Project :	**One World Trade Center** New York, New York
Project Number:	20063.00
Observation Dates:	Various dates between September 13, 2000 and October 25, 2000
Report Prepared By:	William G. Young

Heitmann & Associates, Inc. has performed an on-site evaluation of the current condition of the curtain wall system at the One World Trade Center project. Our evaluation has included the review of the original project construction drawings (as provided on CD ROM.), review of the mock-up shop drawings for the curtain wall system, review of curtain wall inspection reports provided by the Port Authority of New York and New Jersey, interviews with the Building Engineers and visual inspections. The visual inspections were made from the street/plaza level using binoculars, the main roof, setbacks (at levels 7, 41, 75 and 108), and random interior locations of both finished and unfinished spaces. No drops were made using the building's exterior maintenance platform. Our comments and observations noted during the evaluation are summarized as follows.

(Note: All photographs are provided to indicate/clarify typical conditions and may depict conditions from either One or Two World Trade Center.)

I. General Project Description

A. The project Architect was Minoru Yamasaki & Associates with Emery Roth & Sons P. C. of New York City. The construction of the project was completed in approximately 1975. The curtain wall system was designed and installed by Cupples Products of St. Louis, Missouri. Cupples Products is still in operation under a new organization.

B. The curtain wall system consists of vertical strip windows set between tightly spaced aluminum clad building columns (Refer to photographs 1, 2 and 3). Within the vertical strip windows, aluminum spandrel panels occur at each floor line. Aluminum panels are used to clad the four chamfered corners of the tower and the sloped parapet of the main roof (Refer to photograph 3). The finish on the curtain wall framing, aluminum column cladding, corner panels and parapet panels is a clear or natural anodize. The finish on the spandrel panels is darker and could be a light bronze anodized finish.

C. The vision glass is 1/4" thick with a light grey or bronze body tint. The glass is secured/sealed to the framing with neoprene glazing gaskets at both the interior and exterior side.

D. At the typical floors the interior side of the building columns are finished with vermiculite plaster fireproofing with a plaster finish coat. At the mechanical floors (levels 7/8, 41/42, 75/76 and 108/109) the vision glass and spandrel panels are deleted to allow air flow to and from the louvers set behind the line of the curtain wall. The building columns are fully clad in aluminum at these locations (Refer to photograph 4). The gap between the curtain wall and building structure is sealed with an aluminum parapet cap at the bottom and aluminum soffit panels at the top. The concrete walking surface between the curtain wall and the louvers is waterproofed. Additional decorative trim is added to the face of the column cladding to provide added depth to the system (Refer to photograph 2).

E. The sloped parapet panels at the top of the tower are primarily decorative as the concrete slabs and roofing system below provide the main water barriers (Refer to photograph 5). The parapet panels are supported by steel framing anchored to the building the structure. The steel framing is exposed to the weather.

F. The basic curtain wall design is maintained throughout the height of the tower. The appearance of the curtain wall at the mechanical floor and the top of the tower is modified by changing the width of the column cladding and adding components to increase the depth of the system. The curved elements at the top of the tower are add-on members (appliques) that serve no structural purpose (Refer to photograph 3). The base of the curtain wall provides large expanses of glass by combining three typical building columns into one (Refer to photograph 6).

G. The glass panels are cleaned by a robotic washer that is lowered from a roof car (Refer to photograph 7). The robotic washer is guided by stainless steel tracks set into a recess on the face of the column cladding. The roof car can access the full perimeter of the tower via a system of rails and turntables mounted on the roof. The roof car also incorporates a maintenance platform for retrieving the robotic washer should it become inoperative. The maintenance platform is also used to inspect and maintain the curtain wall system.

II. Document Review

A. Curtain Wall Shop Drawings for the Mock-up

1. The curtain wall is a stick built system that incorporates an overlapping section between the bottom of the spandrel panel and the top of the vision glass at each typical floor level (Refer to detail on sheet SK-1). Similar to a modern stack joint, the overlap section serves as a back up gutter for the system and provides a location to accommodate thermal movement of the curtain wall and building structural deflections. The overlap section extends through the column cladding panels at the same location. It appears that the vision glass pockets are weeped (drained) through the open joint at the bottom of the spandrel panel (i.e., the overlap section). Flashing like

deflectors are provided at the top of the overlap section to direct water draining down the inside of the curtain wall or the face of the building structure into the overlap and out the open joint.

2. The aluminum spandrel panels are captured within a glazing pocket on three sides (i.e., the top and both vertical edges) (Refer to detail on sheet SK-2). The bottom edge is left open for drainage of the overlap. The drawings appear to indicate that the spandrel panel is prevented from slipping downward only by the friction of the glazing gaskets at the three captured edges.

B. Inspection Reports

1. In compliance with Local Laws 10 and 11, the Port Authority of New York and New Jersey maintains a program of regular inspections for the curtain wall system. The inspection and repair procedures which appear to be very thorough were developed by Leslie E. Robertson Associates, R.L.L.P (LERA) Consulting Structural Engineers. Leslie E. Robertson was one of the original structural engineers for the project. The inspections are performed by staff of ABM, the building maintenance contractor, in conjunction with a LERA engineer. The inspection program concentrates on one elevation of the tower each year. Thus, in order to fulfill the requirement to inspect the entire building once every five years the inspections are virtually a continuous process. Presently, the physical inspections do not include the panels at the chamfered corners of the tower as these areas are not accessible with the existing work platform. The Port Authority has recently had a special platform designed and constructed for inspecting and maintaining the tower corner panels. The installation and testing of the new platform are scheduled to be completed by the end of this year. Once the new platform is commissioned, physical inspections of the tower corner panels will begin next year. The main issues currently being addressed by the inspections are summarized as follows.

   a. Condition of sealant joints.

      (1) Failed sealants are marked for replacement.

   b. Damaged column cladding.

      (1) Holes and dents in the column cladding are marked for repair. The reports that we reviewed did not indicate the specific cause for the dents or holes in the column cladding. While it is indicated that the holes may be a result of corrosion, there is no indication as to what may have caused the corrosion. A likely cause would be a dissimilar metal in contact with the

aluminum. Based on the inspection reports these conditions appear to be very isolated.

c. Guide tracks for the robotic window washer.

(1) The guide tracks are checked for a variety of conditions including; damage to the track, misalignment between track sections, elongated fastener holes in the track, and loose, damaged or missing fasteners. See additional comments in paragraph II.B.3. below.

d. Spandrel panel position/attachment.

(1) As noted above, it appears that the original design relied on friction to secure the spandrel panel in the correct position. The LERA reports mention lower corner support castings and fixing screws for securing the spandrel panel to the jamb frame. Neither the support castings nor the fixing screws are shown on the shop drawings that we have reviewed. The shop drawings do show castings at the bottom corners of each spandrel panel that are used to cap the jamb extrusions and provide alignment with the jamb extrusions above. There is no indication that the castings are intended to support the spandrel panel. It is possible that the design was changed following the mock-up test. However, without reviewing the project shop drawings it is not possible to determine if the design was changed. Regardless of the design intent, we agree that LERA's remedial recommendation to add a screw to fix the spandrel panel to the jamb extrusion is correct.

e. Attachment of column cladding projections and appliques.

(1) The column cladding projections and appliques are checked for loose/missing fasteners and loose/missing splice plates and connection plates.

2. The conditions noted above are generally repaired on a spot basis following each inspection depending on how critical a situation is relative to safety or performance of the curtain wall system. Thus, issues relating to aesthetic concerns may not be repaired immediately.

3. As the inspections and repair work have progressed over the years, the number of issues needing attention has generally been on the decline. The most significant issue has been related to guide tracks for the robotic window washer. Initially the operation of the robotic window washer was damaging

the guide tracks and the fasteners that attached them to the column cladding. Improvements developed by LERA for the guide system on the robotic wind washer appear to have significantly reduced or eliminated the damage being caused to the guide track and its fasteners. However, there are still repairs to be made to areas of previous damage.

III. Interviews

A. Discussions with Port Authority of New York and New Jersey personnel as facility managers for some of the main tenants indicated that isolated cases of water leakage had occurred in the past and had been repaired. There were no complaints of ongoing water leakage through the curtain wall system. Based on the locations indicated it is likely that at least some of the previous water leakage came through the roofing/waterproofing at the mechanical level setbacks.

IV. Inspections

A. Interior inspections.

1. Random areas of the curtain wall were inspected from the interior of the tower to check for signs of water leakage or other indications of deterioration. Areas were inspected based on accessibility and included both finished and unfinished spaces. Floors 22, 24, 32 and 81 were made available for interior inspections. Our observations are summarized as follows.

a. No signs of water leakage were noted at any of the finished spaces. At some of the unfinished/unoccupied spaces there was staining and efflorescence noted on the plaster finish at the interior side of the column enclosures (between the vision panels) (Refer to photograph 8). These stains could be the results of water leakage through the curtain wall or condensation that formed on the interior surface. It was reported by Port Authority personnel that during certain conditions condensation did form on the inside surface of the curtain wall. This condition is possible as the curtain wall shop drawings that we have reviewed do not indicate any significant amount of thermal insulation within the system.

b. As the plaster finish at the interior side of the column enclosures (between the vision panels) is supported by the curtain wall framing it (the plaster) is subjected to the same deflections that occur in the curtain wall system. These deflections have resulted in horizontal cracks in the plaster finish coat (Refer to photograph 9). While the curtain wall framing is typically designed to limit deflections to 1/175 of the span between supports, members supporting a more rigid material like plaster would be designed to limit deflection to 1/360 of

the span or less. At this time cracks appear to be primarily an aesthetic problem that is addressed with spackle and paint when the floors are renovated.

c. A number of locations were noted where the interior glazing gasket had dropped out of its pocket at either the top or side of the vision glass panel. This condition is a result of the glazing gasket having taken a compressive set and lost some of its flexibility. Additionally, the original design may not have had sufficient engagement between the glazing gasket and the window frame. Thus, under a negative wind load the glass is pressed against the outer gasket, compressing it and opening up the gasket pocket on the interior allowing the gasket to drop out. LERA has proposed replacing the gaskets that have dropped out with new gaskets. As the primary function of the interior gasket is to provide a separator between the glass and metal frame, the existing gaskets could be reinstalled using a few small beads of silicone sealant to the gasket in place.

B. Exterior Inspections.

1. The exterior visual inspections were made from the street/plaza level using binoculars, the main roof and setbacks (at levels 7, 41, 75 and 108). Our observations are summarized as follows.

a. In general the curtain wall system appears to be in good structural condition with no obvious signs of failure.

b. The condition of sealant joints visible at the setbacks varied from poor (sealant is dry and hard) to recently replaced (Refer to photograph 10). Replacement of sealants appears to have been done on a spot basis to address specific areas of failure or reports of water leakage. Additionally, joints that were intended in the original design to be left open have been sealed. The open joints are intended as a drainage path for water that enters the curtain wall system in the floor height above. If the system is functioning as designed, water should not be able to enter the open joints and reach the interior of the tower. However, if failure of internal seals or flashings prevents the system from functioning as designed, it may be necessary to seal the open joints to prevent water entry instead of dismantling the system. When sealing the open joints, caution must be exercised to prevent water being trapped within the curtain wall system.

c. The main issue from the exterior is the overall appearance of the tower. Over time the anodized finish on the column cladding, spandrel panels, corner panels, and sloped parapet panels has deteriorated resulting in a patchwork appearance (Refer to photographs 2 and 3). The discoloration is caused by dirt and chemicals in the atmosphere that embed themselves in the porous surface of the aluminum or cause the aluminum to corrode. Additionally, it appears that the anodized finish of the curtain wall, particularly the spandrel panels, was coated with clear lacquer that is now peeling off (Refer to photographs 11 and 12). The areas where the clear lacquer coating has peeled away are very visible from the street/plaza level. It has been indicated by the Port Authority that the curtain wall system was originally supplied with the clear lacquer coating applied over the anodized finish.

d. From the roof level it was noted that the steel framing that supports the sloped parapet panels is lightly rusted (Refer to photographs 13 and 14). The base of the steel framing is supported on a pedestal that comes up from the building structure below. Steel shim plates used between the steel framing the pedestal to adjust the level are severely rusted (Refer to photograph 15).

V. Summary

A. Based on our onsite observations and evaluation of the documents, the overall condition of the curtain wall system is generally good. While there are ongoing maintenance issues to be addressed, there do not appear to be any significant structural or waterproofing issues that require attention. Nothing in our observations or evaluations leads us to believe that the condition of the curtain wall will deteriorate significantly in the foreseeable future.

B. The ongoing inspections will need to be continued in some form to fulfil the requirements of the Local Laws. Inspection of the guide tracks for the robotic window washer would likely need to be a high priority until such time that the modifications to the guide system are proven to be affective in eliminating damage to the guide tracks and fasteners.

C. The ongoing maintenance work represents a significant capital outlay each year. The maintenance program could be converted to a remedial program whereby repairs for the known problems are applied to the entire tower, bringing the whole of the curtain wall system up to an equal state of repair. This would mean replacing or modifying components before they actually fail. Given the size of the project, a remedial program of this type would be a substantial undertaking. While this approach would have an extremely high up front cost, it should significantly reduce the cost of and need for ongoing maintenance.

D. Our recommendations regarding the issues noted during our inspections are summarized as follows.

1. Water leakage - As there does not appear to be any significant or typical water leakage problems, we recommend that water leaks continue to be addressed as they are reported. A remedial program that addresses sealant repair and replacement for the entire tower would reduce the potential for future water leakage.

2. Cracked plaster - As the cracks present primarily an aesthetic concern, we do not feel that any specific action is required relating to this issue. The cracks can continue to be addressed as floors are renovated. Should a permanent solution be desired it may be possible to replace or clad over the plaster with drywall or other more flexible material.

3. Interior gaskets - The dropping out of the interior glazing gaskets is a minor issue and can be corrected by reinstalling the existing gasket into the glazing pocket with a few small beads of silicone sealant.

4. Sealant joints - While the overall condition of the sealants is poor due to its age and type, actual failures are isolated. Thus, the sealant could continue to be addressed on an "as needed" basis or all sealants could be replaced as part of an overall remedial program.

5. Aluminum finish - While removal of the deteriorated clear lacquer coat would eliminate the blotches and improve the appearance of the tower, it is likely that the patch work appearance would remain due to differences in the shade of the finish on adjacent components. It is our opinion that cleaning the aluminum finish would not significantly reduce the patch work appearance. An option for improving the overall appearance would be to paint the aluminum components in place on the tower. While this process would be a major undertaking on a project of this size, it has been successfully done on large projects. As this is an aesthetic issue there is no need to do anything with the aluminum finish should the current appearance be accepted. If painting is to be considered, it should be integrated with a program to replace the existing exterior seals within the curtain wall system at the same time.

6. Rusted steel framing - While the rusting of the steel framing for the sloped parapet panels is mild at this point, we recommend that the steel framing be cleaned, primed and painted to prevent further deterioration. The rusting of the steel shims is more severe and should also be addressed. The mild steel shims should be replaced with galvanized or stainless steel shims and the pedestals cleaned, primed and painted.

While our inspections and evaluations have covered a random sampling of conditions, we believe that our findings are representative of the entire curtain wall system. Should any additional information or clarification be required, please feel free to contact our office.

Respectfully submitted,
HEITMANN & ASSOCIATES, INC.

William G. Young

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Manager, East Coast Office

Attachments

One & Two World Trade Center
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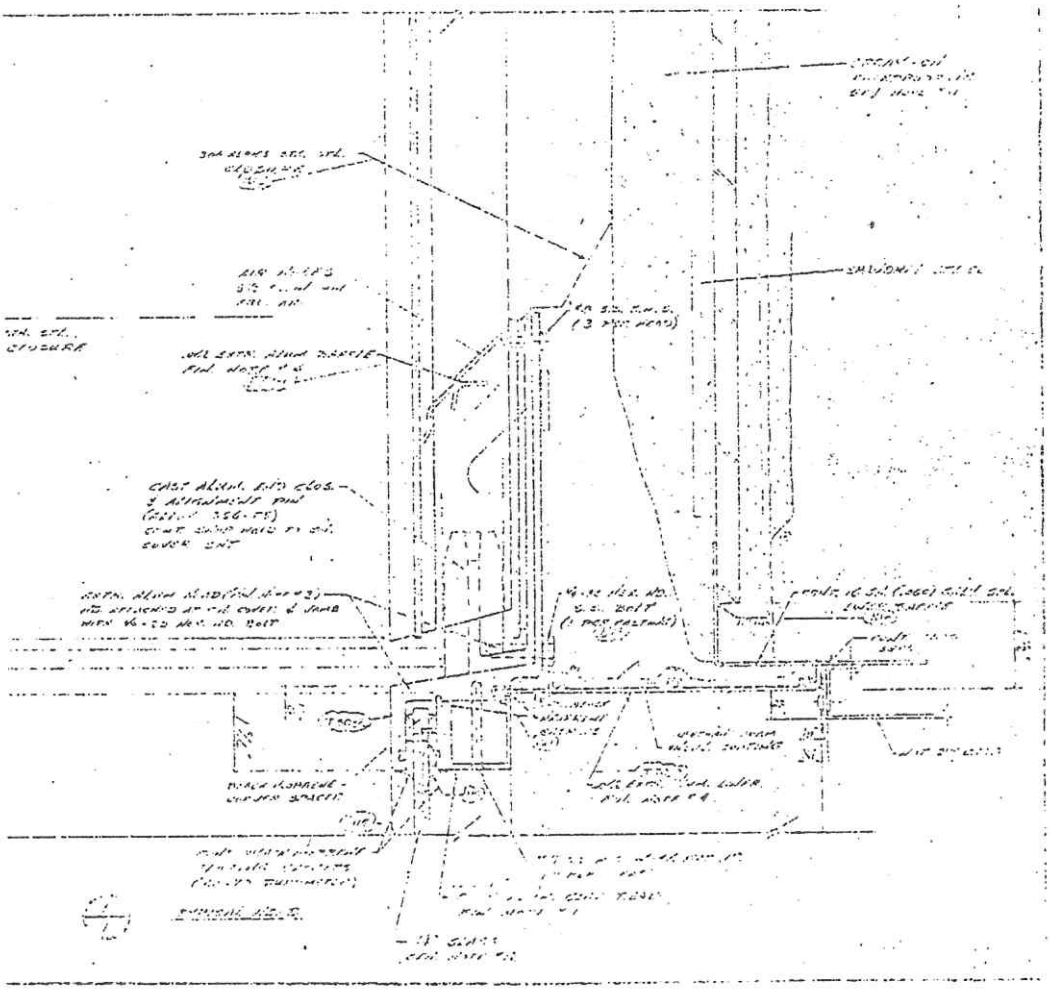

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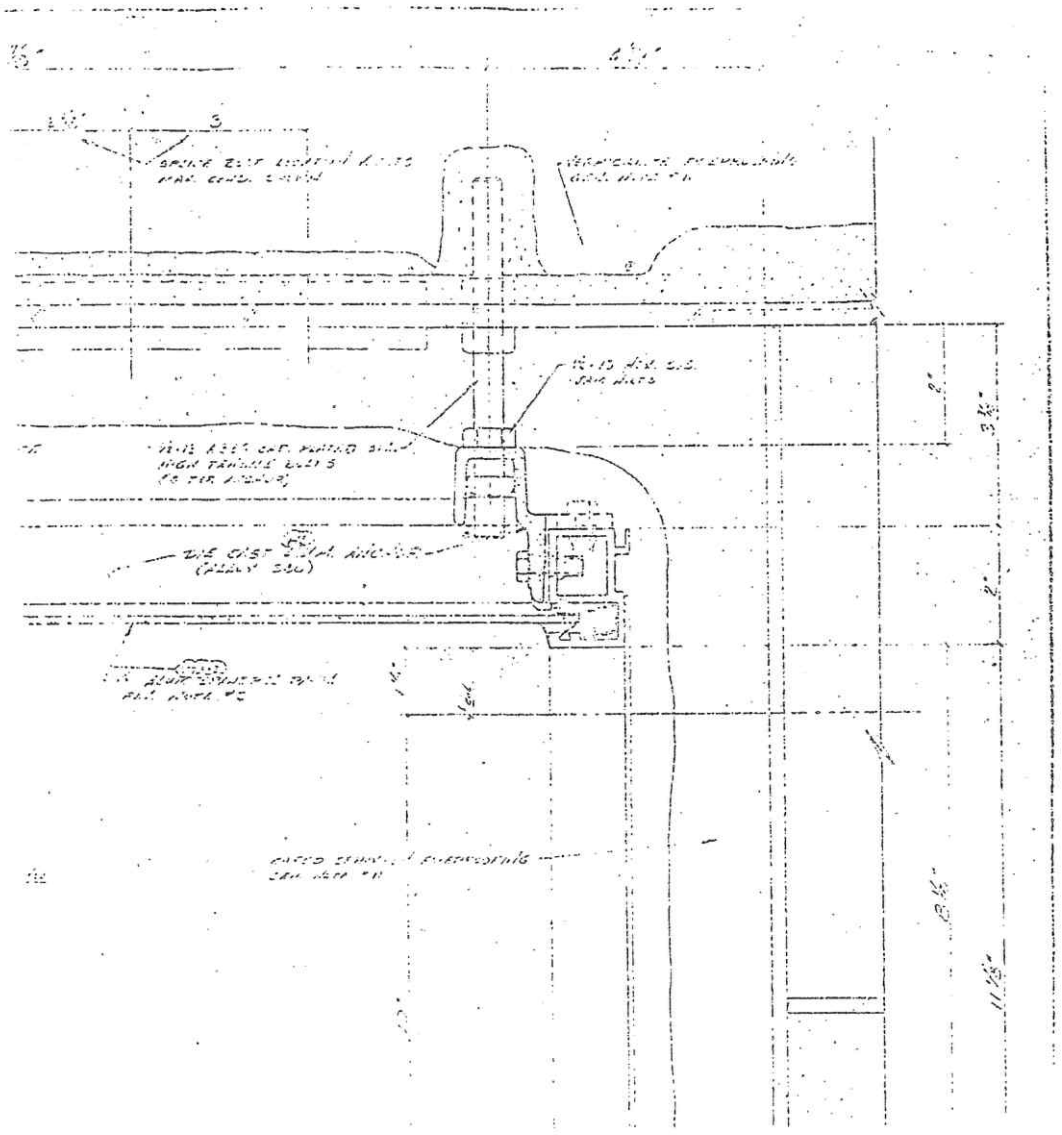

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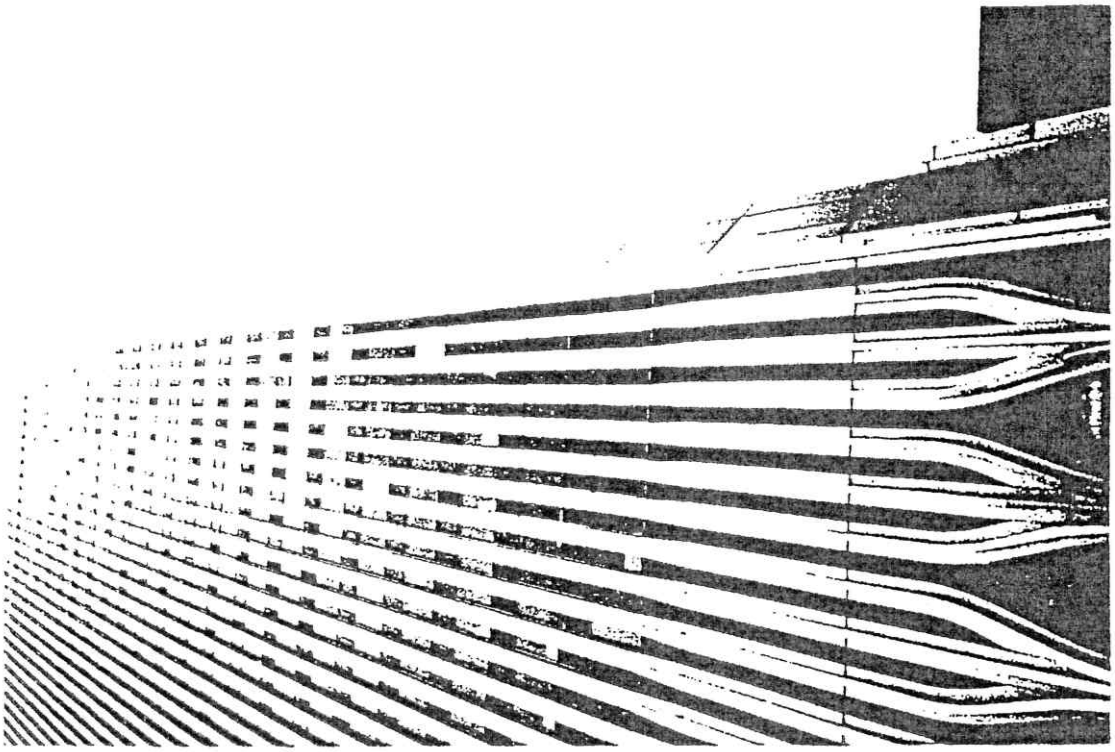

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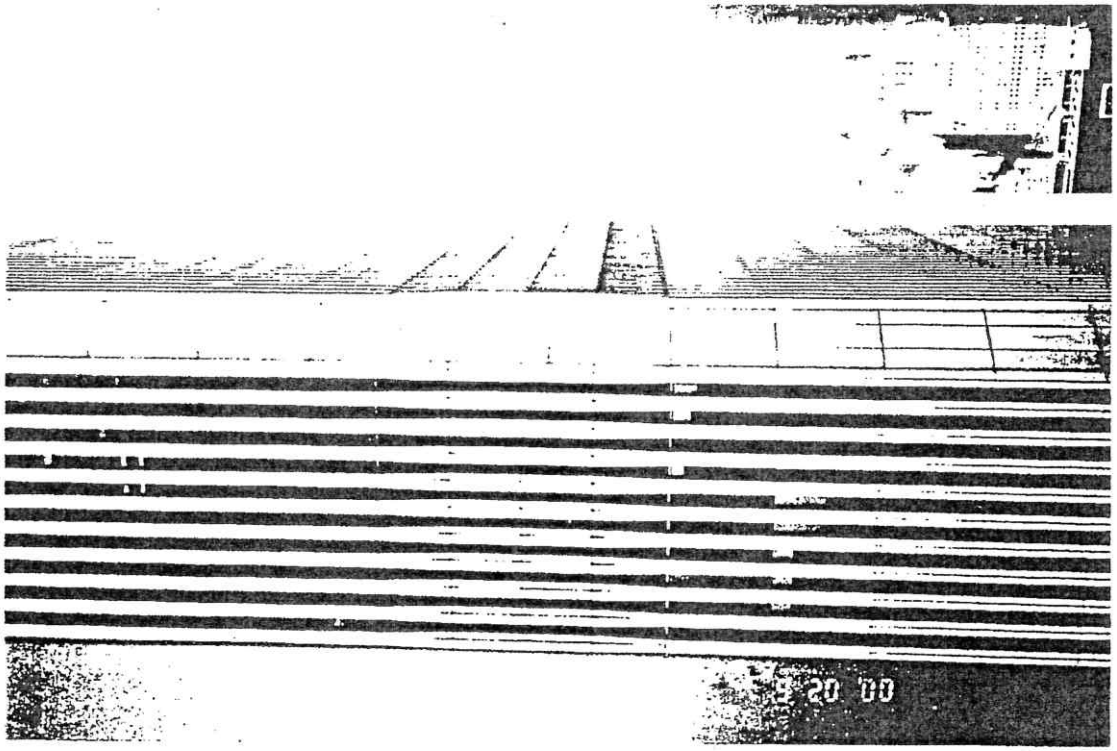

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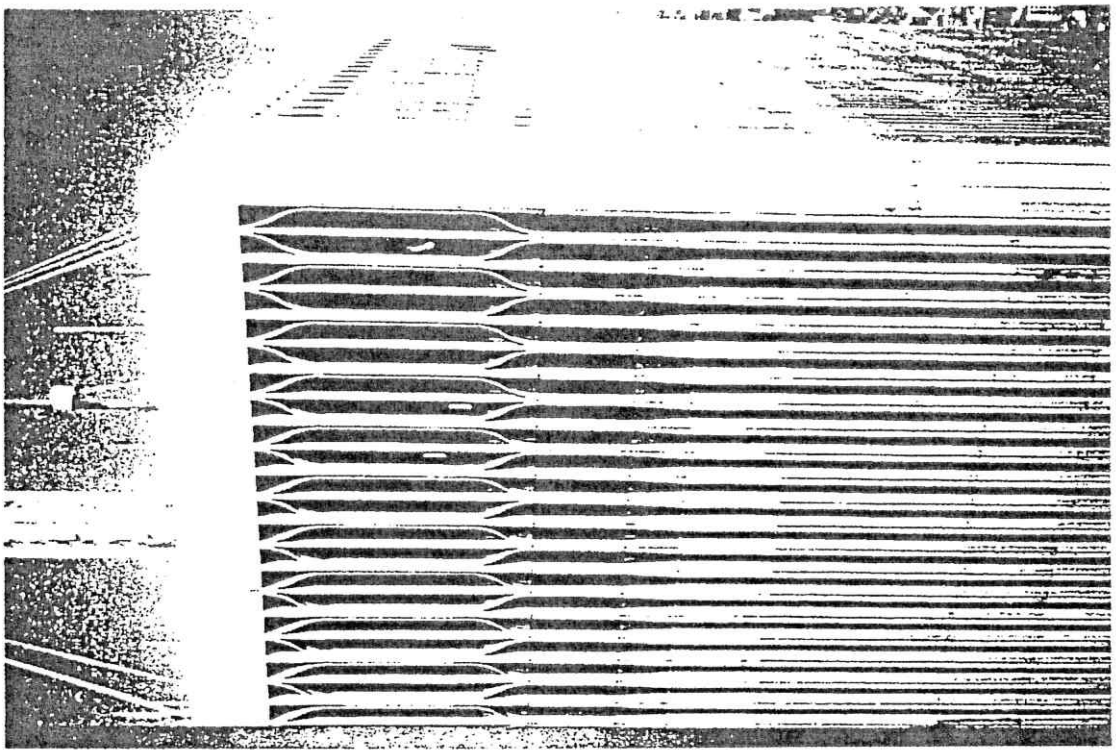

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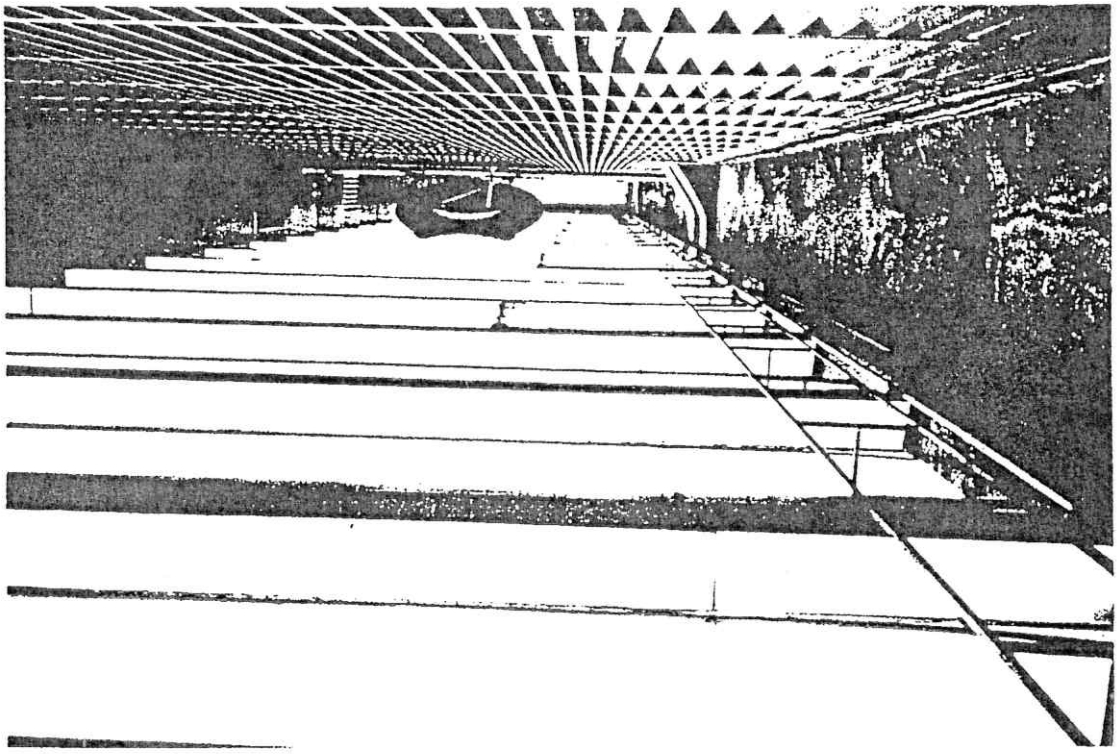

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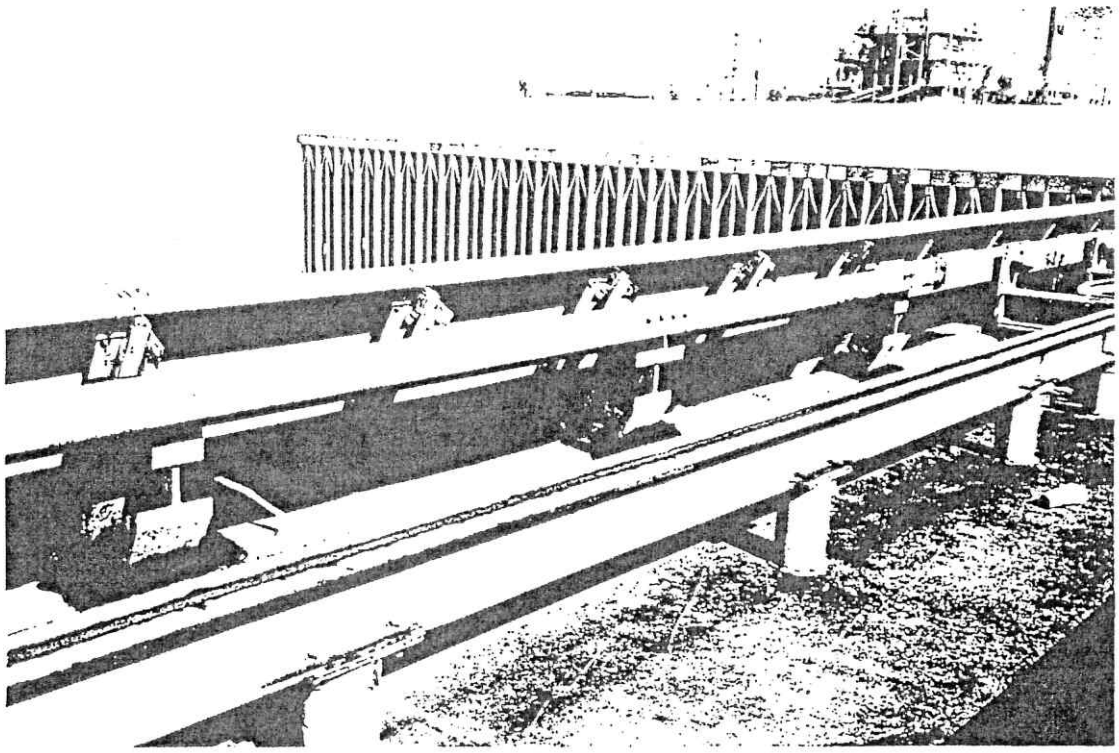

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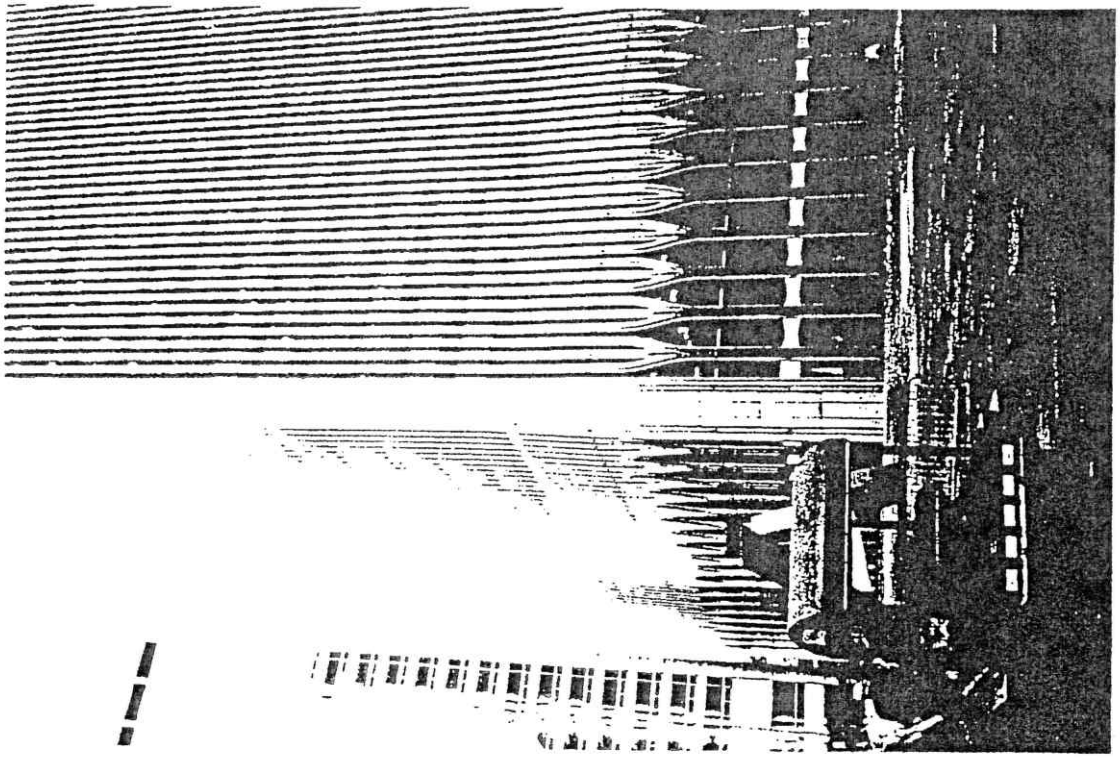

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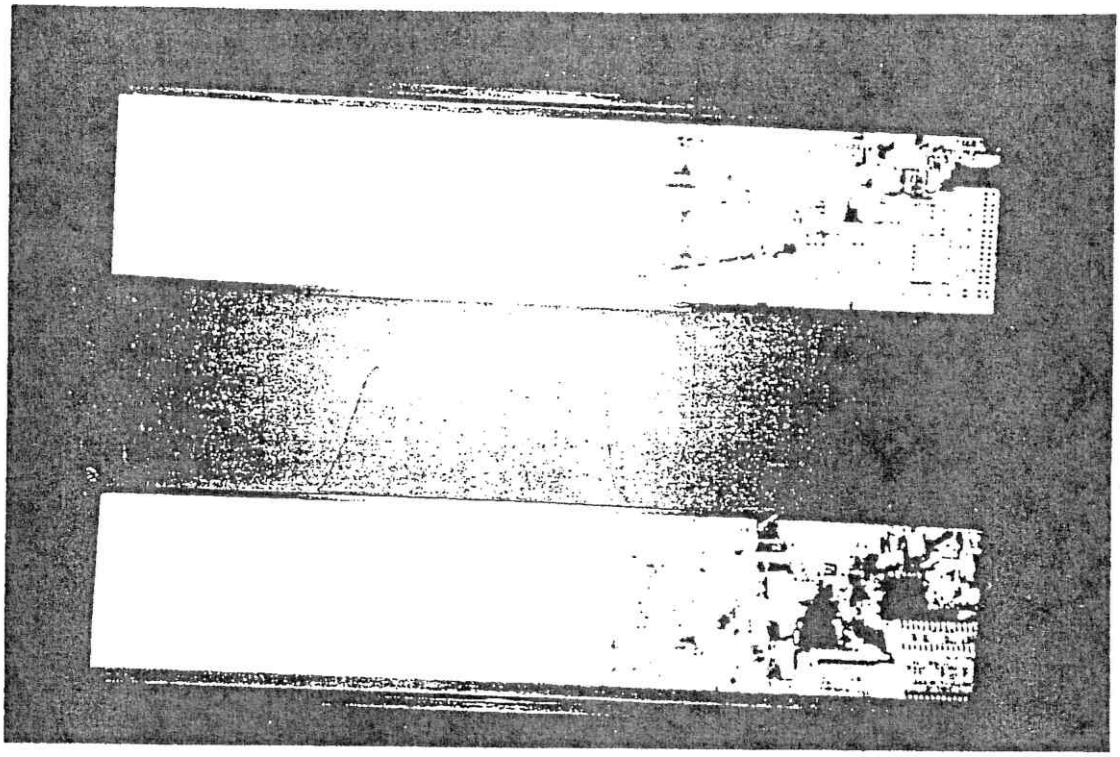

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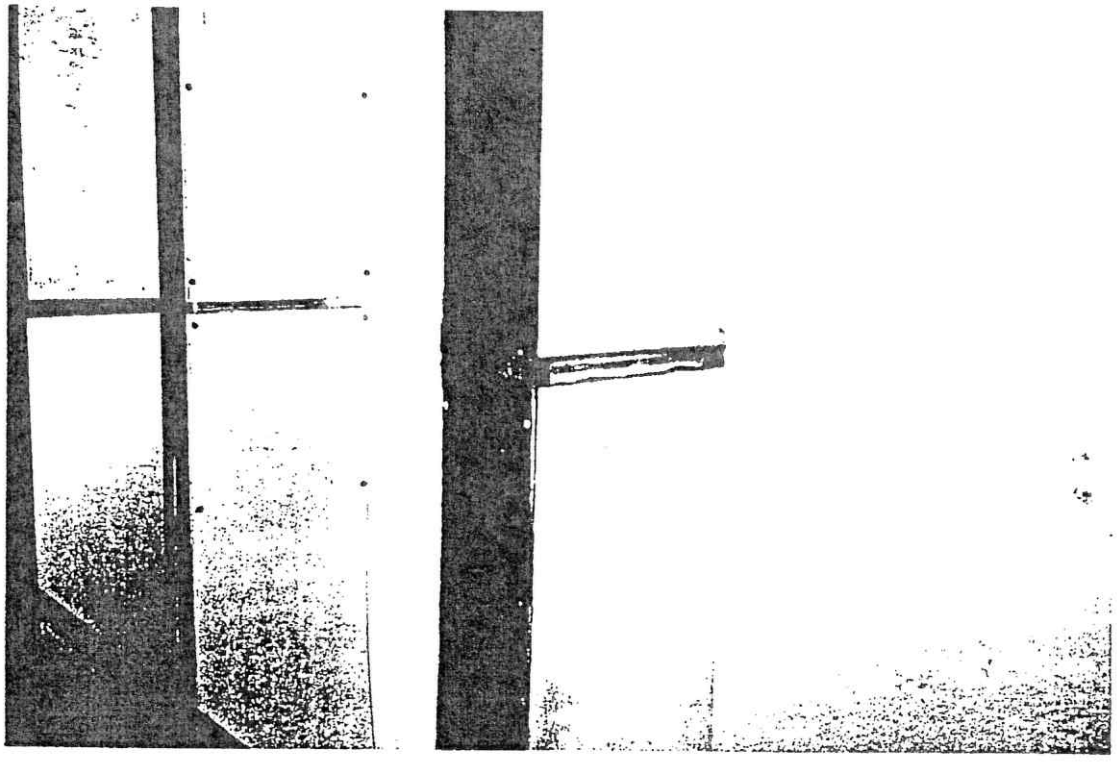

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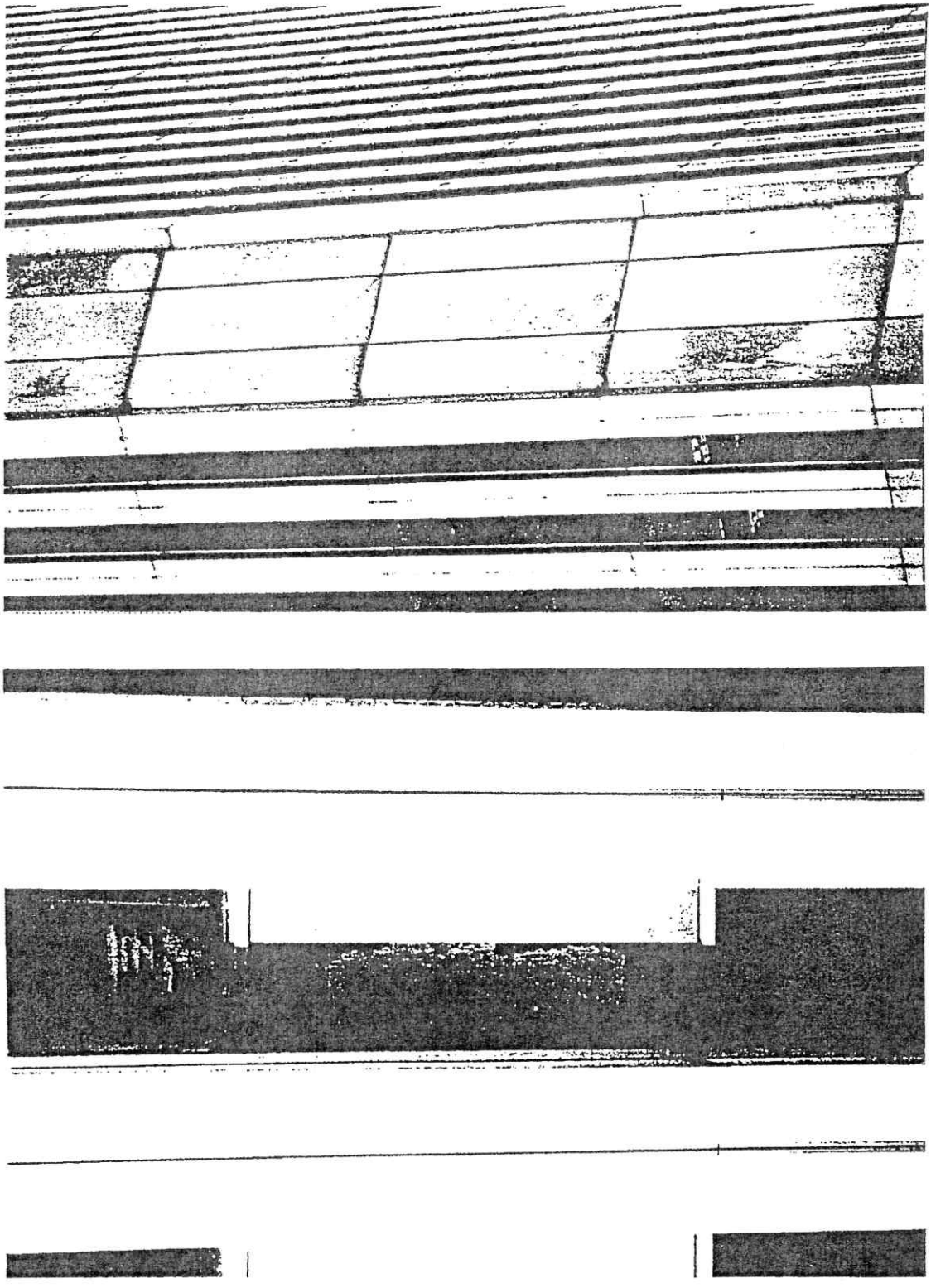

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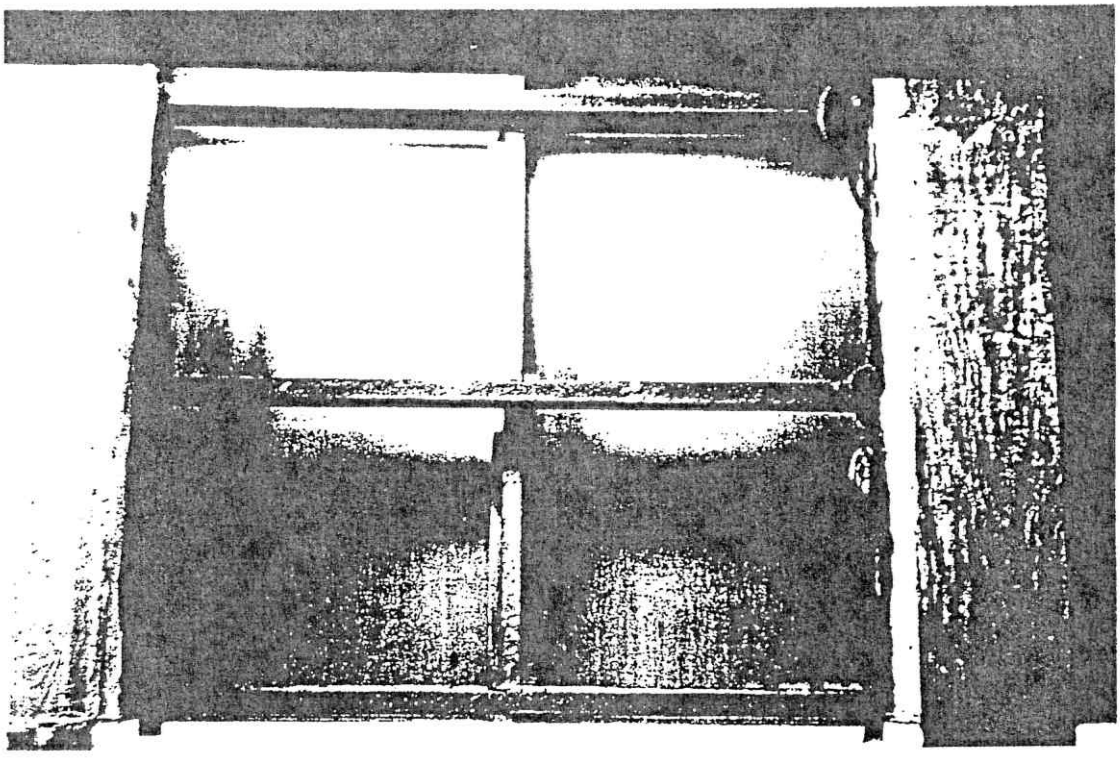

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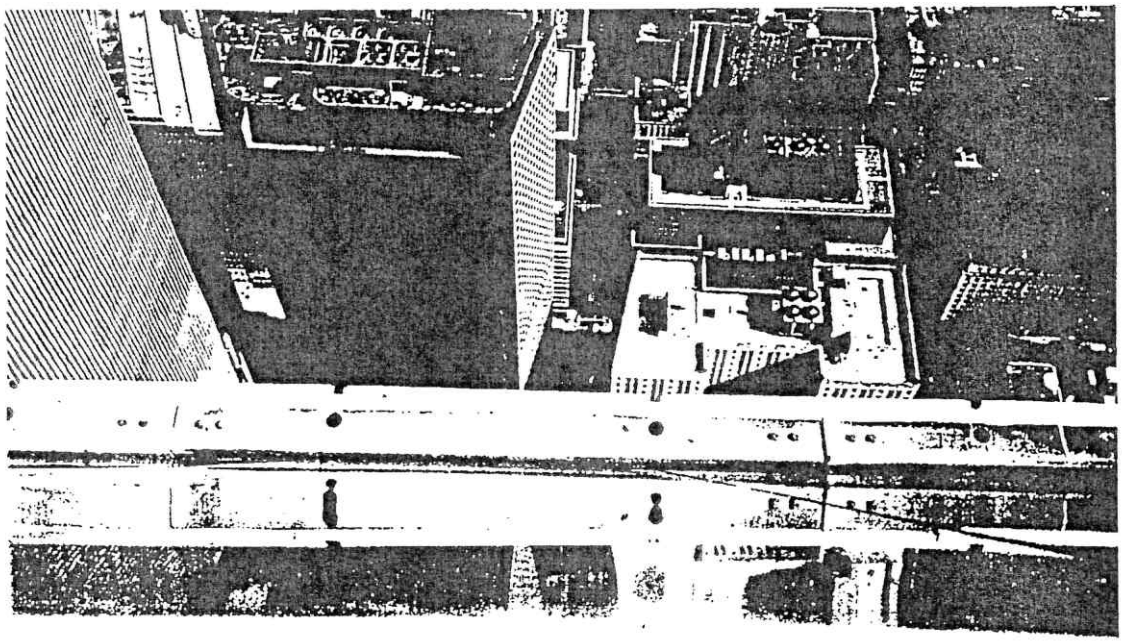

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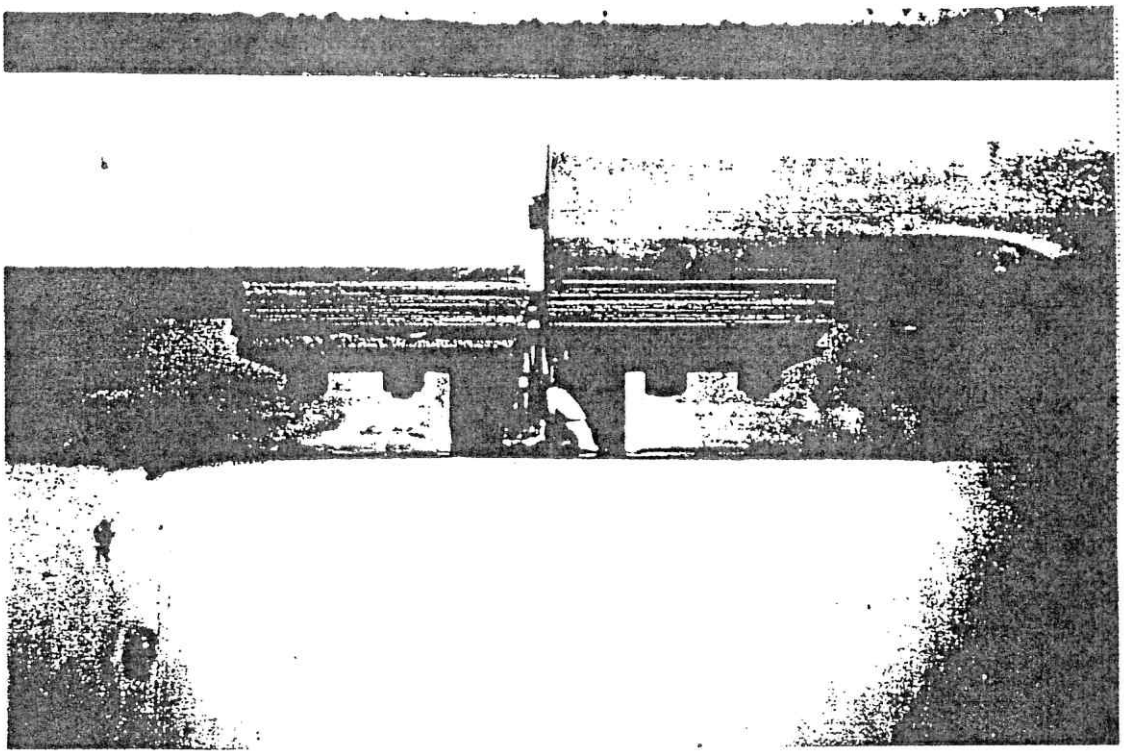

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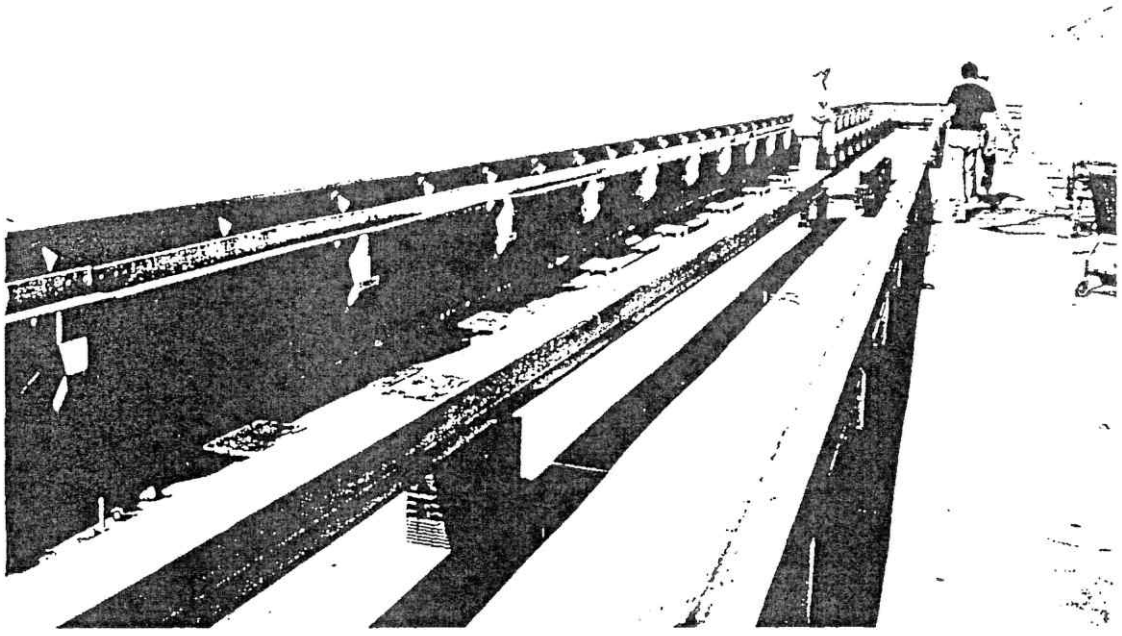

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