Item 3

Fire Test on BISCO SF-20 Silicone Foam And Radiation Shielding Penetration Seals in Masonry Wall Design WP 374

FIRE TEST
ON
BISCO SF-20 SILICONE FOAM AND
RADIATION SHIELDING PENETRATION SEALS
IN MASONRY WALL
DESIGN WP 374

For

BRAND INDUSTRIAL SERVICES, INC.

1420 RENAISSANCE DRIVE

PARK RIDGE, ILLINOIS 60068

WBGBR-215-9759

SERIAL NO. 24963
(4510)

AUGUST 5, 1975

Factory Mutual Research

1151 Boston-Providence Turnpike
Norwood, Massachusetts 02062

WSH/DJC/WGERI
Checked By

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GENERAL

This report describes the construction, the test procedure and lists the results of a fire test conducted on fourteen silicone rubber penetration seals installed in a nominal 12 in. thick concrete block wall. The silicone seals included general purpose foam, radiation shields and flexible silicone boots containing various combinations of electrical conduits and trays, cables, pipe and tubing penetrations.

The penetration components and their general arrangement along with the design method employed to seal these openings were as requested by Brand Industrial Services, Inc. (Bisco). The test wall assembly incorporated the various penetrations as shown on Illustration 1.

Specifications of the Bisco components were supplied and are attached as appendix sheets to this report. The products are not manufactured under Factory Mutual quality assurance follow-up in-plant inspection program.

The object of this test program was to investigate the fire endurance characteristics of the various penetration seals as described herein. The test was performed following the procedures for evaluating wall assemblies as defined under the Standard for Fire Tests of Building Construction and Materials ASTM E119-73, (NFPA 251). The application of the hose stream phase of the test standard was not conducted. Temperature at the unexposed surface of the penetration seals were monitored during the fire test.

The penetration seals remained in place for the 5 hour duration of the fire exposure test and prevented the passage of flame.

DESCRIPTION

MATERIALS

The materials used in the construction of the wall assembly and the designated penetration seal components are described below:

Concrete Block - Nominal 12 in. thick (actual 15-5/8 in. by 7-5/8 in. by 11-5/8 in. thick) 4 hour rated concrete block supplied by Anchor Concrete Products. Blocks manufactured to conform to ASTM Standard C90.

Concrete - Laboratory mixed concrete consisting by volume of 1 part Portland cement, 2 parts sand and 3 parts gravel mixed with 7.0 gallons of water per 94 lb. bag of cement.

Bisco SF-20 Silicone Rubber Penetration Seal - Bisco general purpose foamed-in-place silicone rubber foam. Material designed as a seal for pipe or cable tray openings. The Bisco SF-20 silicone rubber foam used in this test was indicated as being a four component system of Dow Corning silicones formulated by Bisco. The test samples were prepared by Bisco. See Bisco Specification No. 207 under Appendix A.

Bisco SF-150L, SF-250L and SF-300L Flexible Silicone-Bonded Lead Penetration Seals - Bisco radiation shielding stops or seals designed for use with pipe, cable trays, conduit and valve stems that penetrate thru radiation barriers. see Bisco Specification No. 209 under Appendix B.

Bisco Flexible Boot Penetration Seals - These are designed as a seal for moving pipe and duct penetrations and high temperature steam lines. Bisco Specification No. 204 covering the materials and construction of the flexible boot penetration seals see Appendix C.

Damming Materials - These materials are employed to contain the liquid silicone in a specific area until it reacts and expands into a solid silicone rubber product and are left in place. Three types of damming materials were used in the preparation of the test specimens:

a) Bisco Part No. MFB-1600 semi-rigid block insulation - Nominal one inch thick insulation designed for a maximum service temperature of 1200°F.

b) Bisco Part No. CFT-2300 felt insulation - Nominal one inch thick rafractory fiber insulation designed for a maximum service temperature of 2300°F.

c) Bisco Part No. CFR-2300 loose fiber insulation - bulk refractory fiber insulation designed for a maximum service temperature of 2300°F.

ERECTION OF TEST ASSEMBLY:

The wall assembly was erected in a test frame so as to fill the masonry opening as shown in Illustration 1. The wall was constructed of nominal 12 in. concrete block laid in a full mortar bed. The openings were formed and poured using concrete mixed at the test laboratory. The concrete openings were constructed as the blocks reached the upper level of each penetration location. Eleven of the fourteen penetration seals were received at the laboratory as completed units including steel sleeve and all other components which were then installed directly into the prepared openings. Penetration openings designated as Nos. 6, 11 and 12 as shown on Illustration 1 were constructed at the test laboratory.

Following are descriptions of the penetrations as designated and shown on Illustration 1. The pipes contained in the penetration were of the standard weight. The electrical cable insulation was of unidentified material.

1. Steel sleeved rectangular opening, 2 ft. wide by 1 ft. high and containing a 12 by 6 in. solid sheet steel cable tray (no perforations). Within the tray were tightly nested 17 various sized insulated electrical wires ranging in size from 5/16 to 1/2 in. outside diameter. The sleeve opening was sealed for the full depth of wall with Bisco SF20 silicone foam and in addition both sides were faced with 1 in. thick material designated as Bisco Part No. MFB-1600.

2. Twelve inch inside diameter steel pipe with 16 in. square steel flange at unexposed side of wall. The opening within the sleeve was sealed for the full thickness of wall with SF20 silicone foam and in addition, each side of the wall was faced with 1 in. thick Bisco Part No. MFB-1600.

3. Twelve inch inside diameter steel pipe containing a 6 in. inside diameter steel pipe covered with a steel cap at the exposed side. The center of the 6 in. pipe and the annular space between the pipes were sealed wth SF300L silicone-bonded lead for 12 in. depth. The unexposed side of the seal was covered with MFB-1600 of 1 in. thickness.

4. Four inch inside diameter steel pipe containing seven insulated electrical cables equally spaced. The opening sealed with SF250L silicone-bonded lead for full thickness of wall. Both sides unfaced.

5. Four inch inside diameter steel pipe (no penetrating items) sealed with SF150L silicone-bonded lead for full thickness of wall and unfaced.

6. Six inch inside diameter steel pipe containing four 3/4 in. outside diameter insulated electrical cables equally spaced and sealed with SF20 silicone foam. Faced with 1 in. thick MFB-1600 on the exposed side of the penetration. The foam was poured-in-place in the pipe sleeve and then installed in the prepared wall opening. See Illustration 5. The depth of foam was 12 in.

7. Six inch inside diameter steel pipe containing four insulated cables ranging in size from 5/8 in. to 1 in. in outside diameter and equally spaced. The opening was sealed with SF20 silicone foam and the unexposed side faced with 1 in. thick MFB-1600 board. The depth of foam was 12 in.

8. Eight inch inside diameter steel pipe sleeve containing one 2 in. inside diameter steel pipe with ends uncapped. Sealed with SF250L silicone-bonded lead and faced with 1 in. thick MFB-1600 on the unexposed side. The depth of foam was 12 in.

9. An 8 in. inside diameter steel pipe containing four 3/8 in. diameter stainless steel tubes with ends uncapped. Entire opening sealed with SF150L silicone-bonded lead for full depth of wall. In addition, both sides faced with MFB-1600 board of 1 in. thickness.

10. Steel sleeve with a flange having a rectangular opening 41-3/4 by 17 in. and containing a 12 in. by 6 in. solid sheet steel cable tray (no perforations) with thirteen various size electrical insulated cables tightly nested and four steel pipe penetrations. One each of the 2 in. and 6 in. pipes was filled with SF250L silicone-bonded lead and all else was filled with SF20 silicone foam. Both sides of the total opening plus penetrations were faced with 1 in. thick MFB-1600 board. Depth of foam, full thickness of wall.

11. The penetration incorporated a 16 in. inside diameter steel pipe sleeve with a 4 in. inside diameter pipe penetration. The pipe penetration was covered with 4 in. thickness of pre-moulded insulation and sheathed with an aluminum jacket.

    The annular space between the jacket of the insulated pipe and sleeve was unfilled. The unexposed side contained a flexible reinforced silicone-rubber boot.

12. Same as penetration 11 except that the annular space between the insulated 4 in. pipe and the sleeve was faced with 5 in. thickness of CFT-2300 felt insulation reinforced with ni-chrome wire mesh and installed at exposed side.

13. Four inch inside diameter steel pipe sleeves with no penetrations sealed with SF20 silicone foam and faced with MFB-1600 board on the exposed side. Depth of foam, full thickness of wall.

14. Four inch inside diameter steel pipe same as penetration 13 above, but with MFB-1600 board of 1 in. thickness on the unexposed side of the penetration seal. Depth of foam, full thickness of wall.

Illustrations 2 through 11 show the construction and installation of the various penetration seals while Illustrations 12 and 13 show the exposed and unexposed surfaces before the fire endurance test.

FIRE TEST

The test was conducted subjecting one side of the test wall assembly to fire exposure in accordance with the Standard for Fire Tests of Building Construction and Materials ASTM Designation E119-73, (NFPA No. 251). The application of the hose stream phase of the test standard was not conducted. The standard test furnace of the National Gypsum Company for wall assemblies was used for this test.

SAMPLE:

The wall assembly, 10 ft. 1 1/2 in. wide by 10 ft. high, containing the fourteen penetration seals was erected in the test frame as previously described.

METHOD:

The furnace temperatures were measured with 11 thermocouples symetrically located in the furnace chamber as shown on Illustration 14. The unexposed surfaces of the penetration seal face were measured by 13 thermocouples, each covered by a dry asbestos pad cut to fit between the cables and other wall penetration items and two additional thermocouples designed as Nos. 14 and 15 were located at face of the concrete block and at the surface of the cast-in-place concrete adjacent to Penetration 12. The locations of these 15 thermocouples are shown on Illustration 15. Sixteen thermocouples were used to measure the temperatures of the steel sleeves, cable trays and other penetrations as shown on Illustration 16.

The assembly was subjected to a superimposed total load of 3500 lb. uniformly applied to the concrete block wall.

The furnace fire was started, exposing one side of the assembly to gas flames of controlled severity and extent in accordance with the Standard Time-Temperature Curve.

Throughout the test, observations were made to note the character of the fire and its control, the condition of the exposed and unexposed surfaces, and all developments pertinent to the performance of the assembly with reference to stability, passage of flame and generation of smoke.

RESULTS:

Character and Distribution of Fire - The fire was luminous and well distributed throughout the test. The furnace temperatures were controlled in accordance with the Standard Time-Temperature Curve as shown on Illustration 14.

Observations of the Exposed Surface - At 1 minute of exposure the cable insulation was burning on the cables in the large cable tray (No. 10). By 4 minutes the cable insulation was burning at several other locations. At 9 minutes the SF250L foam surface in the 8 in. dia. pipe was turning white (No. 8). At 12 minutes the SF20 foam surfaces of the 6 in. (No. 7) and 4 in. (No. 14) dia. pipes sleeve were forming a white crust. At 18 minutes small flames were coming from the N-1200 insulation surface of the large cable tray. After 32 minutes MFB-1600 insulation on the exposed surfaces of the 8 in. dia. pipe sleeve sealed with SF150L foam (No. 8) and the 4 in. dia. pipe sealed with SF20 (No. 13) was flaming. At 36 minutes all of the silicone foam seals directly exposed to fire were flaming.

The MFB-1600 insulation on the large cable tray (No. 10) was delaminating after 44 minutes of exposure. At 47 minutes small pieces of flaming material were falling from the 12 in. pipe sleeve sealed with SF300L foam (No. 3). At 62 minutes, small pieces of the MFB-1600 insulation were falling from the large cable tray (No. 10). After 86 minutes the penetrations covered with MFB-1600 had a white fibrous appearance. At 120 minutes there was no change in the performance of any of the foam seals, burning and flaming was steady and continuous with the MFB-1600 insulation disintegrating and falling off in small pieces.

At 222 minutes the flaming had subsided from all penetration seals, except for the large cable tray (No. 15). Also, the 6 in. dia. pipe (No. 7) sealed with SF20 and the 8 in. dia. pipe (No. 8) sealed with SF250L which had the foam exposed directly to the furnace flames. After 240 minutes flames were coming from the large cable tray (No. 10) only. Smoke continued from the two 8 in. dia. pipe sleeves (Nos. 8 and 9) while the other seals remained unchanged at 266 minutes of exposure. At 282 minutes the 6 in. dia. pipe sleeve (No. 7) with the SF20 exposed to the furance began to reflame and the large cable tray (No. 10) was smoking slightly. The test was terminated at 300 minutes.

Observations of the Unexposed Surface - At 37 minutes the silicone boot (No. 11), without the fire retardant backing, was smoking slightly from the top of the boot. The light smoke continued for the duration of the test. At 199 minutes, smoke was coming from the 8 in. dia. pipe sleeve (No. 9) sealed with SF150L and containing four stainless steel tubes.

At 233 minutes the silicone boot assembly (No. 11), without the fire retardant backing, tilted downward slightly. No other changes occurred in the appearance of the unexposed surface for the 5 hour duration of the test.

Observations after the Test - At 5 hours of exposure the test was terminated and the assembly was removed from the furance. All SF20 foam seals were flaming as the assembly was withdrawn from the furnace. The silicone fabric boot seal (No. 12), protected with the fire retardant backing, showed no visible effect from the fire exposure, however, the ni-chrome wire mesh was glowing red.

The wall was cooled and the burning material quenched with water. One of the 4 in. dia. pipes (No. 14) sealed with SF20 foam was examined. It was found that the exposed surface had developed a hard char progressing to uneffected foam over 8 in. of the depth of the seal.

Illustrations 17 and 18 show the unexposed surface at 5 hours of exposure and the exposed surface after the test.

Temperatures of the Unexposed Seal Surfaces - The temperatures that developed during the test and the thermocouple locations are shown on Illustration 15. The standard states that limiting end point temperatures are reached when heat transmission through the assembly is sufficient to raise the average temperature 250F above ambient temperature or when the temperature of any individual point raises 30 percent in excess of the allowable 250F rise. In this test the initial temperature was 67F, therefore, based on the above conditions the average limiting temperature was 317F and the individual limiting temperature was 392F.

In this test the performance under fire exposure of discrete elements was evaluated, not a wall assembly. In the opinion of this testing laboratory, the determination of acceptable temperature limits is the responsibility of the authority having jurisdiction, based on the end use conditions of the penetration seals.

Analysis of the unexposed surface, temperatures at the penetration seal surface shows that the measure temperature at Thermocouple 4 exceeded the individual limiting temperature of 392F at 4 hr. and 6 minutes. This thermocouple was located at the 8 in. dia. pipe sleeve (No. 8) sealed with SF250L foam and with the unexposed face covered with MFB-1600 insulation. Thermocouple 5 placed on the 8 in. dia. pipe sleeve (No. 9) sealed with SF150L foam and faced with MFB-1600 insulation on both sides reached 392F at 4 hr. and 34 minutes. Thermocouple 9 on the 12 in. dia. pipe sleeve (No. 3) sealed with SF300L foam and MFB-1600 insulation on the unexposed face reached 392F of 4 hr. and 35 minutes.

Steel Pipe and Cable Temperatures - The temperatures of the steel pipes, sleeves, electrical cables and cable trays was measured at 16 locations as shown on Illustration 16. The temperatures are included for general fire performance information.

CONCLUSIONS

FIRE RESISTANCE PROPERTIES:

The penetration seals as described in this report were subjected to fire exposure for five hours in accordance with the ASTM Standard Time-Temperature Curve.

The silicone rubber penetration seals and flexible reinforced silicone rubber boot penetration seals prevented the passage of flame and excessive smoke through the wall assembly during the test.

The transmission of heat through the silicone rubber seals was below 400°F for a duration in excess of four hours. The temperatures of the unexposed surfaces of the silicone rubber boot penetration seals were not evaluated during the fire endurance test.

PRODUCT UNIFORMITY:

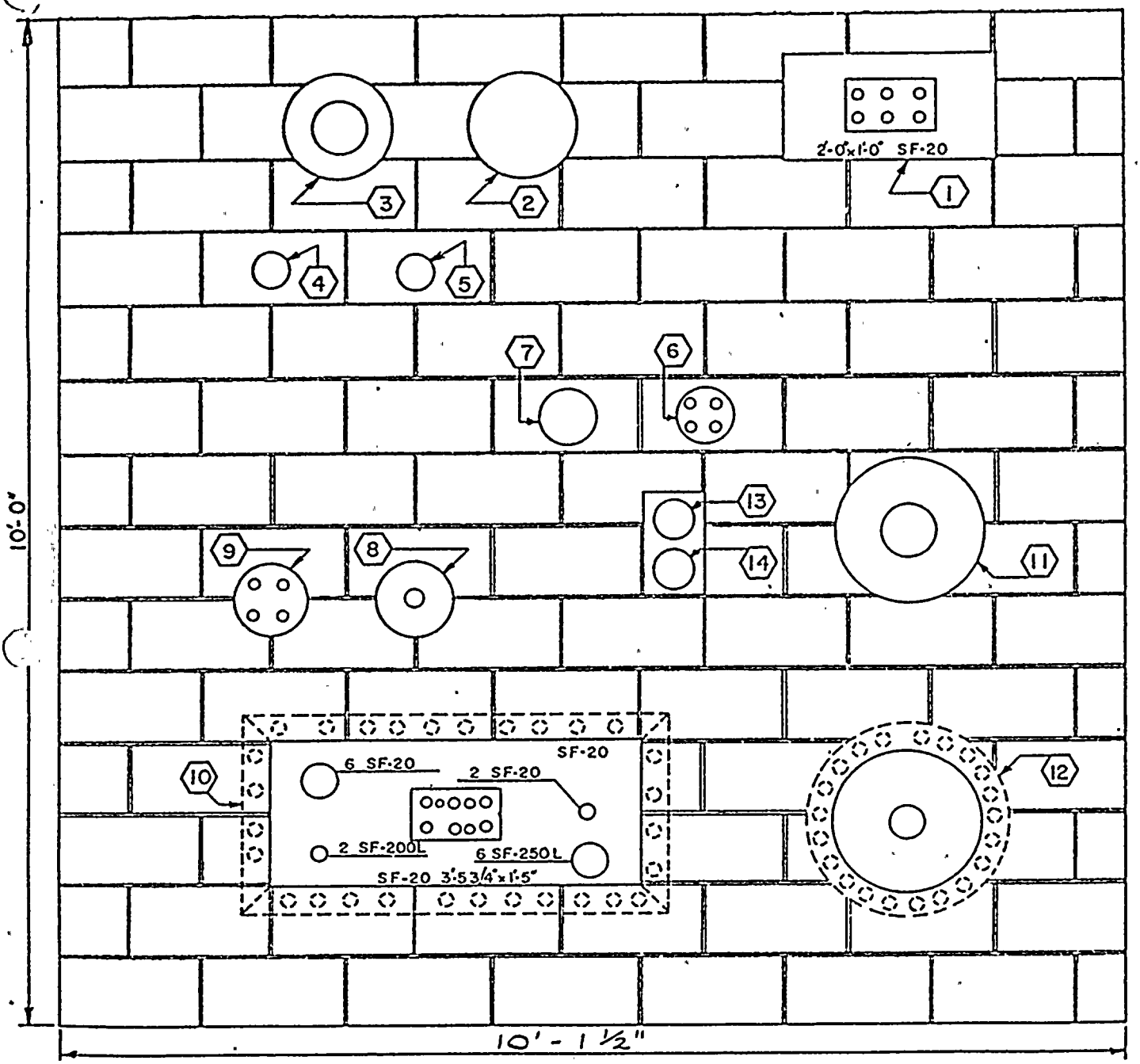
Factory Mutual Research Corporation makes no judgement of product uniformity solely as a result of this fire test. Product uniformity depends in part on manufacturing facilities and procedures which would be inspected under Factory Mutual quality assurance follow-up inspection program and on a written agreement put in force between both the product manufacturer and Factory Mutual.

The components used in the construction of this assembly are not under this quality assurance inspection program.

LABORATORY RESPONSIBILITY:

Factory Mutual Research Corporation makes no judgement of product suitability for its intended end-use. Product acceptance of field installation are usually the prerogative of the authority having jurisdiction.

ILLUSTRATION 1



TYPICAL FIRE TEST WALL
UNEXPOSED SIDE

NOTE:
FOR EXPLANATION OF KEY NUMBERED PENETRATIONS SEE DESCRIPTION IN TEST REPORT

PENETRATION SEALS FIRE TEST WALL		
scale:	approved by:	drawn by: DAK
date: 7-14-75		revised:
BISCO		drawing number: 6645

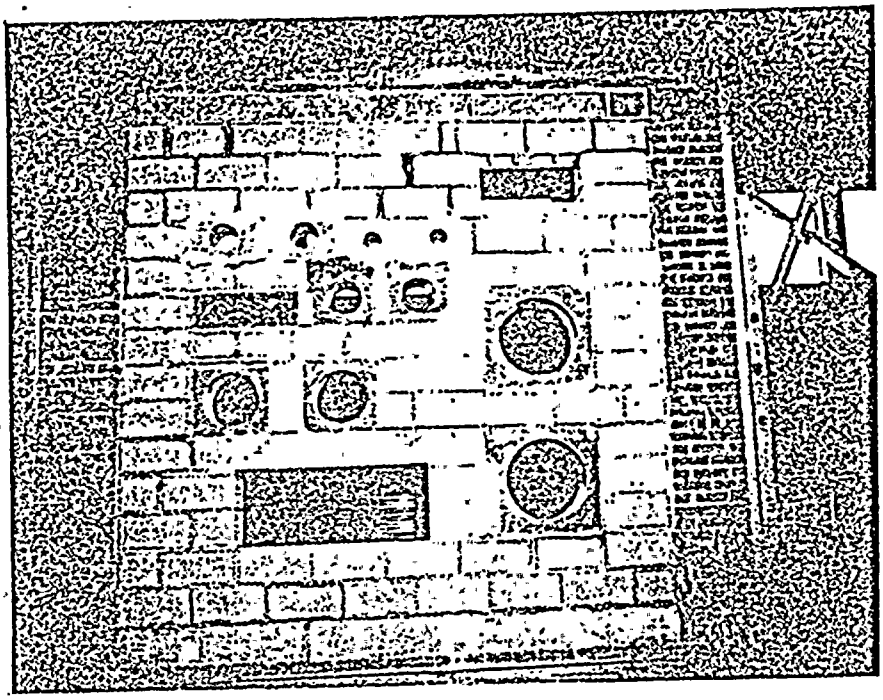


ILLUSTRATION 2

WALL DURING CONSTRUCTION

(3385-1)

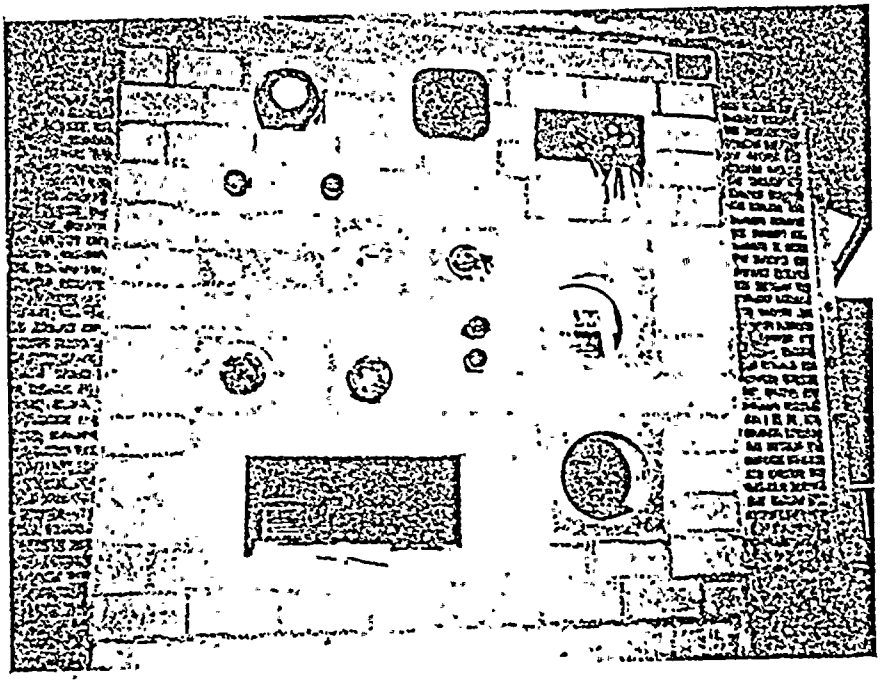


ILLUSTRATION 3

INSTALLATION OF PREASSEMBLED PENETRATION SEALS

(3385-2)

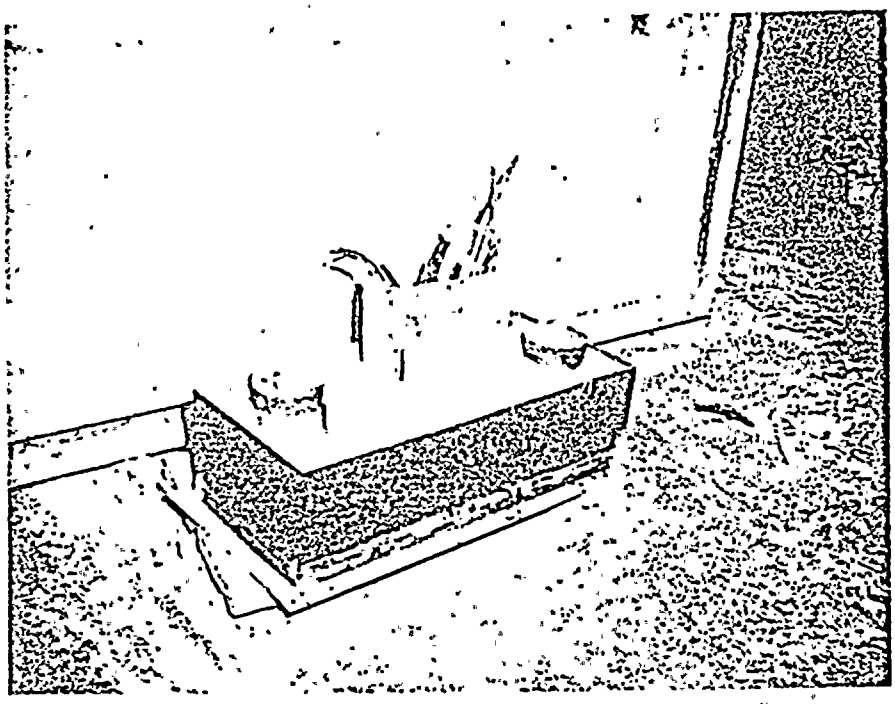


ILLUSTRATION 4

PREASSEMBLED CABLE TRAY AND PIPE SEALS

(3385-3)

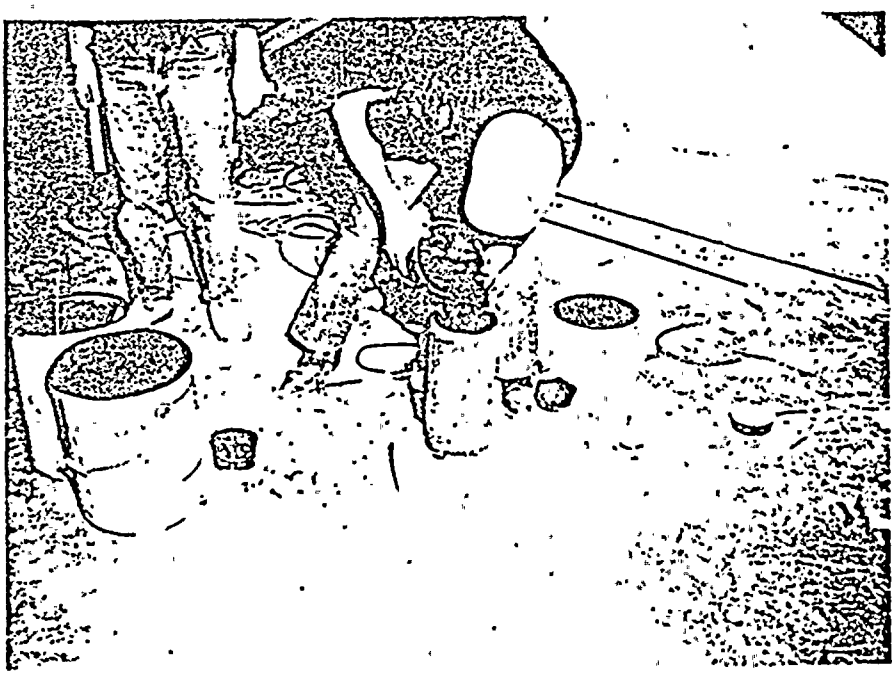


ILLUSTRATION 5

FABRICATION OF SF20 PENETRATION SEAL

(3385-4)

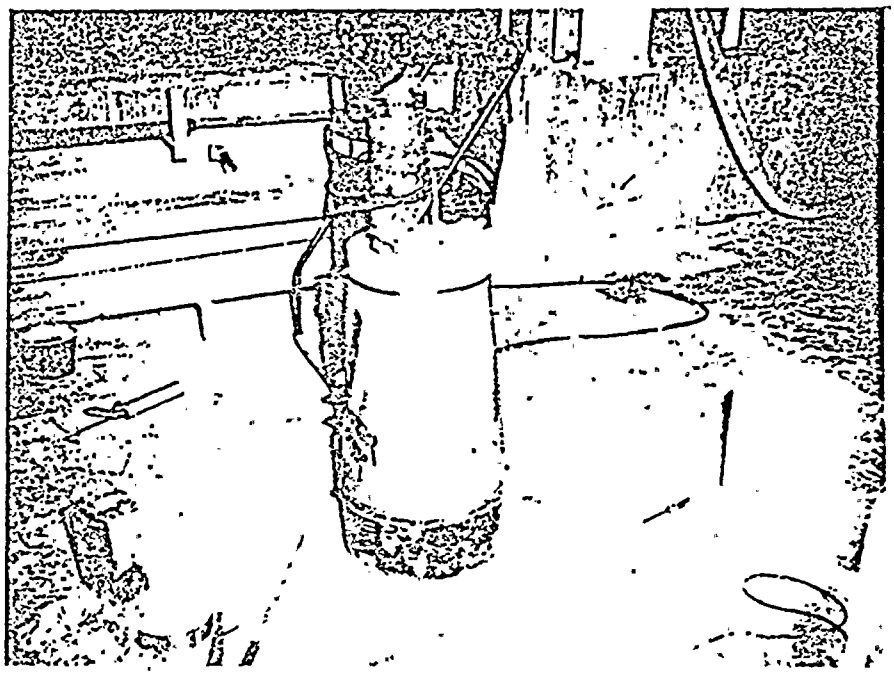


ILLUSTRATION 6

SILICONE BOOT SEAL
DURING CONSTRUCTION

(3385-5)

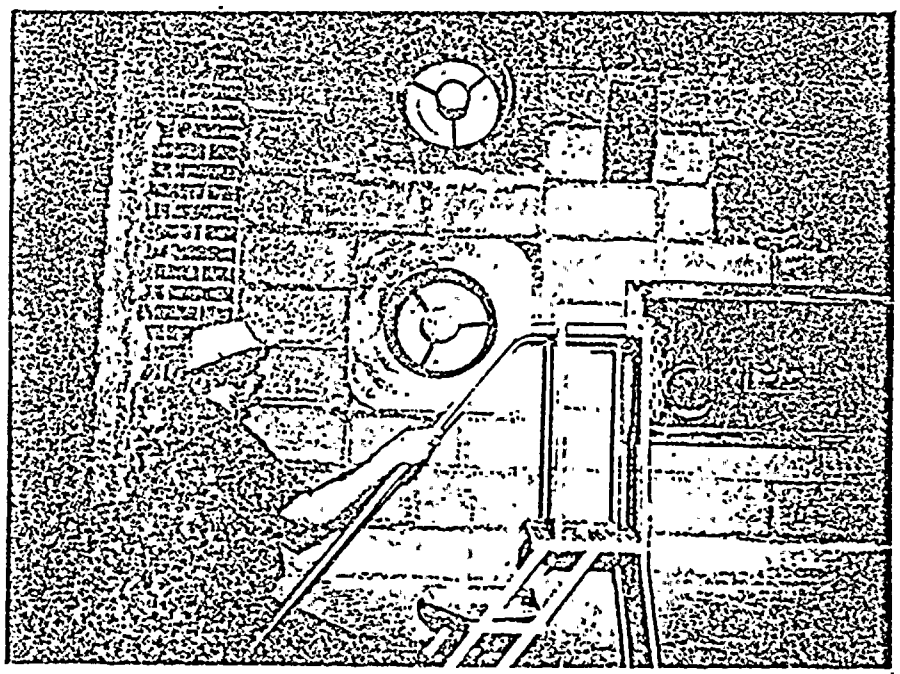


ILLUSTRATION 7

SILICONE BOOT SEAL
DURING CONSTRUCTION

(3385-6)

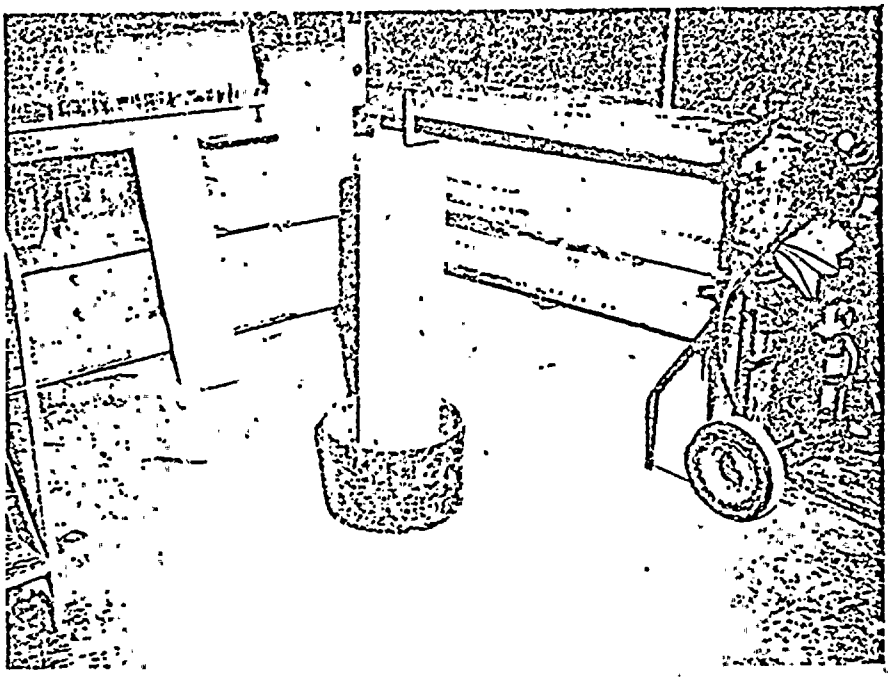


ILLUSTRATION 8

SILICONE BOOT SEAL
DURING CONSTRUCTION

(3385-7)

ILLUSTRATION 9

SILICONE BOOTS BEING
INSTALLED IN WALL

(3385-8)

ILLUSTRATION 10

SILICONE BOOT SEAL
FIRE RETARDANT BACKING

3385-9)

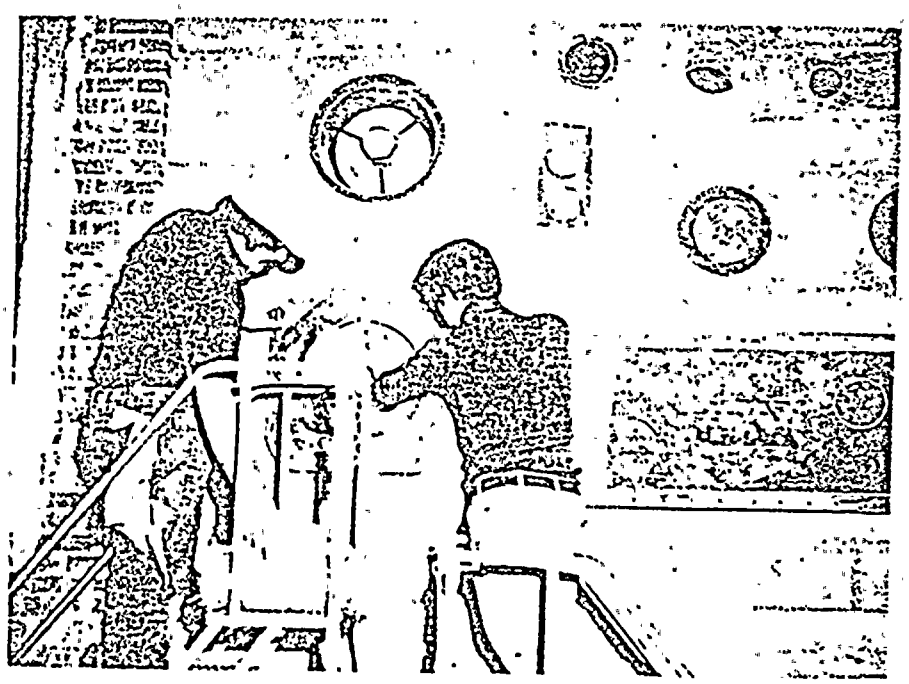


ILLUSTRATION 11

INSTALLATION OF
FIRE RETARDANT BACKING

(3385-10)

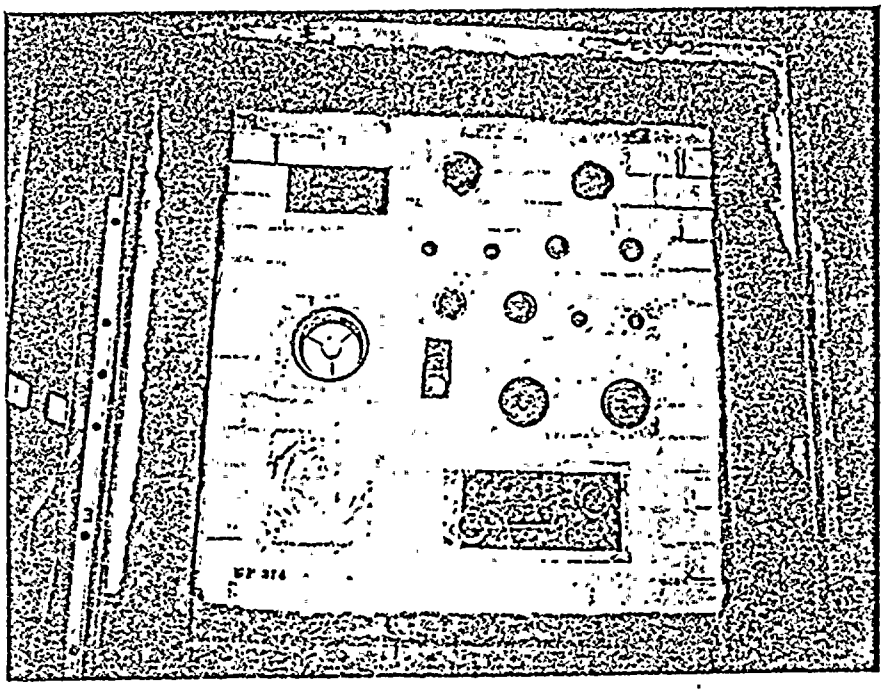


ILLUSTRATION 12

EXPOSED SURFACE BEFORE
FIRE ENDURANCE TEST

(3385-11)

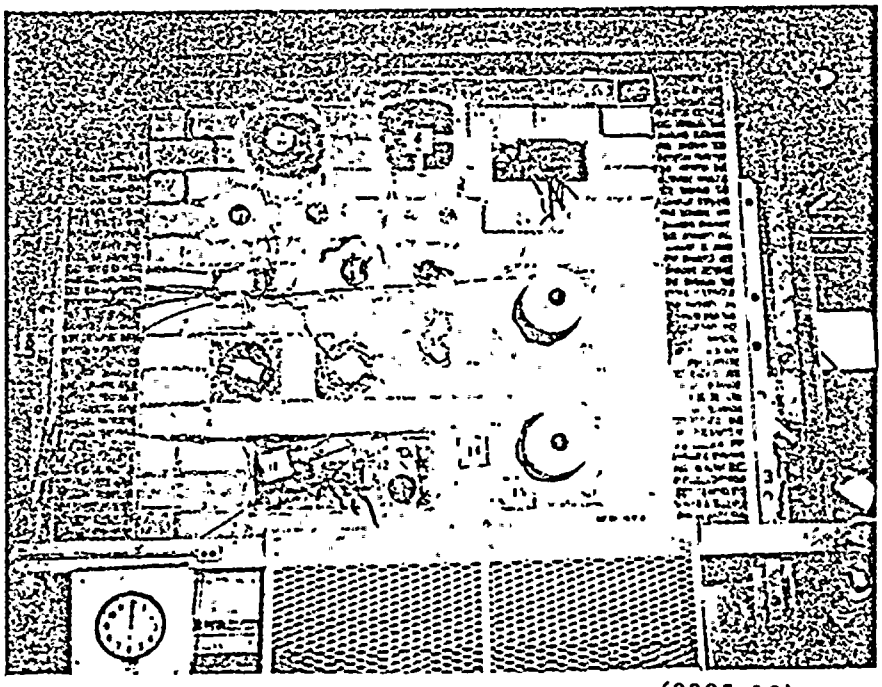


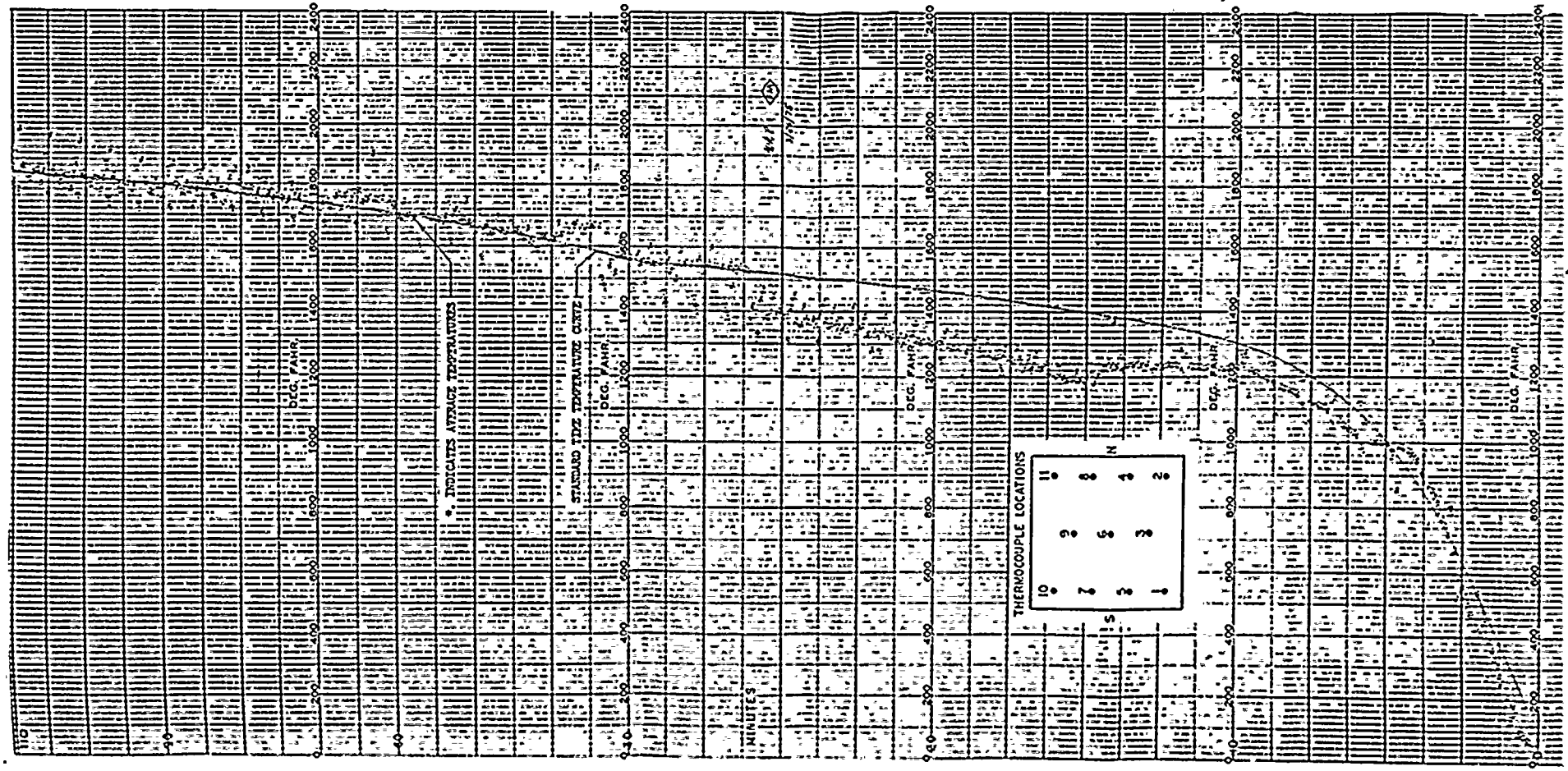
ILLUSTRATION 13

NEXPOSED SURFACE BEFORE
FIRE ENDURANCE TEST

(3385-12)

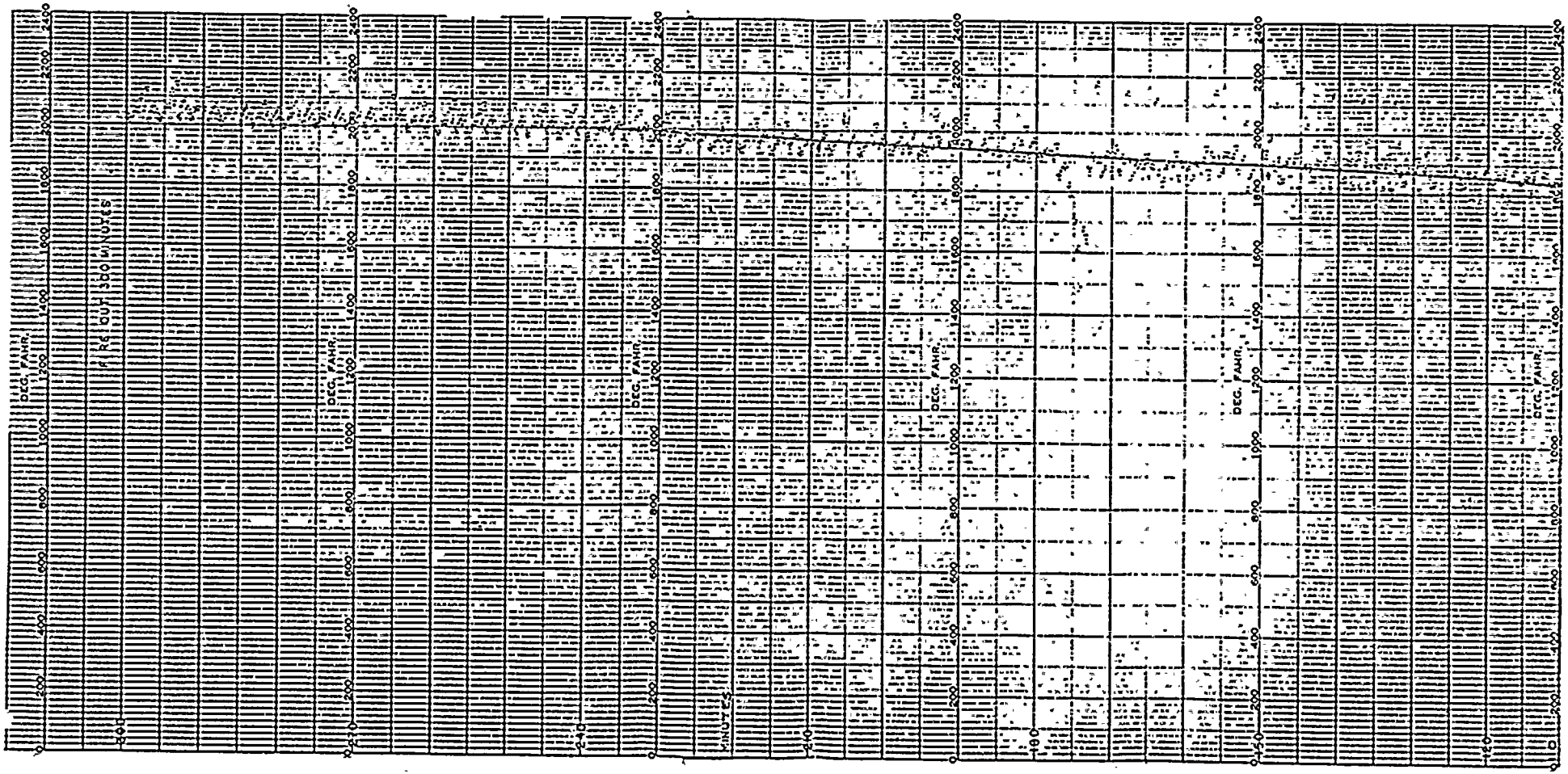
FURNACE TEMPERATURES
(0 to 110 min.)
MARCH 26, 1975
BRAND INDUSTRIAL SERVICES INC.

ILLUSTRATION 14 (Sheet 1 of 2)



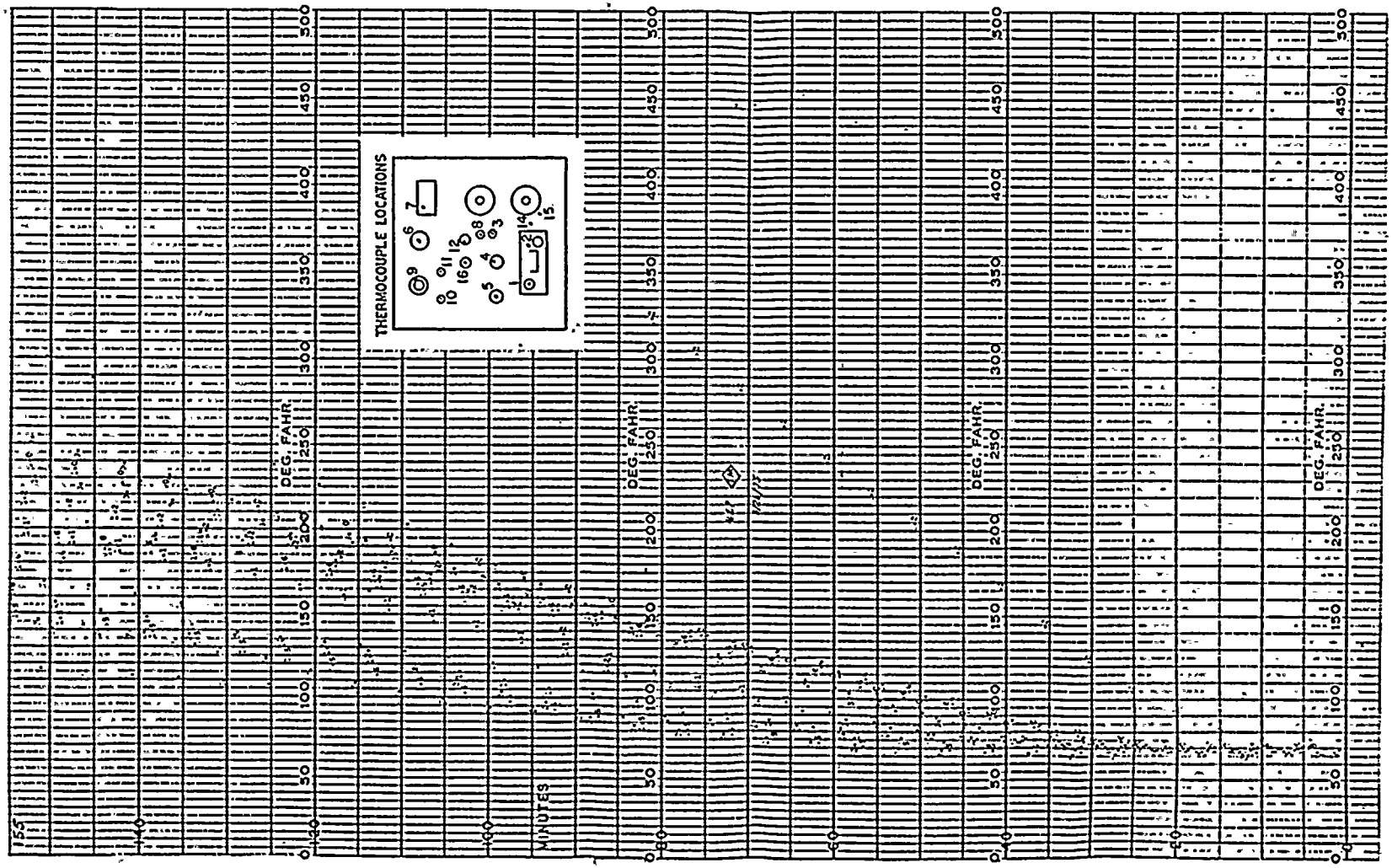
FURNACE TEMPERATURES
(110 min. to 300 min.)
FIRE ENDURANCE TEST
MARCH 26, 1975
BRAND INDUSTRIAL SERVICES INC.

ILLUSTRATION 14 (Sheet 2 of 2)



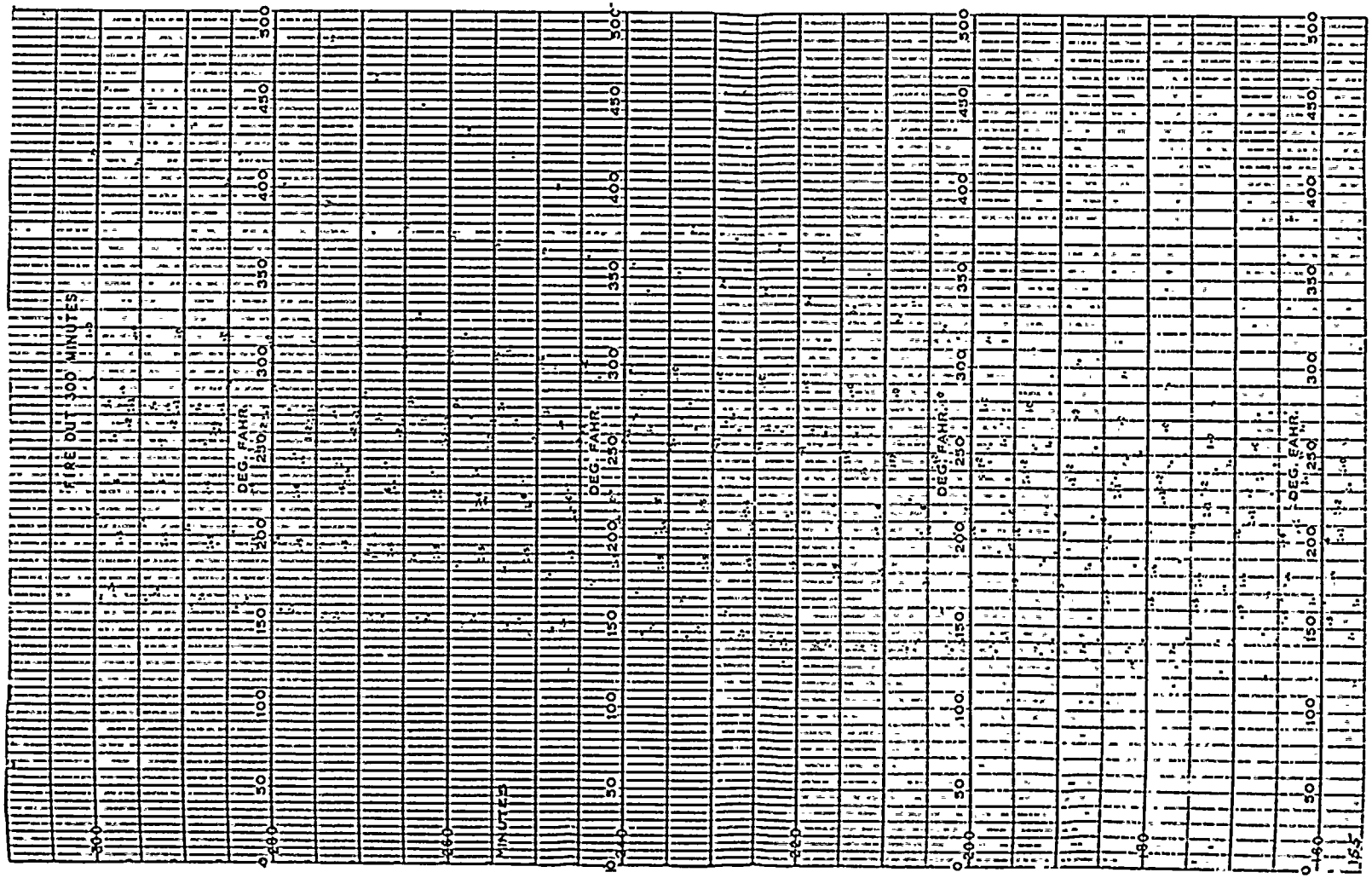
UNEXPOSED SURFACE TEMPERATURE
AT PENETRATION SEALS
(0 to 155 min.)
FIRE ENDURANCE TEST
MARCH 26, 1975
BRAND INDUSTRIAL SERVICES INC.

ILLUSTRATION 15 (Sheet 1 of 2)



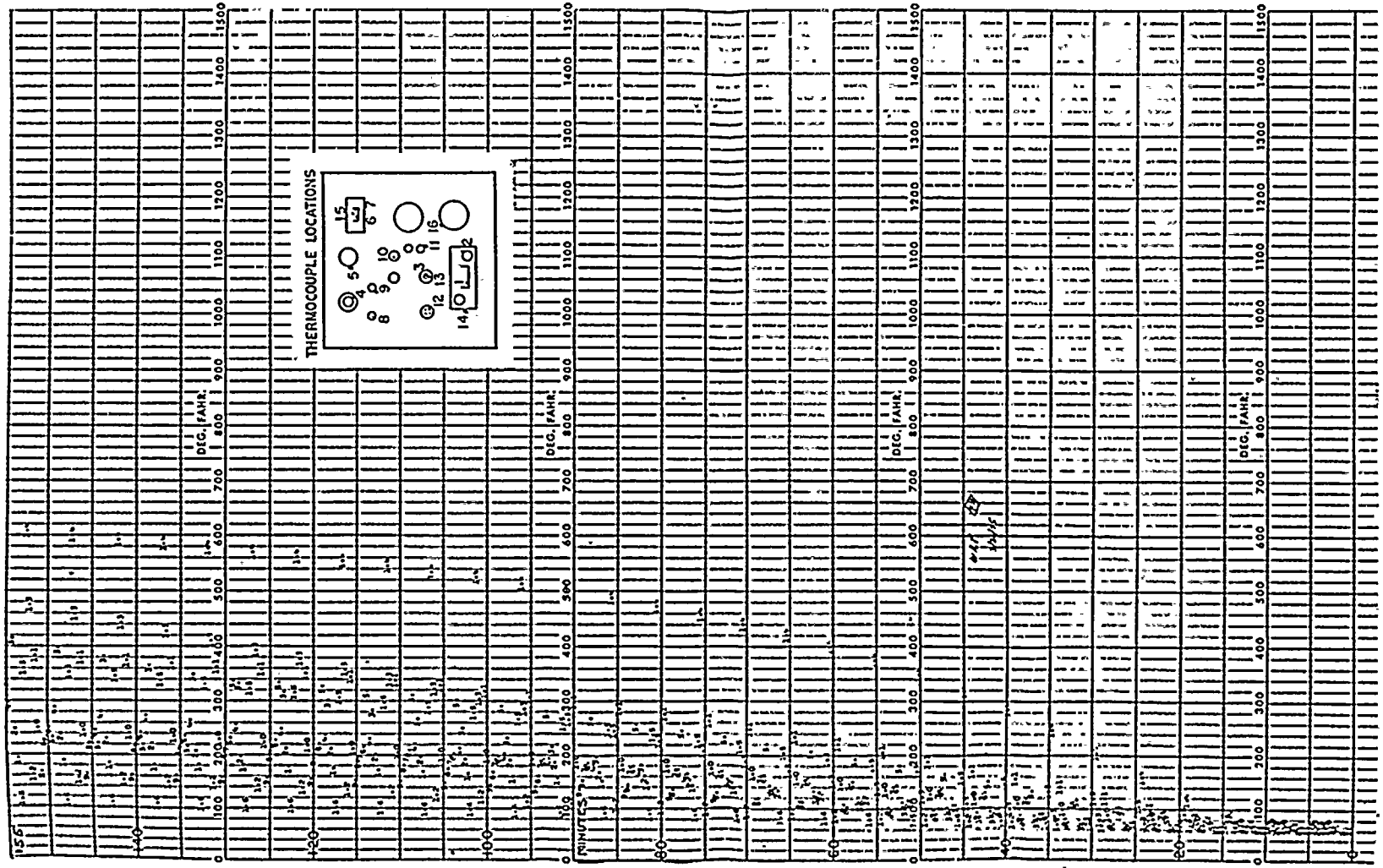
UNEXPOSED SURFACE TEMPERATURES
AT PENETRATION SEALS
(155 min. to 300 min.)
FIRE ENDURANCE TEST
MARCH 26, 1975
BRAND INDUSTRIAL SERVICES INC.

ILLUSTRATION 15 (Sheet 2 of 2)



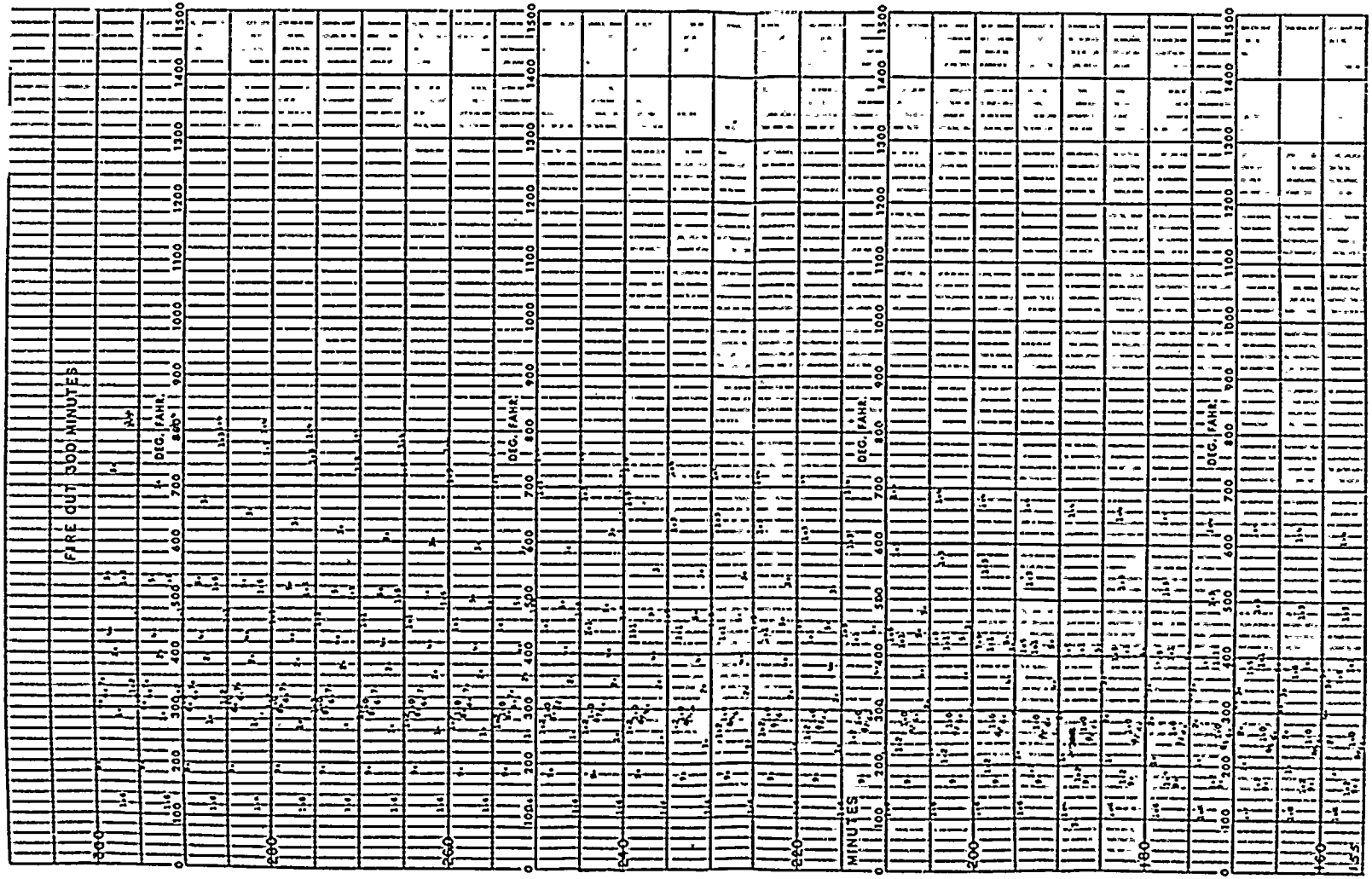
STEEL PIPE AND CABLE TEMPERATURES
(0 to 155 min.)
FIRE ENDURANCE TEST
MARCH 26, 1975
BRAND INDUSTRIAL SERVICES INC.

ILLUSTRATION 16 (Sheet 1 of 2)



STEEL PIPE AND CABLE TEMPERATURES
(155 min. to 300 min.)
FIRE ENDURANCE TEST
MARCH 26, 1975
BRAND INDUSTRIAL SERVICES INC.

ILLUSTRATION 16 (Sheet 2 of 2)



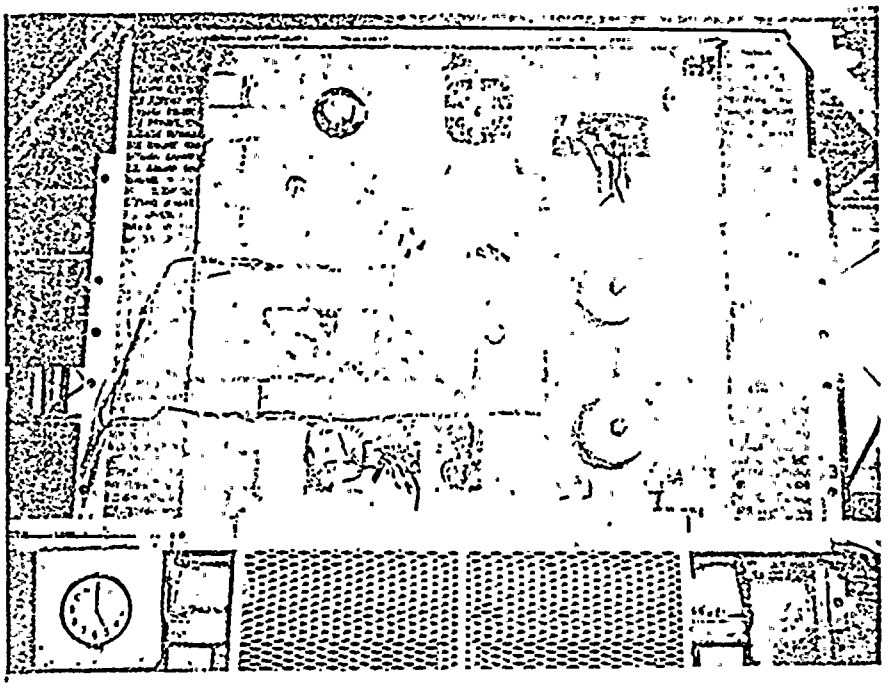


ILLUSTRATION 17

UNEXPOSED SURFACE
AT 5 HOURS OF EXPOSURE

(3385-13)

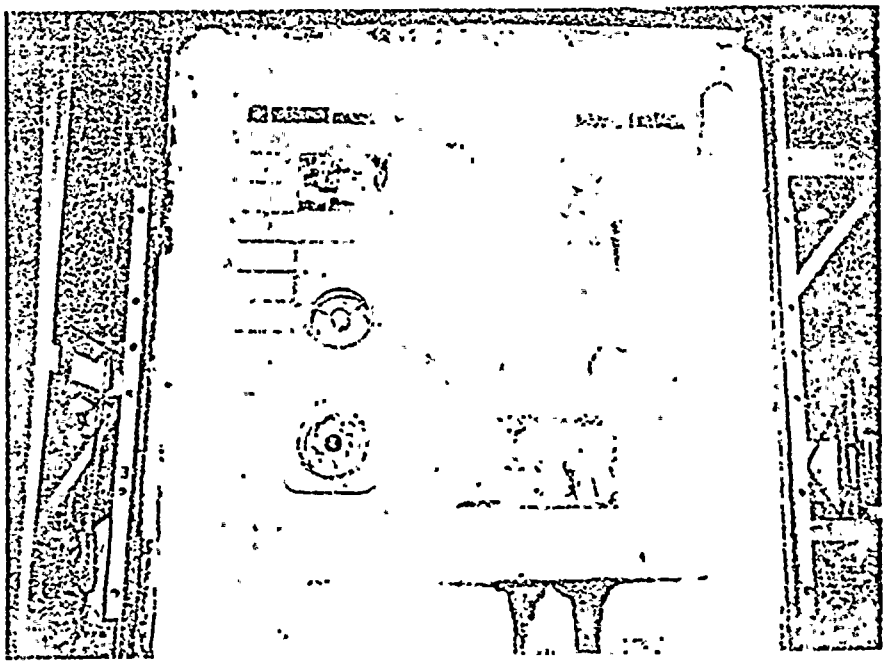


ILLUSTRATION 18

EXPOSED SURFACE AFTER
FIRE ENDURANCE TEST

(3385-14)

TEST BY:

Fire Technology Group
National Gypsum Co.
Design U 374

Report, Technical Supervision of Construction and Fire Test By:

W. R Price (JMK)

W. R. Price
Factory Mutual Project Engineer

REVIEWED BY:

W. F. Shield
Assistant Chief Materials Engineer
Codes/Ratings
Factory Mutual Research Corporation

ATTACHMENT: Appendix Sheets A1 - A4, B1 and C1 - C6.

WFS/mi