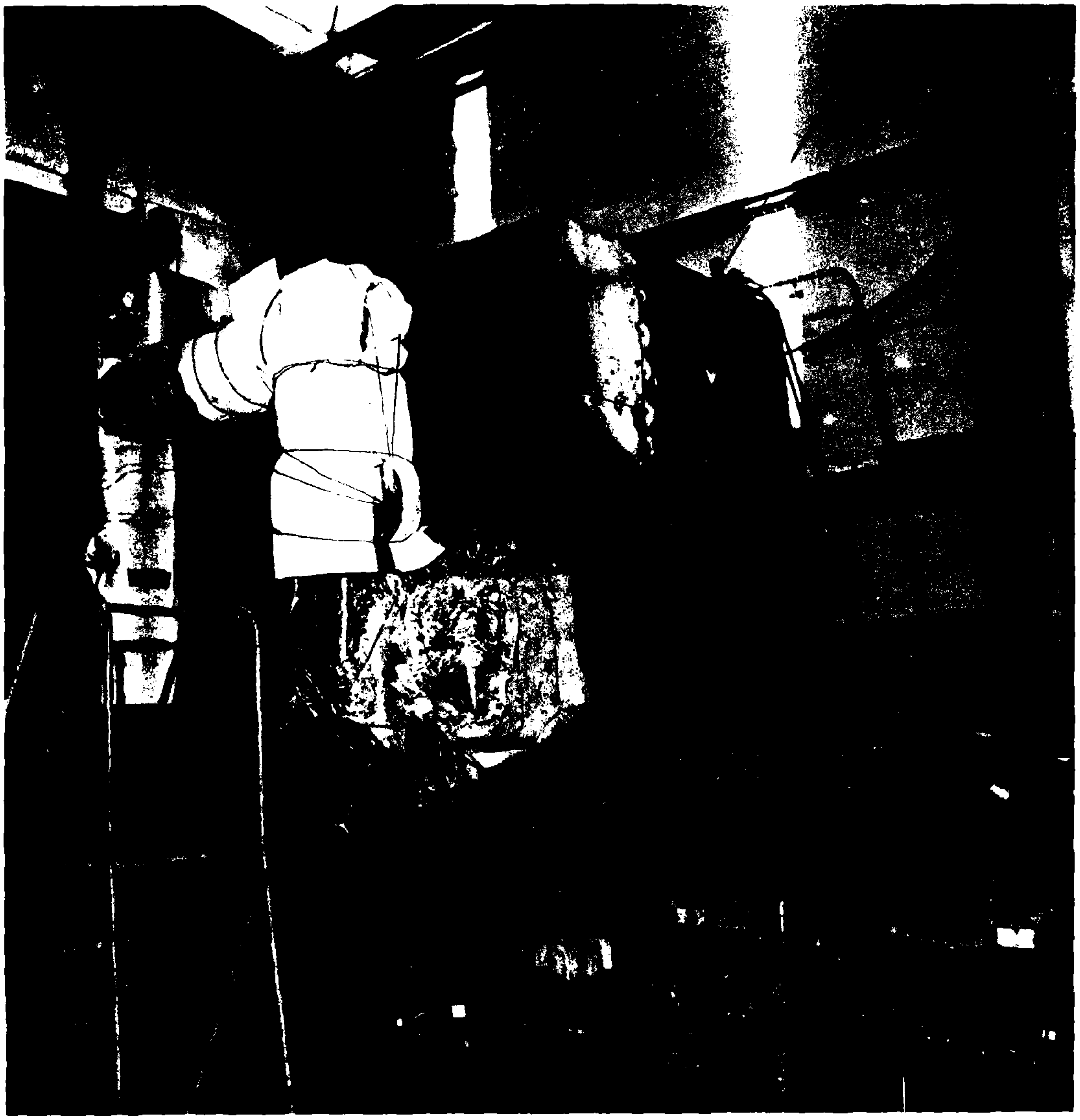

Figure 66. MFI Fixture as Mounted to the Transverse Table and Vibrator (Lower Right) Prior to Transverse 0° Axis Vibration Test

Figure 67. Right Side and Rear Walls in the Main Chamber

Figure 68. Left Side and Rear Walls in the Main Chamber

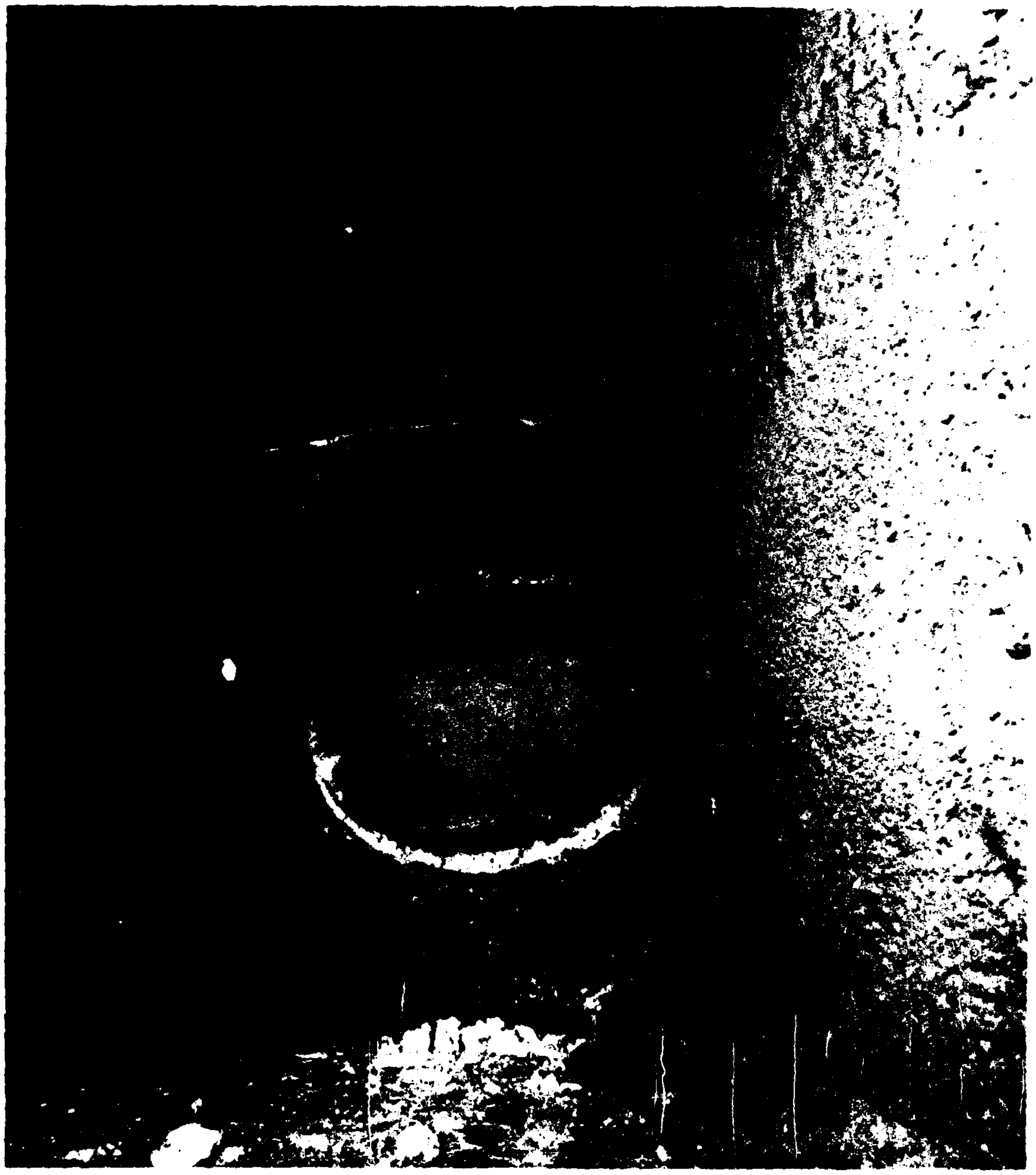

Figure 69. Front (Impingement) and Right Walls in Sewage Chamber, with the Exhaust Port (Center)

Figure 70. Right and Rear (Sewage Port) Walls in the Sewage Chamber

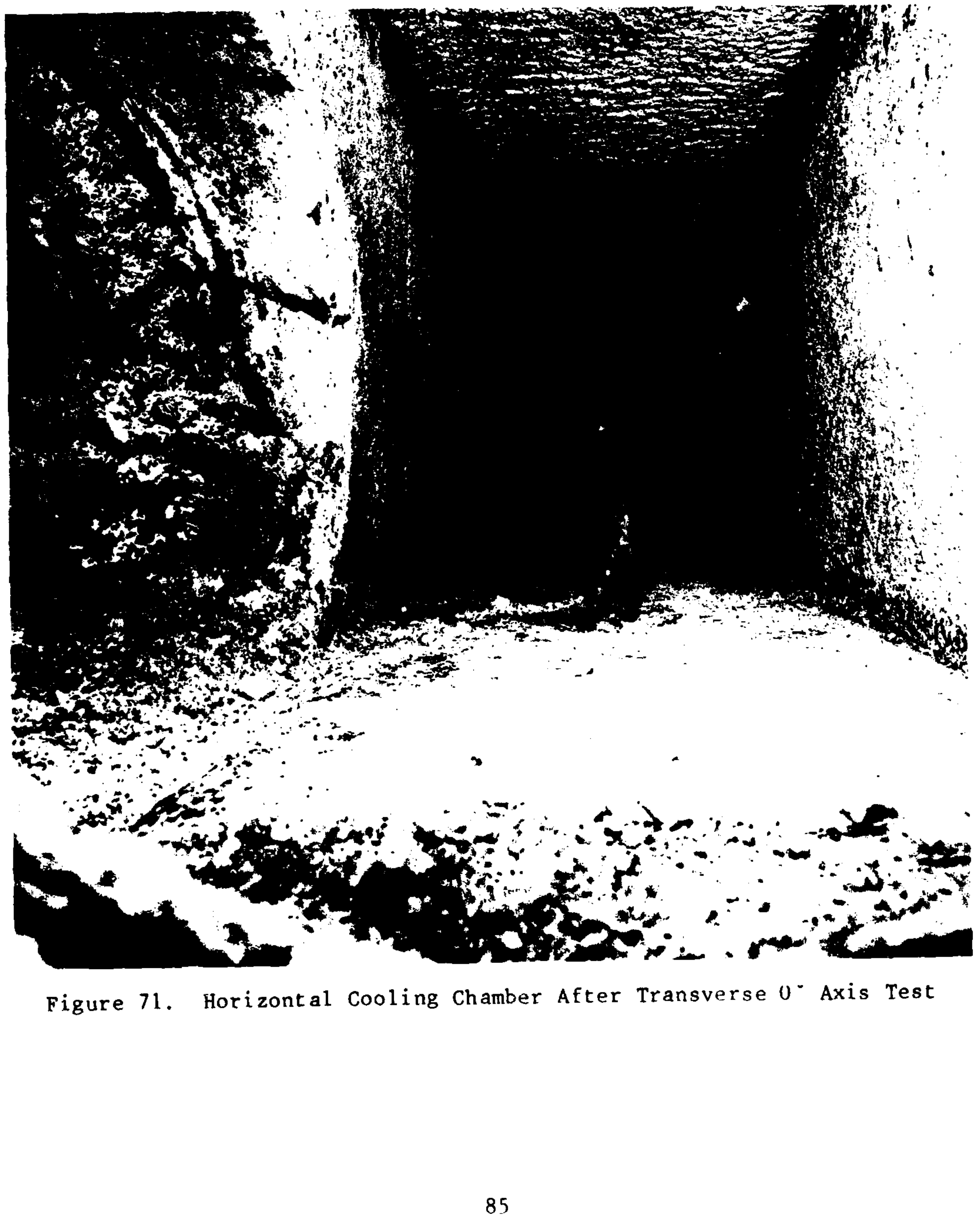

Figure 71. Horizontal Cooling Chamber After Transverse 0° Axis Test

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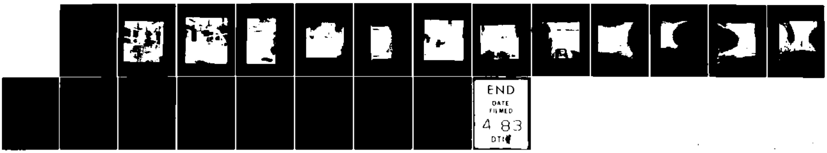

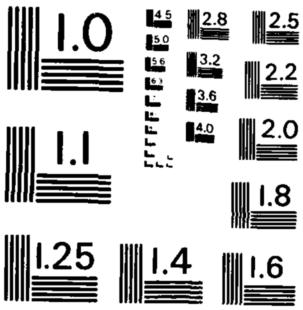

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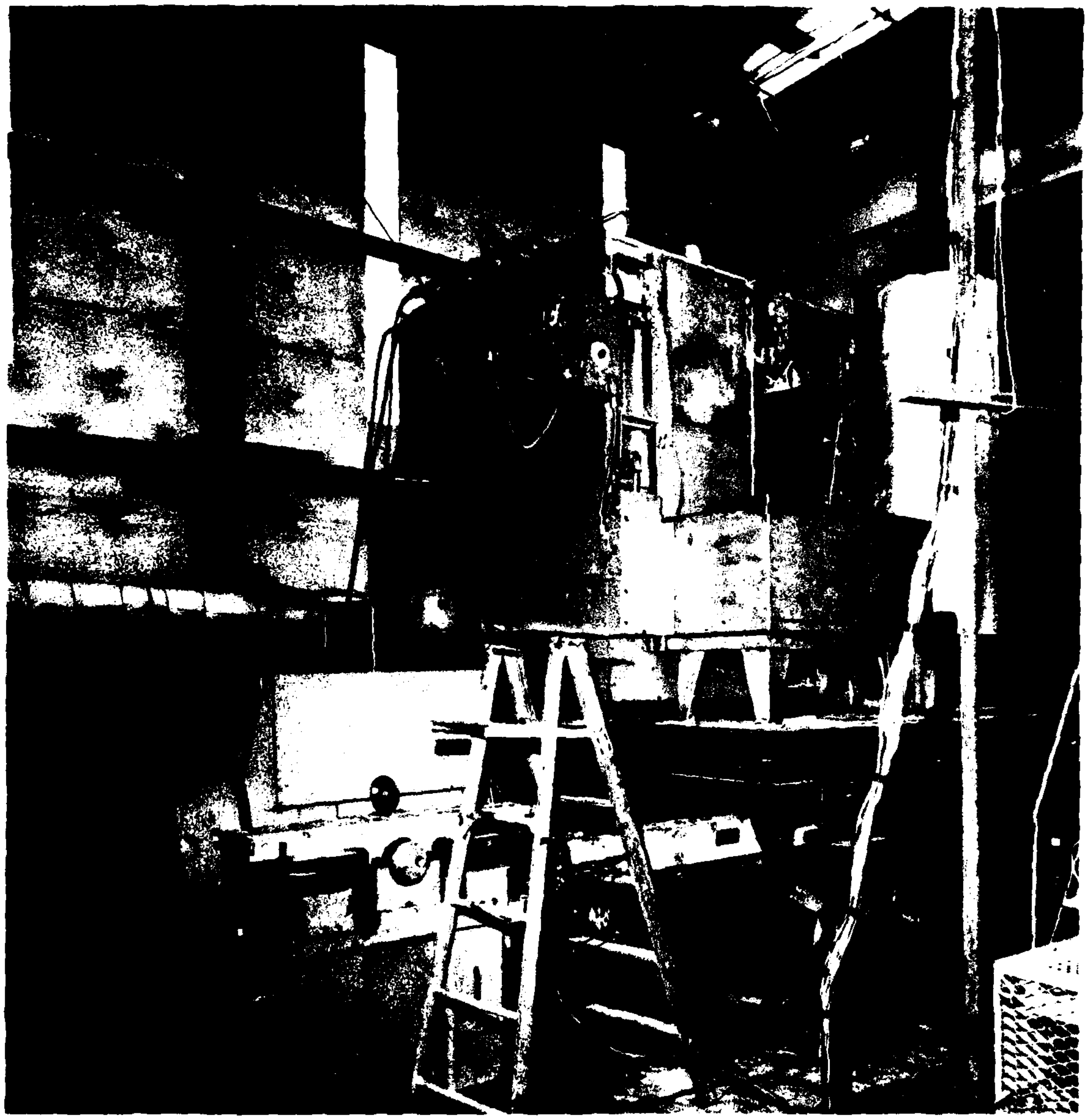

Figure 72. MFI, Fixture, and Vibrator in Place Prior to Transverse 90° Axis Test

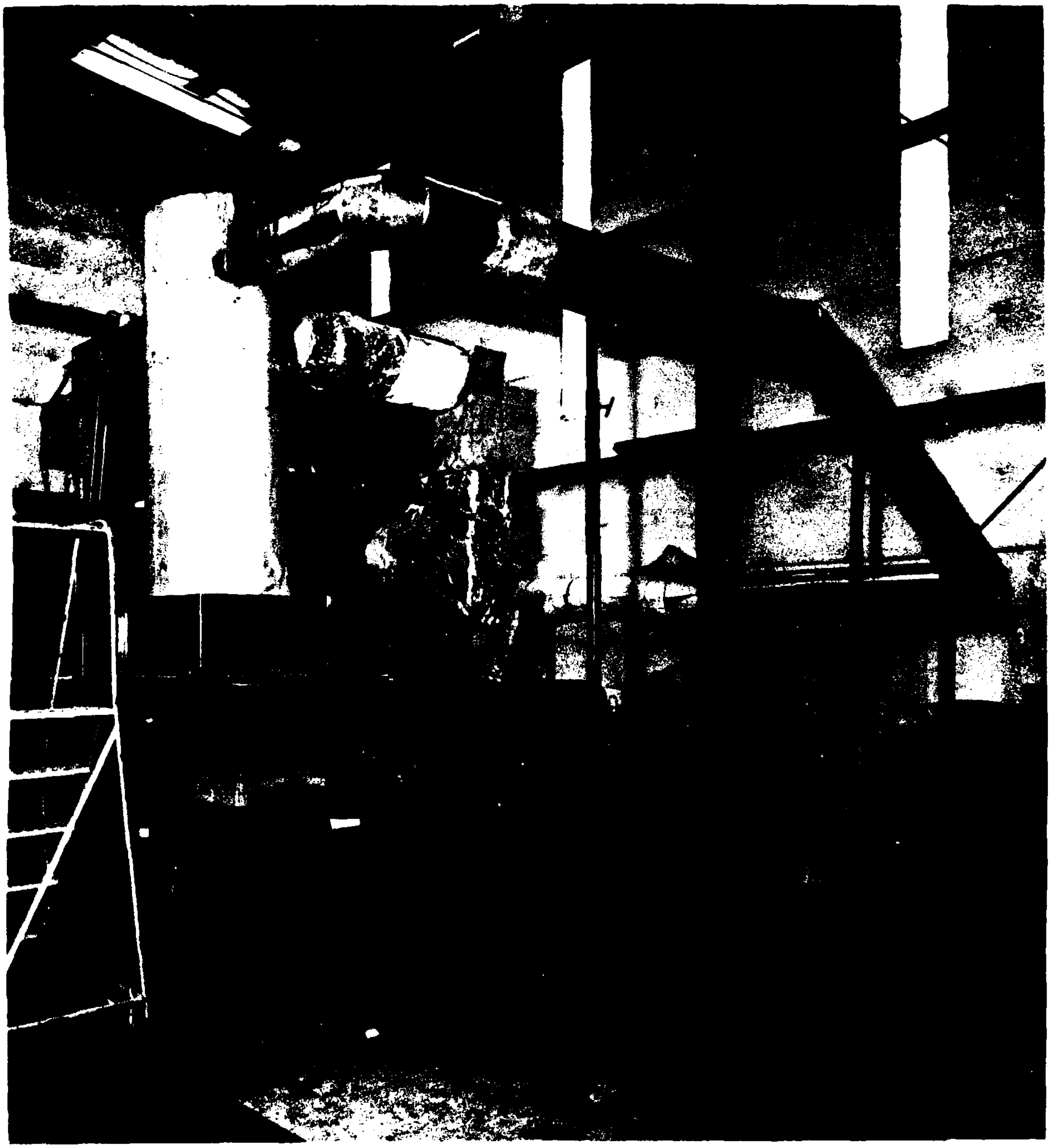

Figure 73. Side View of MFI and Fixture on Transverse Table Prior to Transverse 90° Axis Test

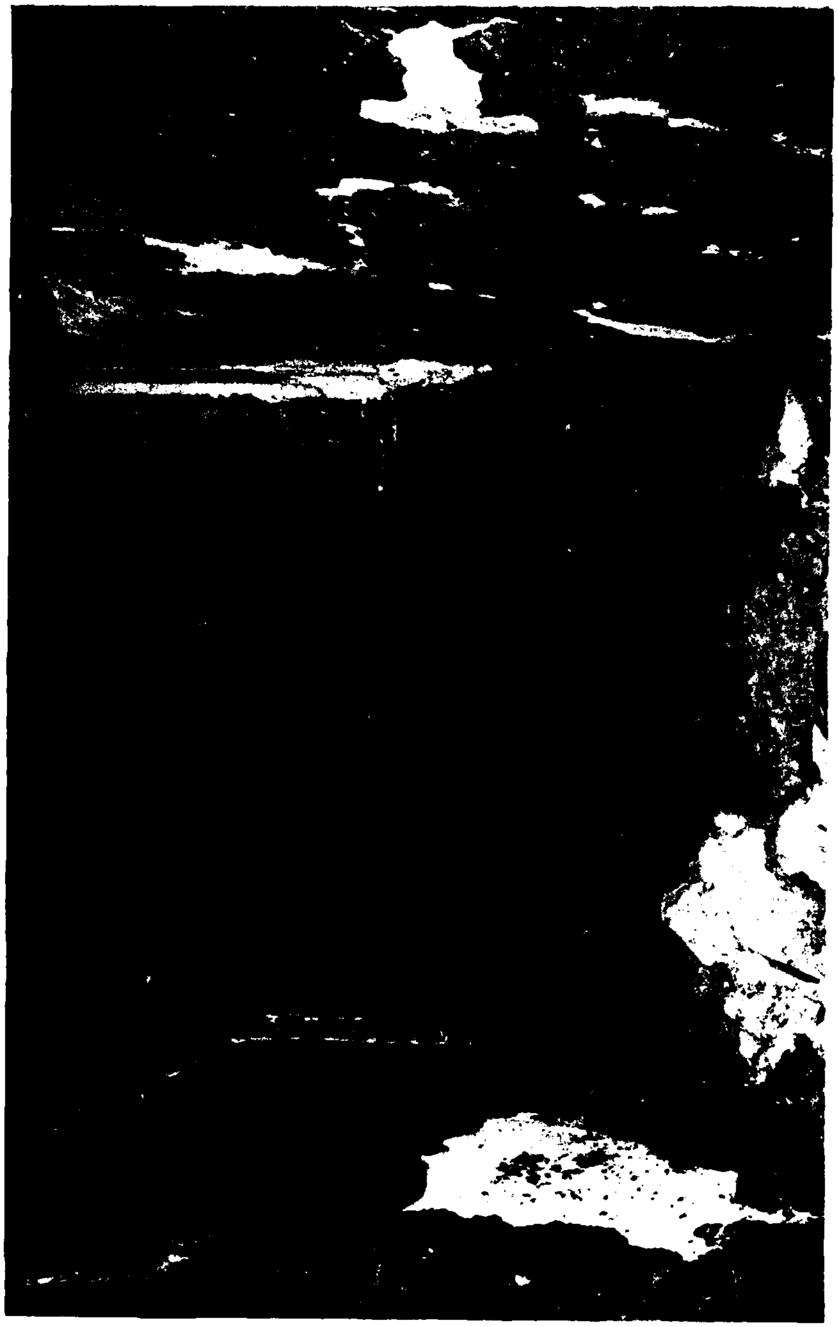

Figure 74. Side and Rear Walls in the Main Chamber

Figure 75. Left Side Wall in the Main Chamber

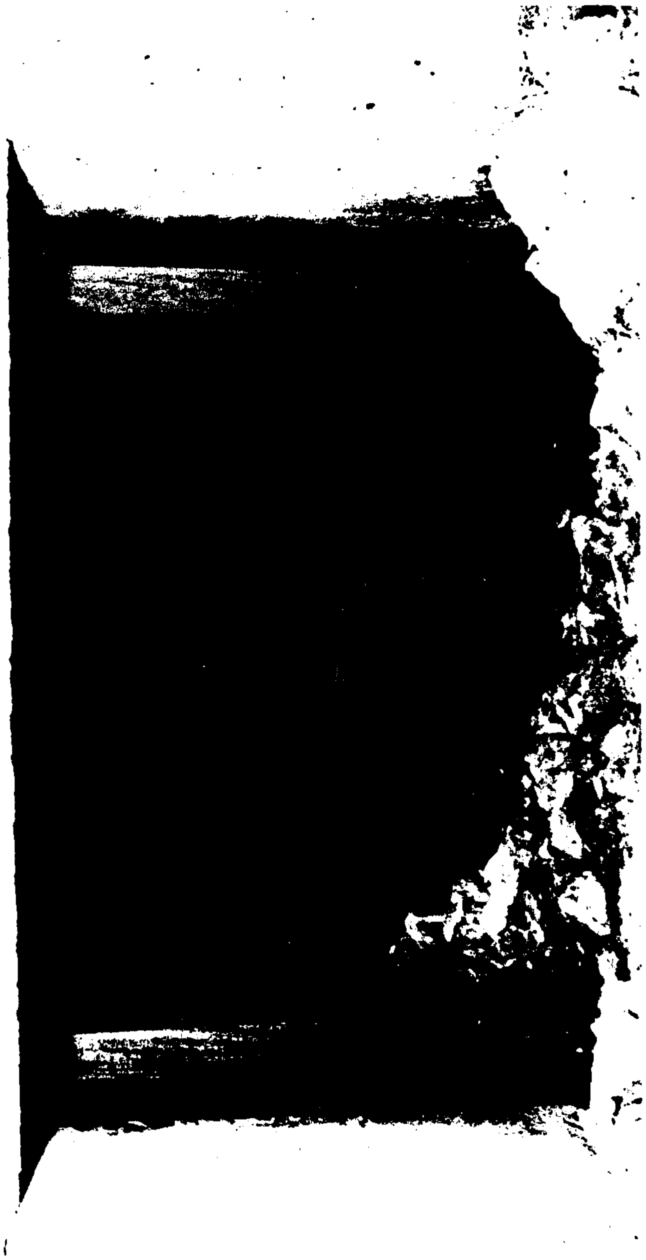

Figure 76. Front Wall and Feed Door Area in the Main Chamber

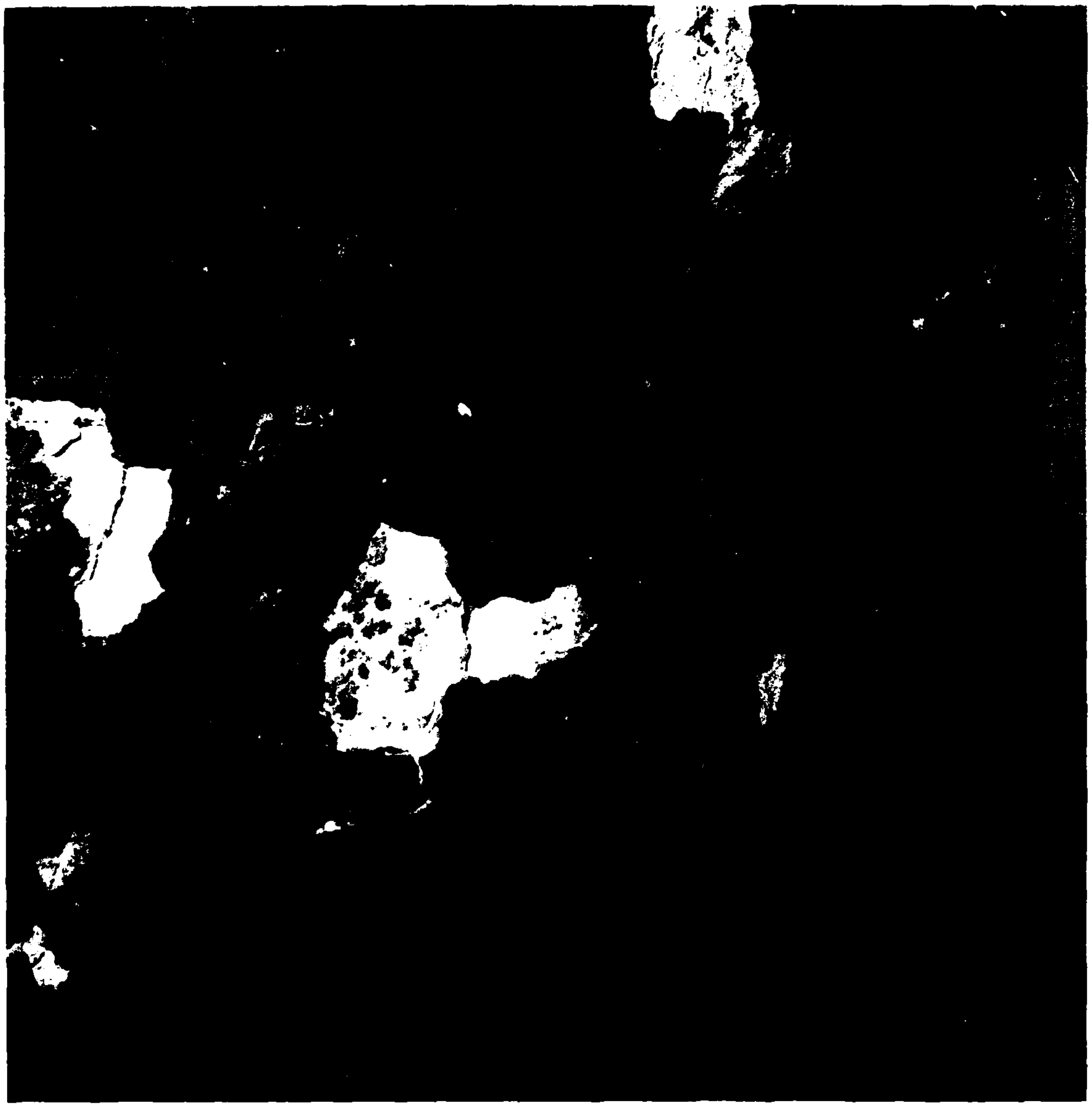

Figure 77. Right Wall and Oil Burner Port in the Main Chamber

Figure 78. Rear Wall and Ash Door Overhead Structure in the Main Chamber

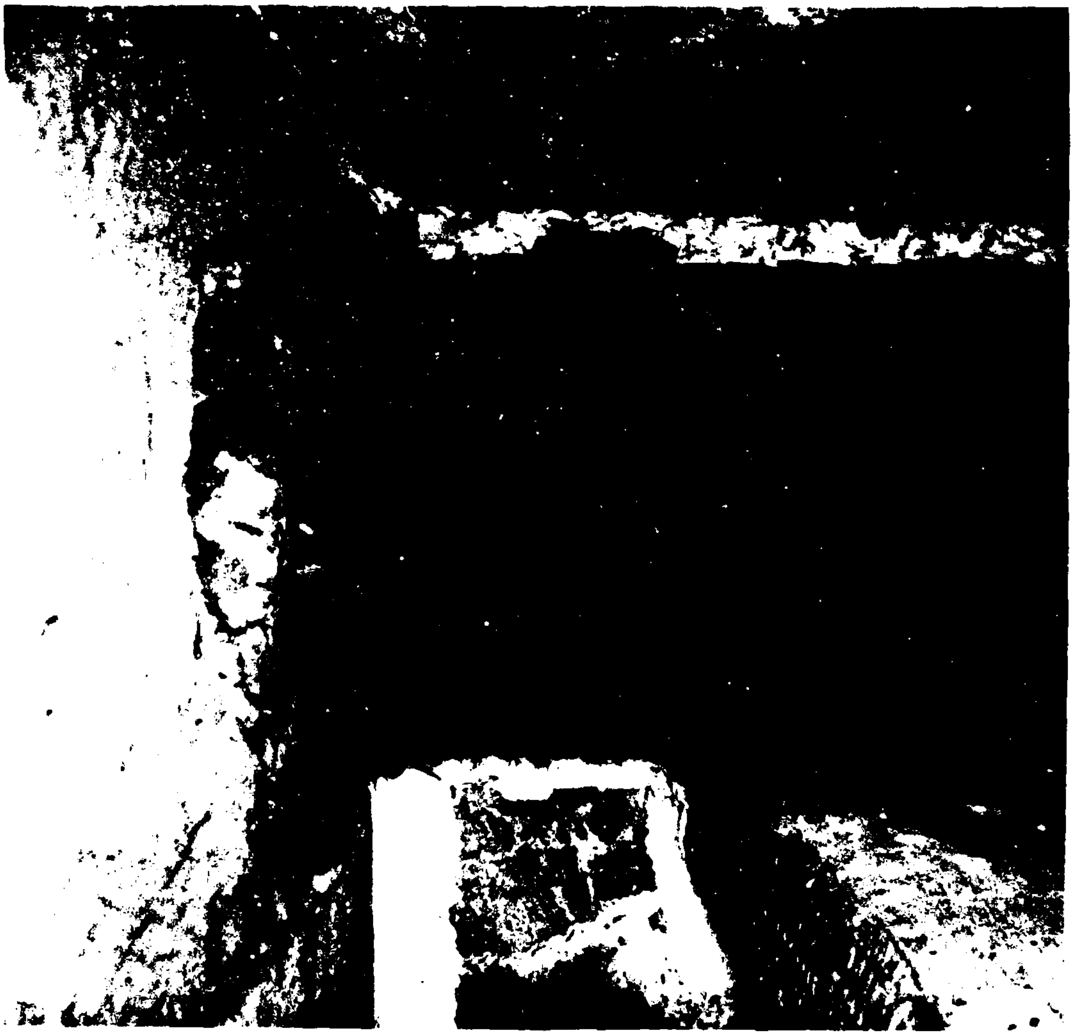

Figure 79. Right and Rear (Sewage Port) Walls in the Sewage Chamber

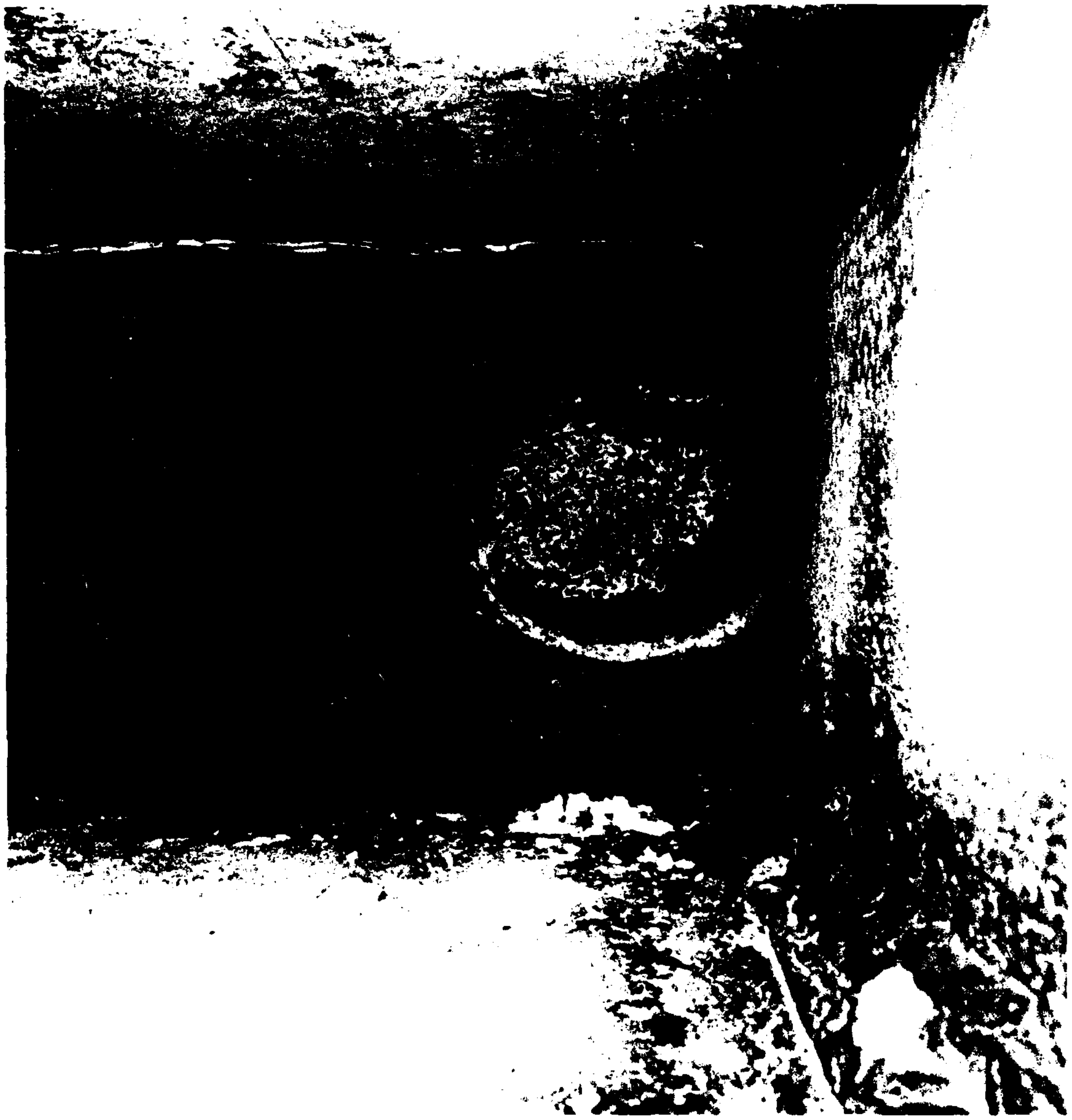

Figure 80. Front (Impingement) and Right Walls in Sewage Chamber

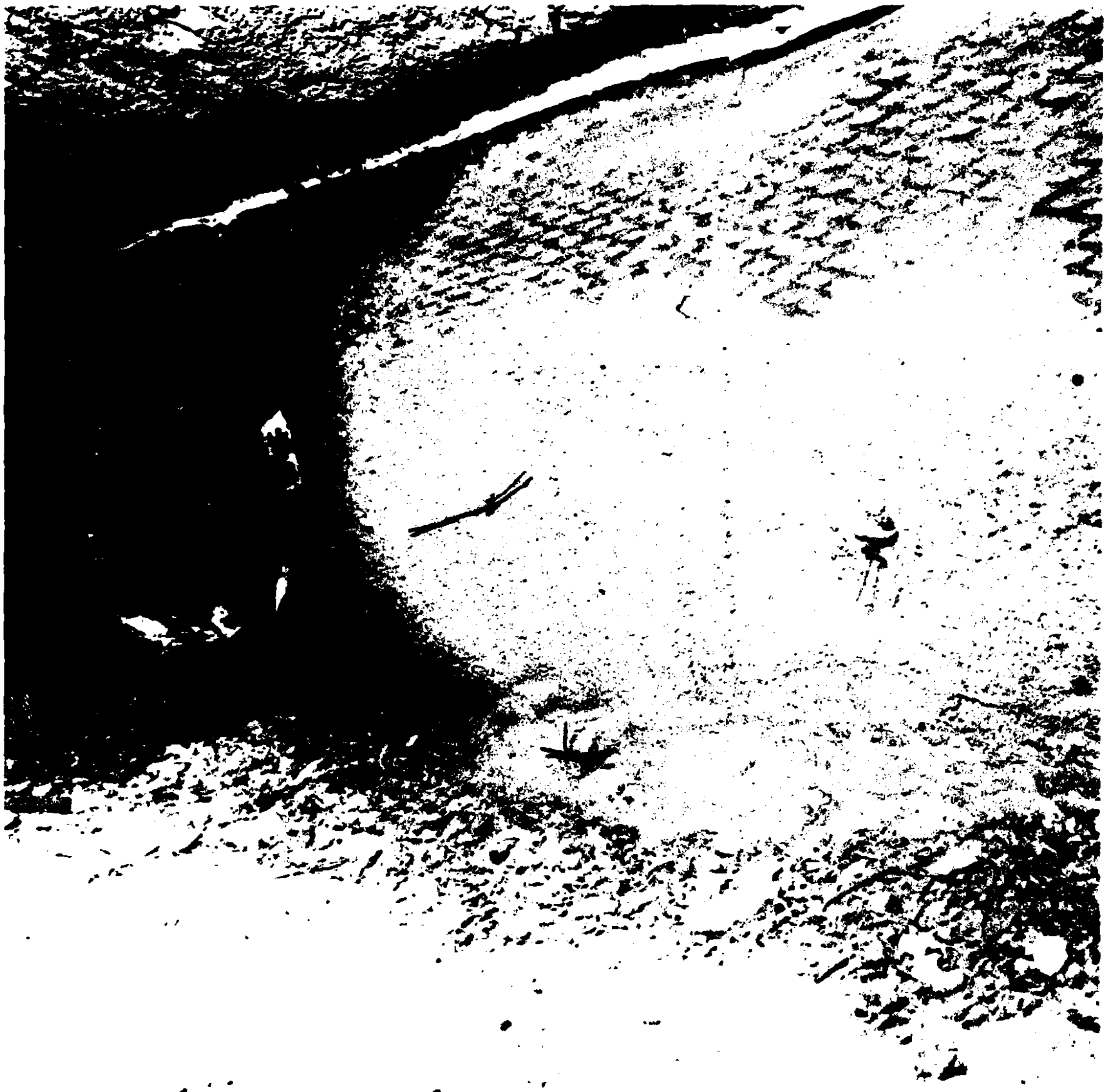

Figure 81. Left Wall and Forward Cleanout Port in Sewage Chamber

Figure 82. Right Wall and Exhaust Port in Sewage Chamber

Figure 83. Horizontal Cooling Chamber After Transverse 90° Axis Test

REFERENCES

1. Naval Surface Weapons Center letter, "Vent-O-Matic Phase I Multifunctional Shipboard Incinerator Test Report" (enclosure), DG-30:RAR:bfb 8073, Dahlgren, Va. (18 May 1976).

2. Fabrication and Assembly of a Shipboard Multifunctional Waste Incinerator (MFI) Phase II, NSWC TR-3904 (Dahlgren, Va., November 1978).

3. Naval Surface Weapons Center letter, "Laboratory Evaluation of a Shipboard Multifunctional Waste Incinerator (MFI Phase II), Interim Report" (enclosure), G-51:FC:mr 9593, Dahlgren, Va., (18 November 1978).

4. Laboratory Evaluation of a Shipboard Multifunctional Waste Incinerator (MFI), Phase II, TR 79-264 (Dahlgren, Va., October 1979).

5. Naval Surface Weapons Center letter, "Laboratory Evaluation of Refractory Repair Material and Other Modifications to a Shipboard Multifunctional Waste Incinerator (MFI), Phase II" (enclosure), G-51:JAB:mr 8073, Dahlgren, Va. (5 July 1979).

6. Naval Ships Engineering Center letter, "TEST PLAN, Phase II Laboratory Evaluation, Shipboard Multifunctional Waste Incinerator" (enclosure), 6159C/SW 9466/593.553 Ser No. 20 (9 December 1977).

7. Military Standard, Mechanical Vibrations of Shipboard Equipment (TYPE I - Environmental and TYPE II - Internally Excited), Department of Defense, MIL-STD-167-1 (Ships), (Washington, D.C., 1 May 1974).

8. Naval Surface Weapons Center letter "Shipboard Multifunctional Waste Incinerator Vibrational Evaluation Test Plan" (enclosure), G-51:JAB:mrb, Dahlgren, Va. (6 March 1980).

9. Naval Surface Weapons Center memorandum, "MFI Vibration Test Data" (enclosure), E23:TM:PKW Dahlgren, Va. (10 August 1981).

10. David W. Taylor, Naval Ship Research and Development Center letter, "Property Evaluations of High Alumina Refractories for Shipboard Incinerators" (enclosure), 2812:WLW 10310, Dahlgren, Va. (24 June 1981).

APPENDIX

VIBRATION TEST DATA

Table 1. Vertical Axis Variable Frequency Vibration Data—5-Min Duration

Freq. (Hz)	Ampl. (in.)	Comments
5	0.06	Noticeable fixture movement; no effect on MFI.
6	0.06	Same as 5 Hz.
7	0.06	FAC swaying 1.
8	0.06	FAC swaying; no other system affected.
9	0.06	FAC ceased swaying, but fixture motion is pronounced.
10	0.06	No effect on MFI.
11	0.06	No effect on MFI.
12	0.06	No effect on MFI.
13	0.06	No effect on MFI.
14	0.06	Slight oscillation in ID fan exhaust elbow.
15	0.06	Definite exhaust elbow movement.
16	0.04	Same as 15 Hz.
17	0.04	Same as 15 Hz.
18	0.04	ID fan and exhaust elbow movement present.
19	0.04	Ram feeder air cylinder vibration; universal joint was loosened.
20	0.04	Severe fixture/vibrator resonance.
21	0.04	Ram feeder and oil burner show some movement.
22	0.04	Much movement and noise from ram feeder and FAC ash drawer. Vibration of oil burner caused loss of two screws from transformer housing.
23	0.03	No notable vibration increases on MFI. Vibrator could not function at 0.04 level, so level was decreased to complete testing.
24	0.03	Flexing of fixture to vibrator mounting plate observed. No MFI problems.
25	0.03	Same as 24 Hz.

Table 2. Transverse 0° Axis Variable Frequency Vibration Data—
5-Min Duration

Freq. (Hz)	Ampl. (in.)	Comments
5	0.06	Swaying fixture motion.
6	0.06	Top MFI accelerometer faulty; replaced. Swaying motion still present.
7	0.06	Slight swaying fixture motion.
8	0.06	System air pressure lost--coupling not properly fitted; refitted--system operational.
9	0.06	No problems.
10	0.06	Same as 9 Hz.
11	0.06	Same as 9 Hz.
12	0.06	FAC cleanout pan begins moving.
13	0.06	Same as 12 Hz.
14	0.06	Ram feeder moving inside housing; noise generated.
15	0.06	Oil burner and ram feeder movement.
16	0.04	Oil burner and ram feeder movement.
17	0.04	Oil burner moving noticeably less, ram feeder internal movement.
18	0.04	Ram feeder unchanged, slight vertical FAC movement.
19	0.04	Ram feeder loosens top retaining bolt--intense rattling, replaced with clamp--accelerometer readings decrease.
20	0.04	Ram feeder readings and noise decrease slightly --some feed door movement.
21	0.04	Same as 20 Hz.
22	0.04	Same as 20 Hz.
23	0.04	Slight cooling jacket fan motion, increase in acceleration readings on ram feeder.

Table 2. Transverse 0° Axis Variable Frequency Vibration Data—5-Min Duration (Cont.)

Freq. (Hz)	Ampl. (in.)	Comments
24	0.04	Poor burner ignition. Problem traced to main control panel. Problem not vibration-related. Chain curtain displays much movement, but no operational problems.
25	0.04	12 g's of acceleration monitored from ram feeder, but no operational problems.

Table 3A. Transverse 90° Axis Variable Frequency Vibration Data—5-Min Duration

Freq. (Hz)	Ampl. (in.)	Comments
5	0.06	Some movement in FAC base (where attached to floor plate--plate movement, not FAC).
6	0.06	Definite rocking motion in FAC--1/2-in. displacement at top. Note: this device will require at least 1/4-in. reinforced deck. Rocking/bending of deck.
7	0.06	All systems stable except FAC. Still some bending motion.
8	0.06	No movement by any component.
9	0.06	No system movements. Transverse motion visible.
10	0.06	No system problems; minor movements.
11	0.06	No system problems; minor movements.
12	0.06	No system problems; air line movement.
13	0.06	Same as 12 Hz.
14	0.06	Same as 12 Hz.
15	0.06	Feed door movement in up position--system OK.
16	0.04	No system movements or problems.
17	0.04	Noticeable FAC tranverse movements; no system problems.
18	0.04	Minor system movements; no problems.

Table 3A. Transverse 90° Axis Variable Frequency Vibration Data—5-Min Duration (Cont.)

Freq. (Hz)	Ampl. (in.)	Comments
19	0.04	No problems; minor movements.
20	0.04	No problems.
21	0.04	Some noticeable cooling jacket fan movements; no system problems. Rattles in feeder noticeable.
22	0.04	Cooling jacket and ID fans have distinct movements. Good 2-hr test frequency. System OK.
23	0.04	CJ and ID fans movements minor. System OK.
24	0.04	Same as 23 Hz.
25	0.04	No major motions by parts; no system problems.

Table 3B. Transverse 90° Axis Vibration Data—2-Hr Duration at 22 Hz

Time begun - 1357 hr	Movement of ID fan caused no system problems.
	An expansion joint between the FAC and ID fan was required to remove stress from duct flanges. Two bolts sheared from flange after 1 hr of testing. No flue gas leakage was apparent.

Table 4. Vertical Axis Endurance Vibration Data

Freq. (Hz)	Ampl. (in.)	Duration (min.)	Comments
14	0.06	60	No operational problems.
15	0.06	30	No operational problems.
22	0.03	30	Amplitude reduced from 0.04 to 0.03 in. to ease load on vibrator. Some white dust visible in exhaust, but no operational problems. No discernible changes in the system draft.

Table 5. Transverse 0° Axis Endurance Vibration Data

Freq. (Hz)	Ampl. (in.)	Duration (min.)	Comments
14	0.06	60	Burner failure. Traced to main panel (not vibration-related; dirty relay).
23	0.04	60	Self-tapping screws on FAC lagging loosened and fell. No operational problems.

Table 6. Transverse 90° Axis Endurance Vibration Data

Freq. (Hz)	Ampl. (in.)	Duration (min.)	Comments
22	0.04	120	Two bolts on ductwork between ID fan and FAC sheared. No leakage in ductwork. No other system problems.

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