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REPORT

on

ELECTRICAL CIRCUIT PROTECTIVE MATERIALS

Under The
CLASSIFICATION PROGRAM

Minnesota Mining and Manufacturing Co.
St. Paul, Minnesota

G E N E R A L

The subject of this Report is the fire test investigation of electrical circuit protective systems installed beneath floor assemblies. The object of this investigation was to establish an hourly fire rating for the electrical circuit protective systems described in this Report.

The test program consisted of constructing two floor assemblies with various electrical circuit protective systems. The floor assemblies were subjected to fire exposure and hose stream tests in accordance with an American Nuclear Insurers (ANI) Standard entitled "ANI/MAERP Standard Fire Endurance Test Method To Qualify A Protective Envelope For Class 1E Electrical Circuits". The fire exposure and hose stream tests for Test Assembly Nos. 1 and 2 were conducted on December 21, 1982 and March 3, 1983, respectively.

The electrical circuit protective systems described herein are: (1) steel cable trays with various types and sizes of electrical cables wrapped in an intumescent mat material and surrounded by an intumescent sheet material enclosure on a steel framework; (2) electrical cable air drops wrapped with layers of an intumescent mat material; (3) rigid steel conduits containing various types and sizes of electrical cables wrapped with layers of an intumescent mat material, and (4) rigid steel conduits containing various types and sizes of electrical cables wrapped in an intumescent mat material and surrounded on three sides by an intumescent sheet material enclosure with the fourth side of the enclosure comprised of a concrete or masonry wall or a concrete floor.

The submitter's goal was to demonstrate that the electrical circuit protective systems would afford protection to the electrical circuits during a standardized fire exposure of 1 h duration followed by a standardized water hose stream test. Detailed summaries of each of the 1 h rated electrical circuit protective systems being promulgated from this investigation appear at the end of this Report.

A total of ten electrical circuit protective systems were included in the first test assembly described herein. Of the ten electrical circuit protective systems tested in the first test assembly, only four systems are being considered for Classification purposes. The remaining six systems were included to develop supplemental heat transfer, physical fire performance and circuit integrity data of a preliminary nature for possible future use. Only the data pertinent to the four electrical circuit protective systems intended for Classification, referenced as System Nos. 1 through 4 of Test Assembly No. 1, are included herein.

A total of four electrical circuit protective systems were included in the second test assembly described herein. Of the four electrical circuit protective systems tested in the second test assembly, only three systems were intended for Classification. The remaining system was included to develop supplemental heat transfer, physical fire performance and circuit integrity data of a preliminary nature for possible future use. Only the data pertinent to the three electrical circuit protective systems intended for Classification, referenced as System Nos. 1 through 3 of Test Assembly No. 2, are included herein.

The fire endurance and hose stream tests were supplemented with other tests and examinations which provided additional information relative to the physical and chemical properties of the materials used in the electrical circuit protective systems for future use in Follow-Up Service Inspection programs.

D E S C R I P T I O N

MATERIALS:

The following is a description of the materials used in the test assemblies.

TEST ASSEMBLY NO. 1

Floor Assembly - The floor assembly consisted of five separate steel-reinforced vermiculite concrete slabs. Two of the slabs measured 5 ft, 2 in. by 13 ft, 8 in. by 8 in. thick. The remaining three slabs were 1 ft, 8 in. by 13 ft, 8 in. by 8 in. thick.

Steel Junction Box - The UL Listed junction boxes used in System No. 1 and 4 each consisted of a five-sided box and a cover. The five-sided boxes measured 12 by 12 by 6 in. high and were formed of 0.077 in. thick (No. 14 gauge) painted steel. The boxes were each provided with two 11 in. long by 1-3/4 in. wide by 0.101 in. thick (No. 12 gauge) painted steel mounting plates which projected 3/4 in. beyond two opposing sides of the box. Each mounting plate was provided with two nominal 5/16 in. diameter mounting holes. The open top of the box was provided with a 3/8 in. wide hemmed edge around its perimeter. The junction box cover was 12-1/4 by 12-1/4 in. by 5/16 in. high and was formed of 0.082 in. thick (No. 13 gauge) painted steel. The interior of the cover was provided with a 3/4 in. wide by 3/16 in. thick neoprene rubber gasket around the entire perimeter. The cover was provided with a nominal 1/4 in. diameter hole at each corner for screw-attachment to the junction box.

Cable Tray System - The 12 in. wide open-ladder cable tray used in System No. 1 consisted of channel-shaped siderails and hat-shaped rungs. The siderails were 6 in. deep and were formed of 0.082 in. thick (No. 14 gauge) galvanized steel. The top and bottom flanges of the siderail were 3/4 in. wide. The hat-shaped rungs were 2-1/8 in. wide with a 1/2 in. high by 5/8 in. wide "crown" and were formed of 0.066 in. thick (No. 16 gauge) galvanized steel. The rungs were spaced 9 in. OC and were welded to the web and flange of the siderails at each end. The loading depth of the trays was 5-3/8 in. The trays were cut into 8 in. and 48 in. lengths for the horizontal and vertical runs, respectively.

The 12 in. wide 90° inside riser elbows used in the cable tray system each had an inside radius of 24 in., an outside radius of 30 in. and a tangent length of 32 in. The siderail members for each elbow were channel-shaped in cross-section with a web-height of 6 in., a top flange width of 3/4 in. and a bottom width of 5/8 in. The siderail members were formed of 0.082 in. thick (No. 14 gauge) galvanized steel. The elbows were provided with the same hat-shaped rungs used in the cable trays. The rungs were spaced nominally 9 in. OC and were welded to the web and bottom flange of the siderails of each end.

The connectors used to join the elbows and cable tray sections consisted of 3-3/4 by 6 by 0.107 in. thick (No. 12 gauge) galvanized steel plates. Each connector plate was provided with eight 3/8 in. diameter by 5/8 in. long slots which aligned with the four 3/8 in. diameter holes drilled at each end of the elbow and cable tray siderails.

Trapeze Support - The trapeze support used near the center of the horizontal run of the cable tray in System No. 1 consisted of a "U"-shaped welded assembly formed from No. 12 gauge Type P1000 Unistrut channels.

Steel Conduit Systems - The nominal 5 in. diameter rigid steel conduits used in System Nos. 2 and 3 were 5.576 in. in diameter with a wall thickness of 0.228 in. Each conduit system consisted of two 30 in. radius 90° elbows with threaded ends, two straight lengths each having one threaded end, three threaded steel couplings and two set-screw bushings.

The nominal 2 in. diameter rigid steel conduit used in System No. 4 had an outside diameter of 2.375 in. and a wall thickness of 0.142 in. The conduit system consisted of two 12 in. radius 90° elbows, two straight lengths, one set-screw connector, three set-screw couplings, two lock nuts and two bushings.

Cables - Three cable types were used in each electrical circuit protective system. The cable types used were single-conductor 300 MCM power cables, seven-conductor No. 12 AWG control cables and two-conductor No. 16 AWG control cables.

The single-conductor 300 MCM power cables consisted of thirty-seven 0.090 in. diameter copper strands. The conductor insulation was cross-linked polyethylene (XLPE). The cable jacket was polyvinyl chloride (PVC). The outside diameter of the cable was 0.890 in. No marking was present on the cable jacket.

Each strand of the seven-conductor No. 12 AWG cable consisted of a 0.079 in. diameter copper strand with XLPE insulation. The outside diameter of each conductor was 0.140 in. The seven conductors were covered with a mylar wrap and the cable jacket was PVC. The outside diameter of the cable was 0.557 in. No marking was present on the cable jacket.

Each conductor of the two-conductor No. 16 AWG cable consisted of a 0.051 in. diameter copper strand with XLPE insulation. The outside diameter of each conductor was 0.109 in. The fillers within the cable construction were polyester strands. The conductors and fillers were encased in a PVC jacket. The outside diameter of the cable was 0.312 in. No marking was present on the cable jacket.

Steel Framing - The steel framing around the junction box and cable tray of System No. 1 consisted of No. 14 gauge Types A1000 and A3300 Unistrut channels and Types A1065, A2223 and modified A2227 Unistrut fittings. The Type A3300 Unistrut channels forming the top and bottom "U"-shaped members at the corners of the longitudinal steel framing around the cable tray were each preassembled and welded prior to installation. The enclosures were assembled using 3/8 in. diameter by 3/4 in. long hex head cap screws in conjunction with Type A3008 Unistrut nuts.

Intumescent Sheets - The foil-faced, sheet-metal backed intumescent elastomeric material sheets used to protect the junction boxes in System Nos. 1 and 4 and used at the interface of each electrical circuit protective system with the underside of the floor, were supplied in nominal 36 in. by 36 in. by 1/4 in. thick sheets. The sheets, manufactured by Minnesota Mining and Manufacturing Co. and designated "Type CS-195", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Threaded Rods - The threaded rods, used to support the steel junction boxes and the intumescent sheets at the floor/protective envelope interface, were nominal 3/8 in. diameter by 12 in. long zinc-plated threaded steel rods.

Intumescent Mat - The flexible foil-faced intumescent mat material, used to protect the cable air drop of System No. 1 and to protect the steel conduits of System Nos. 2, 3 and 4, was nominal 1/4 in. thick and was supplied in nominal 48 in. wide rolls. The flexible foil-faced intumescent mat material was also supplied in 4 in. wide rolls for use as a joint cover for the protective enclosures around the steel junction boxes. The intumescent mat, manufactured by Minnesota Mining and Manufacturing Company and designated "Type M20A", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Hardware Cloth - The hardware cloth consisted of 0.041 in. diameter (No. 19 AWG) galvanized steel wires welded to form a 1/2 in. square grid. The hardware cloth, manufactured by Gilbert & Bennet, Blue Island, Illinois and identified as Code No. 453035, was supplied in nominal 12 in. and 24 in. wide by 100 ft long rolls.

Fasteners - The fasteners, used to secure the intumescent sheet to the steel framing of System No. 1 and to the junction box of System No. 4, were No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws in conjunction with 5/8 in. diameter steel washers.

Banding Strap - The carbon steel banding straps used to secure the intumescent sheet and joint treatment to the junction boxes, were 5/8 in. wide by 0.020 in. thick. The 1 in. long channel-shaped crimp clips, used in conjunction with the banding strap, were 11/16 in. deep with 1/4 in. flanges. The clips were formed of 0.021 in. thick electro-galvanized steel.

Ceramic Cord - The ceramic cord, used to secure the intumescent mat to the conduits and cable air drop, was supplied in 4 in. diameter by 12 in. high spools containing 1400 lin ft of cord. The cord, manufactured by Minnesota Mining and Manufacturing Company and designated "Type 34", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Caulk - The caulk, used to seal the joints of the intumescent sheets and as part of the floor firestop system, was supplied in 10-1/2 oz cartridges. The caulk, manufactured by Minnesota Mining and Manufacturing Company and designated "Type CP-25", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Foil Tape - The 3 in. wide pressure-sensitive aluminum foil tape was supplied in rolls. The tape, manufactured by Minnesota Mining and Manufacturing Company and designated "Type 425", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

TEST ASSEMBLY NO. 2

The floor assembly used for Test Assembly No. 2 was the same floor that was used for Test Assembly No. 1. The nominal 5 in. diameter rigid steel conduit system, threaded steel rods, intumescent sheets, intumescent mat, steel hardware cloth, fasteners, banding straps, ceramic cord, caulk and aluminum foil tape used in Test Assembly No. 2 were the same as those used in Test Assembly No. 1.

Junction Box - The junction box, used in System No. 3 was 12 in. wide by 16 in. long by 6 in. high and was formed of 0.076 in. thick (No. 14 gauge) painted steel. The box was provided with a 2 in. wide by 2-1/2 in. long by 0.180 in. thick (No. 7 gauge) painted steel mounting foot at each corner. The hinged cover of the junction box was 10 in. wide by 14 in. long by 1 in. high and was formed of 0.076 in. thick (No. 14 gauge) painted steel. The cover was provided with two screw-tightened latching mechanisms and a hasp for locking.

Steel Conduit System - The nominal 2 in. diameter rigid steel conduit, used in System No. 3, had an outside diameter of 2.375 in. and a wall thickness of 0.142 in. The conduit system consisted of a 12 in. radius 90° elbow, a straight length, one set-screw connector, one set-screw coupling, two lock nuts and two bushings.

Cable Tray System - The 24 in. wide open-ladder cable tray used in System No. 1 consisted of channel-shaped siderails and boxed-channel rungs. The siderails were 4 in. deep and were formed of 0.061 in. thick (No. 16 gauge) galvanized steel. The top flange of the siderail was 1-3/8 in. wide with a 3/8 in. stiffening flange. The bottom flange of the siderail was 7/8 in. wide with a 1/4 in. stiffening flange. The boxed-channel rungs were 3/4 in. wide by 1 in. deep and were formed of 0.034 in. thick (No. 22 gauge) galvanized steel. The ends of each rung were notched to accommodate the stiffening flange on the bottom flange of each siderail. The rungs were spaced 6 in. OC and were welded to the web of the siderails at each end. The loading depth of the trays was 2-7/8 in. The trays were provided in 34 in. and 61 in. lengths for the horizontal and vertical runs, respectively.

The 24 in. wide 90° inside riser elbows, used in the cable tray system, each had an inside radius of 12 in., an outside radius of 16 in. and a tangent length of 19 in. The siderail members for each elbow were channel-shaped in cross-section with a web-height of 4 in., a top flange width of 3/4 in. and a bottom width of 5/8 in. The siderail members were formed of 0.061 in. thick (No. 16 gauge) galvanized steel. The elbows were provided with the same boxed-channel type rungs used in the cable trays. The rungs were spaced nominally 6 in. OC and were welded to the web and bottom flange of the siderails of each end.

The connectors, used to join the elbows and cable tray sections, consisted of 3-3/4 by 6 by 0.107 in. thick (No. 12 gauge) galvanized steel plates. Each connector plate was provided with eight 3/8 in. diameter by 5/8 in. long slots which aligned with the four 3/8 in. diameter holes provided at each end of the elbow and cable tray siderails.

The cable trays, elbows and connectors were manufactured by Chalfant Manufacturing Company, Cleveland, Ohio.

Trapeze Support - The trapeze support, used at the center of the horizontal run in System No. 1, consisted of a "U"-shaped welded assembly formed from Type P1000 Unistrut channels.

Cables - Three cable types were used in the various cable tray and conduit systems. The cable types used were single-conductor 300 MCM power cables, seven-conductor No. 12 AWG control cables and two-conductor No. 16 AWG control cables.

The single-conductor 300 MCM power cables consisted of thirty-seven 0.090 in. diameter copper strands. The stranded conductor was encased in a mylar film. The conductor insulation was cross-linked polyethylene (XLPE). The outside diameter of the cable insulation was 0.755 in. The cable insulation was marked "300 MCM CU XLP Type XHHW 600V (UL) E-11486".

Each conductor of the seven-conductor No. 12 AWG cable consisted of seven 0.030 in. diameter copper strands stranded together and covered with a celophane wrap and XLPE insulation. The outside diameter of each conductor was 0.158 in. The fillers within the cable construction consisted of six nominal 0.052 in. diameter PVC filler strands. The fillers and conductors were encased in a cellophane wrap and covered with a PVC jacket. The outside diameter of the cable was 0.623 in. The cable jacket was marked "12 AWG TYPE TC XHHW CDRS. SUNLIGHT RESISTANT 600 V E60749 (UL) DIRECT BURIAL".

Each conductor of the two-conductor No. 16 AWG cable consisted of sixteen 0.010 in. diameter soft annealed tinned copper strands stranded together and covered with a tissue paper wrap and XLPE insulation. The outside diameter of each conductor was 0.084 in. The fillers within the cable construction were hemp. The fillers and conductors were wrapped in tissue paper and covered with a PVC jacket. The outside diameter of the cable was 0.245 in. The cable jacket was marked "MULTICONDUCTOR POWER CONTROL (UL) 16 AWG 600 V 90 C UL FR-1 NEC340".

Steel Framing - The steel framing for the cable tray of System No. 1 and for the junction box of System No. 3 consisted of No. 14 gauge, Types A1000 and A3300 Unistrut channels and Types A1065, A2223 and modified A2227 Unistrut fittings. The Type A3300 Unistrut channels forming the top and bottom "U"-shaped members at the corners of the longitudinal steel framing around the cable tray were each preassembled and welded prior to installation. The enclosures were assembled using 3/8 in. diameter by 3/4 in. long hex head cap screws in conjunction with Type A3008 Unistrut nuts.

Putty - The putty used in conjunction with the composite fire barrier sheet at the interface of the electrical circuit protective systems with the floor, was manufactured by Minnesota Mining and Manufacturing Company and designated "Type 303", the putty is Classified as a "Fill, Void or Cavity Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

ERECTION OF TEST ASSEMBLIES:

TEST ASSEMBLY NO. 1

The full-scale floor test assembly was constructed in accordance with the methods specified by the submittor, as shown in ILLS. 1 through 20. The construction of the test assembly was observed by members of the technical and engineering staff of Underwriters Laboratories Inc.

Nominal 6 by 6 by 1/2 in. thick structural steel angles were placed along the walls of the test frame such that the top of the horizontal leg was 8 in. below the top edges of the test frame. The five reinforced vermiculite concrete floor slabs were installed in the test frame as shown in ILL. 1. Prior to installation of the floor slabs, nominal 1-1/4 in. thick mineral-wool batts were placed over the structural steel angles to form a smoke and heat seal. The average bearing of each floor slab on the structural steel angles was 4-1/2 in. A 6 in. separation was maintained between adjacent floor slabs to accommodate the electrical circuit systems.

Two W4X13 steel beams, 17 ft long, were placed over the top of the floor slabs as shown in ILL. 1. The beams rested on and were secured to the projecting steel reinforcement of each slab (bottom chord of inverted Type 8H2 steel joist) to prevent differential deflection of the various slabs during fire exposure.

The location of the various electrical circuit protective systems in the floor assembly is shown in ILL. 2.

The nominal 12 in. wide cable tray system into which the cable air drop from System No. 1 projected was assembled into a "U"-shape as shown in ILL. 3. The cable tray system was assembled with steel connectors in conjunction with 3/8 in. diameter by 3/4 in. long steel carriage bolts and steel lock nuts. After assembly, the system was lifted through the nominal 6 in. slots in the floor and was oriented such that it projected 36 in. above and below the floor slabs. The cable tray system was suspended by means of nominal 3 by 3 by 1/4 in. steel angles, 20 in. long, spanning across the projecting steel reinforcement of the floor slabs and welded to the cable tray siderails, as shown in ILL. 3. The cable tray system was additionally supported by means of a welded trapeze support formed of Type P1000 Unistrut channels at the center of the horizontal run, as shown in ILL. 3. The Unistrut trapeze support was secured to the floor using Type P2072 Unistrut fittings in conjunction with 3/8 in. diameter threaded steel rods with nuts and steel washers.

Prior to installation of the steel junction boxes for System Nos. 1 and 4, 2-3/8 in. diameter holes for the nominal 2 in. diameter Trade Size steel conduit were die-cut in the center of the bottom and cover of each junction box. In order to effect a good seal with the underside of the floor, a 15 in. square piece of intumescent sheet with a nominal 3 in. diameter hole at its center was installed as a gasket between the underside of the floor and the bottom surface of the five-sided box. First, a nominal 1 in. wide band of Type CP-25 caulk was applied around the entire perimeter of the junction box at its bottom. The aluminum foil-faced side of the nominal 15 in. square piece of intumescent sheet was then pressed into the Type CP-25 caulk. Each steel junction box was then secured to the underside of the floor using four nominal 3/8 in. diameter threaded steel rods in conjunction with steel nuts and 1-1/4 in. diameter steel washers, as shown in ILLS. 4 and 6.

The nominal 2 in. diameter rigid steel conduit for System No. 4 was installed as shown in ILL. 6. The vertical leg of the nominal 2 in. diameter rigid steel conduit projected 36 in. above the top of the floor and was secured in place by means of nominal 3 by 3 by 1/4 in. steel angles, 20 in. long, spanning across the projecting steel reinforcement of the floor slabs and welded to the sides of the conduit, as shown in ILL. 6.

The nominal 5 in. diameter rigid steel conduits for System Nos. 2 and 3 were each assembled into a "U" shape as shown in ILL. 5. The conduits were assembled with threaded steel connectors. The two open ends of each conduit were provided with bushings. After assembly, the systems were lifted through the nominal 6 in. slots in the floor and were oriented such that they projected 36 in. above and below the floor slabs. The conduit systems were suspended by means of nominal 3 by 3 by 1/4 in. steel angles 20 in. long, spanning across the projecting steel reinforcement of the floor slabs and welded to the conduit sides, as shown in ILL. 5.

With the exception of System No. 4, three cable types were installed in each electrical circuit system. The single-conductor 300 MCM cables were cut-to-size and installed individually in the electrical circuit systems. The seven-conductor No. 12 AWG and the two-conductor No. 16 AWG cables were each looped back-and-forth and installed in the system in bundles.

The cable group for System No. 1 was bundled together with nylon ties spaced approximately 18 in. OC prior to installation. The cable group passed through the steel junction box and projected 36 in. above the top surface of the floor. The opposite end of the cable group draped over to the elbow of the cable tray system, on top the cables in the cable tray, and extended through the floor opening to a point 36 in. above the top surface of the floor, as shown in ILL. 4.

The cable groups installed in the conduits of System Nos. 2, 3 and 4 were bundled together with nylon ties spaced approximately 18 in. OC. The cable groups were then installed in the conduit systems such that each end of the cable group projected 36 in. above the top surface of the floor.

The total quantity of each cable type installed in each system is tabulated below:

	Quantity of Cables Used		
System Number	300 MCM	7/C-12 AWG	2/C-16 AWG
1 (Air Drop)	2	2	2
1 (Cable Tray)	12	31	114
2	4	11	42
3	1	1	1
4	-	1	1

After installation of the cable tray, conduits, junction boxes and cables, the four nominal 6 in. wide slots in the floor assembly containing the vertical legs of the various systems were filled with vermiculite concrete as a firestop. Removable forms were placed beneath each slot, flush with the underside of the floor slab. Small pieces of mineral-wool batt were stuffed between the edges of the forms and the cables to minimize leakage of the vermiculite concrete. Nominal 7 in. lengths of nominal 1/2 in. diameter deformed steel rods were wedged into each slot to act as reinforcement. The vermiculite concrete, composed of five parts expanded vermiculite aggregate to one part Portland cement, by bulk volume, and mixed with water, was pumped into the slots and struck with a trowel. After drying for 24 h, the forms were removed from the underside of the assembly.

The steel framing for the protective enclosure around the cable tray of System No. 1 was installed as shown in ILLS. 7 through 10 As shown in ILLS. 9 and 10, a gasket formed from intumescent sheet and caulk was installed between the steel framing and the underside of the floor at both ends of the cable tray system. The steel framing was installed such that no contact was made between the framing and the cable tray system except at the trapeze support. Intumescent sheet was cut-to-size and screw-attached to the steel framing (aluminum foil face on exterior) with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers, as shown in ILLS. 8 and 11. The screws were located at each corner of the sheets to hold each sheet in position. The section of the protective enclosure containing the cable air drop was left open. After installation of the protective wrap on the cable air drop, the protective enclosure around the cable tray was completed. A bead of caulk was applied over the butted joints of the intumescent sheet and each joint was covered with a layer of 4 in. wide intumescent mat (aluminum foil face on exterior) and a 4 in. wide strip of steel hardware cloth, as shown in ILLS. 8, 11 and 12. The intumescent mat and steel hardware cloth were secured to the intumescent sheet with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter washers spaced approximately 6 in. OC. The intumescent sheets and joint covers were additionally secured in place with steel banding straps wrapped around the enclosure and spaced approximately 6 to 8 in. OC, as shown in ILL. 8. The steel banding straps were secured with crimp clips and were covered with aluminum foil tape. As a final step, an 8 in. wide strip of intumescent mat (aluminum foil face on exterior) and an 8 in. wide strip of steel hardware cloth were formed into an angle with 2 in. and 6 in. legs and was installed at the interface of the protective enclosure and the underside of the floor around the entire perimeter of the protective enclosure, as shown in ILL. 10. The 2 in. legs of the intumescent mat and steel hardware cloth angles were secured to the intumescent sheets of the protective enclosure with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers and with a supplemental steel banding strap. The 6 in. legs of the intumescent mat and steel hardware cloth angles were secured to the underside of the floor with Type 8d coated sinker nails in conjunction with 5/8 in. diameter steel washers.

A thick bead of caulk was applied around the trapeze support at its two points of egress from the protective enclosure around the cable tray. The two vertical legs of the trapeze support were each protected with two wraps of intumescent sheet (aluminum foil face on exterior), as shown in ILL. 13. The first layer of intumescent mat was secured in place with aluminum foil tape along the vertically-oriented seam. The second layer of intumescent mat was installed such that its vertically-oriented seam was diametrically opposed from that of the first layer. The second layer of intumescent mat was secured in place with aluminum foil tape and was additionally wrapped in a criss-cross pattern with ceramic cord on 2 in. centers. The trapeze support/floor interface was protected as shown in ILL. 14.

The steel framing for the protective enclosure around the junction box of System No. 1 was installed as shown in ILL. 15. The steel framing of the protective enclosure was in contact with the intumescent sheet gasket sandwiched between the steel junction box and the underside of the floor. The steel framing was installed such that no contact was made between the framing and the junction box. Intumescent sheet was cut-to-size and screw-attached to the steel framing (aluminum foil face of exterior) with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers. The screws were located at each corner of the sheet to hold each sheet in position. The bottom of the protective enclosure containing the cable air drop was left open. After installation of the protective wrap on the cable air drop, the protective enclosure around the junction box was completed. A bead of caulk was applied over the butted joints of the intumescent sheets and each joint was covered with a layer of 4 in. wide intumescent mat (aluminum foil faced on exterior) and a 4 in. wide strip of steel hardware cloth. The intumescent mat and steel hardware cloth were secured to the intumescent sheet with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter washers spaced approximately 3 in. OC. The intumescent sheets and joint covers were additionally secured in place with a steel banding strap wrapped around the top and bottom of the enclosure and secured with crimp clips. As a final step, an 8 in. wide strip of intumescent mat (aluminum foil face on exterior) and an 8 in. wide strip of steel hardware cloth were formed into an angle with 2 in. and 6 in. legs and was installed at the interface of the protective enclosure and the underside of the floor around the entire perimeter of the enclosure, as shown in ILL. 16. The 2 in. legs of the intumescent mat and steel hardware cloth angles were secured to the intumescent sheet of the protective enclosure with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws and a steel banding strap. The 6 in. legs of the intumescent mat and steel hardware cloth angles were secured to the underside of the floor with Type 8d coated sinker nails in conjunction with 5/8 in. diameter steel washers.

The cable air drop, extending from the steel junction box to the cable tray of System No. 1, was protected with five wraps of intumescent mat installed in the same manner as the wraps on conduit, as shown in ILL. 17. Each layer of mat was wrapped around the cable air drop and secured in position with steel staples spaced maximum 3 in. OC along the longitudinal seam. Adjacent lengths of intumescent mat overlapped the preceding length by 1 to 3 in. Succeeding layers of intumescent mat were installed in the same fashion with the stapled longitudinal seam of each layer diametrically opposed from that of the preceding layer. The overlap locations for each succeeding layer was offset a minimum of 6 in. from the overlap of the preceding layer. The fifth layer of intumescent mat on the cable air drop was wrapped with aluminum foil tape and was additionally secured with ceramic cord criss-crossed and spaced 2 in. OC in both directions. The five layer intumescent mat wrap on the cable air drop extended 9 in. into the protective envelope of the cable tray and projected into the protective enclosure of the junction box such that it butted against the bottom of the junction box. The crescent-shaped opening in the protective enclosure for the cable tray and junction box to accommodate the cable air drop was nominally 7-1/4 in. long by maximum 3-3/4 in. wide. After installation of the intumescent sheets completing the protective envelopes for the cable tray and junction box of System No. 1, a wide bead of caulk was applied around the periphery of the intumescent mat wrap on the cable air drop at its interface with the protective envelopes. The cable air drop/protective envelope interface was then covered with aluminum foil tape.

The nominal 5 in. diameter rigid steel conduit of System Nos. 2 and 3 were each protected with three layers of intumescent mat, installed as shown in ILL. 17. Starting at the top of one of the vertical legs, a length of intumescent mat was cut to the required width and wrapped around the steel conduit such that the longitudinal seam was oriented on the side of the conduit. The intumescent mat wrap abutting the underside of the floor was slit 4 in. parallel with the longitudinal seam at 4 in. intervals around the perimeter of the wrap and folded 90° such that the flaps were against the underside of the assembly. The longitudinal seam of the intumescent mat wrap was secured using aluminum foil tape. Adjacent lengths of intumescent mat overlapped the preceding length a minimum of 1/2 to 3 in. The various lengths of intumescent mat wrap continued around the conduit system up to the other vertical leg's interface with the floor. At the floor interface, the intumescent mat wrap was slit in the same manner as at the other vertical leg. Each successive layer was installed in the same manner as the first layer with the longitudinal seam of each layer diametrically opposed to the longitudinal seam of the preceding layer and with the overlap locations for each succeeding layer offset a minimum of 6 in. from the overlap of the preceding layer. After all three layers were installed, nominal 4 by 8 in. pieces of intumescent mat were folded 90° and installed around the perimeter of the outermost wrap at the interface with the floor. Each folded piece overlapped the preceding piece approximately 1/2 to 1 in. and was secured to the conduit wrap with aluminum foil tape. After the perimeter treatment was completed, two pieces of intumescent sheet were cut to conform to the contours of the conduit wrap and to cover the perimeter wrap. The two-piece intumescent sheet cover extended approximately 6 in. beyond the conduit wrap and was held in place with 3/8 in. diameter threaded steel rods installed through the floor slab and secured with steel nuts in conjunction with 1-1/4 in. diameter steel washers, as shown in ILL. 18. As a final step, the conduit wrap was loosely tied with ceramic cord which criss-crossed in both directions and was spaced a maximum of 2 in. OC.

The junction box of System No. 4 was protected with intumescent sheet directly-attached to the sides and bottom of the junction box as shown in ILL. 16. The intumescent sheets were attached to the sides and bottom of the junction box with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers at each corner of the sheets. A bead of caulk was applied over each butted joint at the corners of the box and each joint was covered with a layer of 4 in. wide intumescent mat and 4 in. wide steel hardware cloth in the same manner as done for the steel junction box of System No. 1. The steel junction box/floor interface was also protected in the same manner as done for the steel junction box of System No. 1.

The five layers of intumescent mat wrap on the nominal 2 in. diameter rigid steel conduit was installed in the same manner as described for the nominal 5 in. diameter rigid steel conduits of System Nos. 2 and 3. The ends of the mat at the interface with both the floor and the bottom of the junction box were slit and flared out. The end of the protective wrap on the nominal 2 in. diameter conduit at the interface with the floor was protected with a perimeter treatment of intumescent mat in the same manner as was done for the nominal 5 in. diameter conduits in System Nos. 2 and 3. At the interface with the bottom of the junction box, nominal 4 in. wide pieces of steel hardware cloth were folded 90° and installed with the horizontal leg over the flaps of the intumescent mat and with the vertical leg against the conduit wrap. The hardware cloth was secured to the bottom of the junction box with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws in conjunction with 5/8 in. diameter steel washers.

On the unexposed side of the assembly, the open ends of the nominal 5 in. diameter rigid steel conduit of System No. 2 and the open end of the nominal 2 in. diameter rigid steel conduit of System No. 4 were sealed with Type CP-25 caulk. The open end of the nominal 5 in. diameter rigid steel conduit of System No. 3 was sealed with a cap formed from intumescent sheet with the steel backing removed and sealed around the periphery with Type CP-25 caulk. The through openings in the floor for passage of the cables and conduit ends of System Nos. 1 and 4 were sealed with vermiculite concrete.

The appearance of the exposed surface before the fire test is shown in ILLS. 19 and 20.

TEST ASSEMBLY NO. 2

The full-scale floor test assembly was constructed in accordance with the methods specified by the submittor, as shown in ILLS. 7 through 18 and 25 through 31. The construction of the test assembly was observed by members of the technical and engineering staff of Underwriters Laboratories Inc.

The same floor assembly from Test Assembly No. 1 was used for Test Assembly No. 2. After the fire test of Test Assembly No. 1, the vermiculite concrete grout was removed from the 6 in. separation between floor slabs and the cable trays, steel conduits and junction boxes were removed from the assembly.

The location of the various electrical circuit protective systems in the floor assembly is shown in ILL. 25.

The cable tray system for System No. 1 was assembled into a "U"-shape as shown in ILL. 26. The cable tray system was assembled with steel connectors in conjunction with 3/8 in. diameter by 3/4 in. long steel carriage bolts and steel lock-nuts. After assembly, the system was lifted through the nominal 6 in. slots in the floor and was oriented such that it projected 36 in. above and below the floor slabs. The cable tray system was suspended by means of nominal 3 by 3 by 1/4 in. steel angles, 20 in. long, spanning across the projecting steel reinforcement of the floor slabs and welded to the cable tray siderails, as shown in ILL. 26. The cable tray was additionally supported at the center of its horizontal run by a steel trapeze support installed as shown in ILL. 26.

The nominal 5 in. diameter rigid steel conduit for System No. 2 was assembled into a "U"-shape as shown in ILL. 27. The conduit was assembled with threaded steel connectors. The two open ends of the conduit were provided with bushings. After assembly, the conduit system was lifted through the nominal 6 in. slots in the floor and was oriented such that it projected 36 in. above and below the floor slabs. The conduit system was suspended be means of nominal 3 by 3 by 1/4 in. steel angles, 20 in. long, spanning across the projecting steel reinforcement of the floor slabs and welded to the conduit sides, as shown in ILL. 27.

Prior to installation of the steel junction box for System No. 3, two nominal 2-3/8 in. diameter holes for the nominal 2 in. diameter Trade Size steel conduit were die-cut in the bottom and side of the steel enclosure as shown in ILL. 28. The steel junction box was attached to the underside of the floor with 3/8 in. diameter threaded steel rods passing through the floor and secured with steel lock-nuts in conjunction with 1-1/4 in. diameter steel washers. The nominal 2 in. diameter rigid steel conduit was then installed as shown in ILL. 28. The vertical leg of the conduit elbow projected approximately 3 in. above the top surface of the floor.

Three cable types were installed in the cable tray of System No. 1. A total of 11 single-conductor 300 MCM cables were cut-to-size and installed individually along the west third of the cable tray. The seven-conductor No. 12 AWG and the two-conductor No. 16 AWG cables were each looped back-and-forth such that the cable loading for each cable type was comprised of an individual cable. A total of 13 runs of the seven-conductor No. 12 AWG cables were installed along the east third of the cable tray system. A total of 30 runs of the two-conductor No. 16 AWG cables were installed in the center third of the cable tray system. Each cable installed in the cable tray system was tightly secured to every other rung of the cable tray system with nylon ties. The cable fill resulted in a single layer of cables across the entire width of the cable tray system.

In addition to the single layer fill, 12 in. lengths of the three cable types were placed in the horizontal portion of the cable tray system, evenly distributed across two cable tray rungs, as shown in ILLS. 8 and 26. A total of twenty-three 12 in. lengths of 300 MCM cable, forty-four 12 in. lengths of seven-conductor No. 12 AWG cables and 220 12 in. lengths of two-conductor No. 16 AWG cables were installed. The cable lengths were tightly packed and completely filled the cable tray flush with the top plane of the cable tray siderails. The total weight of the 12 in. lengths of cable installed in the cable tray system was 46.2 lb.

In System No. 2, one 300 MCM cable, one seven-conductor No. 12 AWG cable and two two-conductor No. 16 AWG cables were grouped together and bundled with nylon ties. The cable bundle was then installed in the rigid conduit.

Two cable types were installed in the junction box and conduit of System No. 3. One seven-conductor No. 12 AWG cable and two two-conductor No. 16 AWG cables were grouped together and bundled with nylon ties spaced approximately 18 in. OC. The cable bundle passed through the conduit and junction box with each end of the cable projecting through the floor and extending 36 in. above the floor surface.

After installation of the cable tray, conduits and junction box, the four nominal 6 in. wide slots in the floor assembly containing the vertical legs of the cable tray and conduit systems were filled with vermiculite concrete as a firestop. Removable forms were placed beneath each slot, flush with the underside of the floor slab. A nominal 1 in. thick bead of Type 303 putty was applied to the cables of System No. 1 around the edges of the forms to minimize leakage of the vermiculite concrete. Nominal 7 in. lengths of nominal 1/2 in. diameter deformed steel rods were wedged into each slot to act as reinforcement. The vermiculite concrete, composed of five parts expanded vermiculite aggregate to one part Portland cement, by bulk volume, and mixed with water, was pumped into the slots and struck with a trowel. After drying for 24 h, the forms were removed from the underside of the floor assembly.

The protective enclosure for the cable tray of System No. 1 was installed as shown in ILLS. 7 through 12. Starting at the top of one of the vertical legs, a length of intumescent mat was cut to the required width and wrapped around the cable tray such that the longitudinal seam was centered over the top of the cable tray. The overlap at the longitudinal seam was 6 in. The intumescent mat wrap abutting the underside of the floor was slit 4 in. parallel with the longitudinal seam at each corner of the cable tray and folded 90° such that the flaps were against the underside of the floor. The flaps were secured to the floor with Type 8d coated sinker nails in conjunction with 5/8 in. diameter steel washers. The longitudinal seam of the intumescent mat wrap was secured using aluminum foil tape. Adjacent lengths of intumescent mat wrap overlapped the preceding length 3 to 6 in. The various lengths of intumescent mat wrap continued around the cable tray system up to the interface with the trapeze support. The intumescent mat wrap terminated at the bottom and one side of the cable tray where it abutted the trapeze support. At that point, a bead of Type CP-25 caulk was applied at the intumescent mat wrap/trapeze support interface. The intumescent mat wrap on the second half of the cable tray system was applied in the same manner. The intumescent mat wrap from the two halves of the cable tray system were butted over the top and one side of the trapeze support. The butted joint was covered with a 9-1/4 in. wide piece of intumescent mat, centered over the butted joint. All joints were covered with aluminum foil tape.

The steel framing for the protective enclosure around the cable tray of System No. 1 was installed as shown in ILLS. 7 through 10. As shown in ILLS. 9 and 10, a gasket formed from intumescent sheet and caulk was installed between the steel framing and the underside of the floor at both ends of the cable tray system. The steel framing was installed such that no contact was made between the framing and the cable tray system except at the trapeze support. Intumescent sheet was cut-to-size and screw-attached to the steel framing (aluminum foil face on exterior) with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws, as shown in ILLS. 8 and 11. The screws were located at each corner of the sheets to hold each sheet in position. A bead of caulk was applied over the butted joints of the intumescent sheets and each joint was covered with a layer of 4 in. wide intumescent mat (aluminum foil face on exterior) and a 4 in. wide strip of steel hardware cloth, as shown in ILLS. 8, 11 and 12. The intumescent mat and steel hardware cloth were secured to the intumescent sheet with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers near each end of each strip. The intumescent sheets and joint covers were additionally secured in place with steel banding straps, with crimp clips, wrapped around the enclosure and spaced approximately 6 in. OC, as shown in ILL. 8. As a final step, an 8 in. wide strip of intumescent mat (aluminum foil faced on exterior) and an 8 in. wide strip of steel hardware cloth were formed into an angle with 2 in. and 6 in. legs and was installed at the interface of the protective enclosure and the underside of the floor around the entire perimeter of the enclosure, as shown in ILL. 10. The 2 in. leg of the intumescent mat and steel hardware cloth angles were secured to the intumescent sheet of the protective enclosure with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers with additional steel banding straps. The 6 in. leg of the intumescent mat and steel hardware cloth angles were secured to the underside of the floor with Type 8d coated sinker nails in conjunction with 5/8 in. diameter steel washers.

The nominal 5 in. diameter rigid steel conduit of System No. 2 was protected with two layers of intumescent mat, as shown in ILL. 17. Starting at the top of one of the vertical legs, a length of intumescent mat was cut to the required width and wrapped around the steel conduit such that the longitudinal seam was oriented on the side of the conduit. The intumescent mat wrap abutting the underside of the floor was slit 4 in. parallel with the longitudinal seam at 4 in. intervals around the perimeter of the wrap and folded 90° such that the flaps were against the underside of the floor assembly. The longitudinal seam of the intumescent mat wrap was secured using aluminum foil tape. Adjacent lengths of intumescent mat overlapped the preceding length a minimum of 4 in. The various lengths of intumescent mat wrap continued around the conduit system up to the interface with the floor at the other vertical leg. At the interface with the floor, the intumescent mat wrap was slit in the same manner as at the other vertical leg. The second layer of intumescent mat was installed in the same manner as the first layer with the longitudinal seam of the second layer diametrically opposed to the longitudinal seam of the first layer and with the overlap location offset a minimum of 6 in. from the overlap of the first layer. After both layers of intumescent mat were installed, nominal 4 by 8 in. pieces of intumescent mat were folded 90° and installed around the perimeter of the outermost wrap at the interface with the floor. Each folded piece overlapped the preceding piece approximately 1 in. and was secured to the conduit wrap with aluminum foil tape. After the perimeter treatment was completed, two pieces of intumescent sheet were cut to conform to the contours of the conduit wrap and to cover the perimeter wrap. The two-piece cover extended approximately 6 in. beyond the conduit wrap and was held in place with 3/8 in. diameter threaded steel rods installed through the floor slab and secured with steel nuts in conjunctions with 1-1/4 in. diameter steel washers, as shown in ILL. 18. As a final step, the conduit wrap was loosely tied with ceramic string spaced approximately 2 in. OC.

The steel framing for the protective enclosure around the junction box of System No. 3 was installed as shown in ILL. 15. The steel framing was installed such that no contact was made between the framing and the junction box. Intumescent sheet was cut-to-size and screw-attached to the steel framing (aluminum foil face on exterior) with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws. The screws were located at each corner of the sheet to hold each sheet in position. A 2-3/8 in. diameter hole was cut in the intumescent sheet to accommodate the nominal 2 in. diameter rigid steel conduit. A bead of caulk was applied over the butted joints of the intumescent sheets and each joint was covered with a layer of 4 in. wide intumescent mat (aluminum foil face on exterior) and a 4 in. wide strip of steel hardware cloth. The intumescent mat and steel hardware cloth were secured to the intumescent sheet with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers spaced approximately 6 in. OC. As a final step, a 4 in. wide strip of intumescent mat (aluminum foil faced on exterior) and a 4 in. wide strip of steel hardware cloth were formed into an angle with 2 in. legs and were installed at the interface of the protective enclosure and the underside of the floor around the entire perimeter of the enclosure, as shown in ILLS. 16 and 29. The intumescent mat and steel hardware cloth angles were secured to the intumescent sheet of the protective enclosure with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers. The intumescent mat and steel hardware cloth angles were secured to the underside of the floor with Type 8d coated sinker nails in conjunction with 5/8 in. diameter steel washers.

After installation of the protective enclosure around the steel junction box of System No. 3, the nominal 2 in. diameter rigid steel conduit was wrapped in a single layer of intumescent mat, as shown in ILL. 29. The mat butted against the junction box protective enclosure and was installed with the longitudinal seam located on the side of the conduit. The intumescent mat wrap on the conduit was installed in two pieces, with the two pieces overlapped 2-1/2 in. At the interface with the floor, the intumescent mat wrap was slit parallel with the longitudinal seam at 2 in. intervals around the perimeter of the wrap and folded such that the flaps were against the underside of the assembly. The flaps were secured to the underside of the floor using Type 8d coated sinker nails. The longitudinal seam of the intumescent wrap was secured using steel staples spaced approximately 1-1/4 in. OC and covered with aluminum foil tape.

After installation of the intumescent mat wrap on the steel conduit of System No. 3, three "U" sections of steel framing were formed from Type P100 Unistrut channels and Type A1026 fittings and were secured to the steel framing of the junction box and the underside of the floor as shown in ILL. 29. A three-sided enclosure was formed from intumescent sheet as shown in ILL. 29. Adjacent lengths of the three-sided enclosure were butted and centered over the intermediate "U"-shaped steel framing and were secured to the steel framing at both ends with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws as shown in ILL. 29. The hemmed edges of the three-sided enclosure were secured to the underside of the floor with 3/8 in. diameter threaded steel rods passing completely through the floor and spaced 12 in. OC on both sides of the enclosure. The interface of the three-sided enclosure with the protective enclosure from the steel junction box was sealed with a bead of Type CP-25 caulk and was covered with nominal 4 in. wide strips of intumescent mat and steel hardware cloth formed into angles and secured to the intumescent sheet of the two protective enclosures with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter washers. The butted joint of the intumescent sheet at the center of the 6 ft long three-sided enclosure were also sealed with a bead of caulk and covered with a 4 in. wide strip of intumescent mat and steel hardware cloth secured with the steel screws and washers. The end of the enclosure was sealed with a rectangular piece of intumescent sheet secured to the steel framing with steel screws. The joints at the end of the protective enclosure were covered with 4 in. wide strips of intumescent mat and steel hardware cloth.

The appearance of the exposed and unexposed surfaces of the assembly before the fire test are shown in ILLS. 30 and 31, respectively.

CJJ/KWH:jmd

T E S T R E C O R D N O. 1

FIRE ENDURANCE TEST:

The fire endurance test was conducted with the furnace temperatures controlled in accordance with the Standard, Fire Tests of Building Construction and Materials, UL 263 (ASTM E119).

SAMPLE

The fire endurance test was conducted on Test Assembly No. 1 constructed as previously described in this Report under the section entitled "Erection of Test Assemblies" and as shown in ILLS. 1 through 20.

The installation of the electrical cable systems and electrical circuit protective systems was completed approximately seven days before the fire endurance test was conducted.

METHOD

The standard equipment of Underwriters Laboratories Inc. for testing floor assemblies was used for the fire endurance test.

The temperatures of the furnace chamber were measured by 16 thermocouples which were placed 12 in. from the underside of the floor assembly, located as shown in ILL. 21. In addition, the temperatures of the furnace chamber in the "U" of System Nos. 2 and 3 and in the "U" of the cable tray receiving the cable air drop of System No. 1 were measured by three thermocouples placed 12 in. from the bottom surface of the floor at the center of each system, as shown in Appendix A, ILL. A1.

The temperatures of the cables, junction boxes, steel conduits and electrical circuit protective systems on the exposed side of the assembly were measured by 108 thermocouples, located as shown in App. A, ILLS. A1 through A6.

Each conductor of each cable in each electrical circuit protective system was energized and monitored for circuit integrity throughout the fire endurance test. With the exception of System No. 4, each system contained seven separate electrical circuits. The details of the electrical circuits and the monitoring device are shown in ILL. 22.

Throughout the fire test, observations were made of the character of the fire and its control, the conditions of the exposed and unexposed surfaces, and all developments pertaining to the fire and its control, the conditions of the exposed and unexposed surfaces, and all developments pertaining to the performance of the electrical circuit protective systems with special reference to circuit integrity.

RESULTS

Character and Distribution of Fire - The fire was luminous and well-distributed, and the furnace temperatures following the Standard Time-Temperature Curve as outlined in the Standard, UL 263, and as shown in ILL. 21. The temperatures of the furnace chamber measured in the "U" of the two conduit systems also followed the Standard Time-Temperature Curve outlined in the Standard, UL 263, and as shown in Appendix A, ILLS. A36 and A37.

Observations During Test - By 1 min, the intumescent sheets forming the protective enclosures for the cable tray and junction box of System No. 1 and the junction box of System No. 4 were flaming and the aluminum foil tape was peeling from the joints and corners. The intumescent mat on the cable air drop of System No. 1 and on the conduits of System Nos. 2, 3 and 4 was also flaming slightly. As the test progressed, the flaming of the intumescent mat diminished. The flaming of the intumescent sheets became heavier and commenced smoking profusely by 10 min. The smoking and flaming of the intumescent sheets continued throughout the fire test.

By 4-1/2 min, light smoke was rising from the floor firestops on the unexposed side of the assembly. The smoke density and volume gradually increased as the test progressed.

The furnace fire was extinguished at 62 min, 30 s.

Temperatures of the Assembly - The temperatures measured by the various thermocouples were recorded at 2 min intervals during the fire test. These temperatures are tabulated in App. A, ILLS. A7 through A35.

HOSE STREAM TEST:

SAMPLE

The hose stream was applied to the exposed surface of the floor assembly. The hose stream test commenced approximately 5 min, 30 s after the furnace fire was extinguished.

METHOD

Following the fire exposure, the test assembly was lifted from the furnace and moved to the hose stream area. During the move to the hose stream area, the electrical circuits in each electrical circuit protective system were energized and monitored for circuit integrity. No electrical faults developed in any of the electrical circuit protective systems during the move from the furnace to the hose stream area.

The hose stream test was conducted in accordance with the American Nuclear Insurers (ANI) Standard entitled "ANI/MAERP Standard Fire Endurance Test Method to Qualify a Protective Envelope for Class 1E Electrical Circuits" dated July, 1979. The electrical circuit protective systems were subjected to the action of a 30 psi hose stream applied for a duration of 2 min, 30 s. The hose stream was applied with a 1-1/8 in. diameter nozzle at a perpendicular distance of approximately 17 ft, 3 in. from the center of the test assembly and on a line approximately 27° from a line normal to the center of the test assembly.

Each conductor of each cable in each electrical circuit protective system was energized and monitored for circuit integrity during the hose stream test.

RESULTS

The electrical circuit protective systems remained intact during the hose stream exposure. No electrical faults developed in any of the electrical circuit protective systems during the hose stream test.

OBSERVATIONS AFTER TEST:

The appearance of the exposed surface of the assembly after the fire endurance and hose stream tests is shown in ILLS. 25 and 24.

In System No. 1, the intumescent sheet enclosures on the cable tray and junction box were black and intumesced but remained in place. The intumescent mat wrap on the cable air drop was eroded by the water hose stream but remained in place. Beneath the intumescent mat wrap on the cable air drop, the cable bundle appeared undamaged. However, within the steel junction box and within the cable tray, the cable bundle showed signs of heat damage.

In System Nos. 2 and 3, the intumescent mat wrap on the steel conduits was eroded by the hose stream. Beneath the intumescent mat, the steel conduits appeared unchanged except for a slight discoloration. Within the steel conduits, the jacket material on the two-conductor No. 16 AWG cables was softened and distorted, but none of the insulation on any of the cable conductors was damaged.

In System No. 4, the intumescent sheet enclosure on the steel junction box was blackened and intumesced but remained in place. The intumescent mat wrap on the steel conduit was eroded by the hose stream but remained in place. Beneath the intumescent mat, the steel conduit appeared unchanged except for a slight discoloration. Within the steel conduit, the jacket material on the two-conductor No. 16 AWG cables was softened and distorted, but none of the insulation on any of the cable conductors was damaged. However, within the steel junction box, the cable jacket and insulation material was heat damaged and the copper conductors were visible.

TEST RECORD NO. 2

FIRE ENDURANCE TEST:

The fire endurance test was conducted with the furnace temperatures controlled in accordance with the Standard, Fire Tests of Building Construction and Materials, UL 263 (ASTM E119).

SAMPLE

The fire endurance test was conducted on Test Assembly No. 2 constructed as previously described in this Report under the Section entitled "Erection of Test Assemblies" and as shown in ILLS. 25 through 31.

The installation of the cable systems and electrical circuit protective systems was completed approximately seven days before the fire endurance test was conducted.

METHOD

The standard equipment of Underwriters Laboratories Inc. for testing floor assemblies was used for the fire endurance test.

The temperatures of the furnace chamber were measured by 16 thermocouples which were placed 12 in. from the underside of the floor assembly, located as shown in ILL. 32. In addition, the temperatures of the furnace chamber in the "U" of System Nos. 1 and 2 were measured by two thermocouples placed 12 in. from the bottom surface of the floor at the center of each system, as shown in App. B, ILL. B1.

The temperatures of the cables, cable tray, junction box, steel conduits and electrical circuit protective systems on the exposed side of the assembly were measured by 129 thermocouples, located as shown in App. B, ILLS. B1 through B5.

Each conductor of each cable in each system was energized and monitored for circuit integrity throughout the fire endurance test. With the exception of System No. 3, each electrical circuit protective system contained seven separate electrical circuits. The details of the electrical circuits and the monitoring device are shown in ILL. 22.

Throughout the fire test, observations were made of the character of the fire and its control, the conditions of the exposed and unexposed surfaces, and all developments pertaining to the performance of the electrical circuit protective system with special reference to circuit integrity.

RESULTS

Character and Distribution of Fire - The fire was luminous and well-distributed, and the furnace temperatures followed the Standard Time-Temperature Curve as outlined in the Standard, UL 263, and as shown in ILL. 32. The temperatures of the furnace chamber measured in the "U" of System Nos. 1 and 2 also followed the Standard Time-Temperature Curve outlined in the Standard, UL 263, and as shown in App. B, ILL. B40.

Observations During Test - By 1 min, light flames were issuing from the intumescent mat joints on the nominal 5 in. diameter rigid steel conduit of System No. 2. By 2-1/2 min, the intumescent sheet enclosure of System Nos. 1 and 3 were flaming. By 6 min, all of the systems were flaming profusely and light smoke was issuing from System Nos. 1 and 3. By 13 min, the flaming of the intumescent mat wrap of System No. 2 had stopped. At that time, the intumescent sheet enclosures of System Nos. 1 and 3 continued to flame. The flaming of the intumescent sheet enclosures of System Nos. 1 and 3 continued throughout the fire test at a diminishing rate.

At 38 min, it was noted that the edge of the intumescent sheet on the bottom surface of System No. 1 immediately adjacent to the south side of the trapeze support had slipped from beneath the steel banding strap and was bowing downward such that a maximum 1 in. high vertical opening was present at the center of the sheet edge. The vertical opening at the center of the sheet edge increased in size as the test progressed. By 60 min, the maximum vertical opening at the center of the sheet edge was approximately 4 in.

By 19 min, a small amount of smoke was rising from the floor firestops on the unexposed side of the assembly. The smoke density and volume gradually increased as the test progressed.

The furnace fire was extinguished at 61 min, 20 s.

Temperatures of the Assembly - The temperatures measured by the various thermocouples were recorded at 2 min intervals during the fire test. These temperatures are tabulated in App. B, ILLS. B6 through B39.

HOSE STREAM TEST:

SAMPLE

The hose stream was applied to the exposed surface of the floor assembly. The hose stream test commenced approximately 5 min, 40 s after the furnace fire was extinguished.

METHOD

Following the fire exposure, the test assembly was lifted from the furnace and moved to the hose stream area. During the move to the hose steam area, the electrical circuits in each electric circuit protective system were energized and monitored for circuit integrity. No electrical faults developed in any of the systems during the move from the furnace to the hose stream area.

The hose stream test was conducted in accordance with the American Nuclear Insurers (ANI) Standard entitled "ANSI/MAERP Standard Fire Endurance Test Method to Qualify a Protective Envelope for Class 1E Electrical Circuits" dated July, 1979. The electrical circuit protective systems were subjected to the action of a 30 psi hose stream applied for a duration of 2 min, 30 s. The hose stream was applied with a 1-1/8 in. diameter nozzle at a perpendicular distance of approximately 17 ft, 3 in. from the center of the test assembly and on a line approximately 27° from a line normal to the center of the test assembly.

Each conductor of each cable in each electrical circuit protective system was energized and monitored for circuit integrity during the hose steam test.

RESULTS

The electrical circuit protective systems remained intact during the hose stream exposure. No electrical faults developed in any of the systems during the hose stream test.

OBSERVATIONS AFTER TEST:

The appearance of the exposed surface of the assembly after the fire endurance and hose stream tests is shown in ILL. 33.

In System No. 1, the intumescent sheet enclosure on the cable tray was black and intumesced and, in some locations, was eroded by the water hose stream such that the steel backer plate was exposed. The intumescent sheet which had bowed downward during the fire endurance test was back in almost its original position. Beneath the intumescent sheet, the intumescent mat wrap on the cable tray was intumesced and remained securely in position. Beneath the intumescent mat wrap, the single-conductor No. 300 MCM cables and the two-conductor No. 16 AWG cables appeared to be undamaged. The jacket material on the seven-conductor No. 12 AWG cables was melted, charred and, in some places, completely missing from the insulated conductors. Beneath the heavily damaged jacket material, the insulation on the individual cable conductors was discolored in areas but appeared essentially undamaged.

In System No. 2, the intumescent mat wrap was eroded by the water hose stream but remained in place. Beneath the intumescent mat wrap, the steel conduit was discolored but undamaged. Within the conduit, the single-conductor No. 300 MCM cable and the two-conductor No. 16 AWG cable was melted, charred and, in some places, completely missing from the insulated conductors. Beneath the heavily damaged jacket material, the insulation on the individual cable conductors was discolored in areas but appeared undamaged.

In System No. 3, the intumescent sheet enclosure on the steel junction box and around three sides of the steel conduit was blackened and intumesced but remained in place. Beneath the intumescent sheet enclosure, the intumescent mat wrap on the steel conduit remained intact. Beneath the intumescent mat wrap, the steel conduit was discolored but appeared undamaged. Within the steel conduit, the two-conductor No. 16 AWG cables appeared undamaged but the jacket material on the seven-conductor No. 12 AWG cable was melted and charred. Beneath the melted, charred jacket material, the insulation on the individual cable conductors appeared undamaged. Within the steel junction box, the insulation and jacket materials on both the two-conductor No. 16 AWG cables and the seven-conductor No. 12 AWG cable were partially consumed such that the copper conductors were exposed.

STUDY FOR CLASSIFICATION:

As noted in the preceding sections of this Report entitled "Observations After Test" in Test Record Nos. 1 and 2, the cables within the steel junction boxes were partially consumed such that some of the copper conductors were exposed. However, no electrical faults showed up on the circuit monitoring device since the exposed copper conductors did not contact either each other or the steel junction box. However, based on the physical evidence following the tests, it was determined that the electrical circuit protective systems on the steel junction boxes are not eligible for Classification.

In System No. 1 of Test Assembly No. 1 (cable air drop), the cable bundle protected by the five layers of intumescent mat wrap withstood the fire endurance and hose stream tests without sustaining heat damage and without developing electrical faults. However, the portions of the air drop cable bundle within the steel junction box and cable tray were heavily damaged. Based on the satisfactory performance of the cable air drop, it was determined that the cable air drop protective system would be eligible for Classification as a 1 h rated system provided that it was used in conjunction with 1 h rated electrical circuit protective systems at both ends.

In System No. 4 of Test Assembly No. 1, the cables within the nominal 2 in. diameter rigid steel conduit protected by five wraps of intumescent mat withstood the fire endurance and hose stream tests without sustaining heat damage and without developing electrical faults. However, the cables within the steel junction box were heavily damaged. Based on the satisfactory performance of the electrical circuit protective system around the nominal 2 in. diameter rigid steel conduit away from the steel junction box, it was determined that the conduit protective system would be eligible for Classification as a 1 h rated system provided that it was used on uninterrupted conduit runs penetrating fire rated walls or floors at both ends.

In System No. 3 of Test Assembly No. 2, the cables within the nominal 2 in. diameter rigid steel conduit protected by a single wrap of intumescent mat and a three-sided enclosure formed from intumescent sheet withstood the fire endurance and hose stream tests without developing electrical faults. However, the cables within the steel junction box were heavily damaged. Based on the satisfactory performance of the electrical circuit protective system around the nominal 2 in. diameter rigid steel conduit away from the steel junction box, it was determined that the conduit protective system would be eligible for Classification as a 1 h rated system provided that it was used on uninterrupted conduit runs penetrating fire rated walls or floors at both ends.

As noted in the preceding section of this Report entitled "Observations After Test" in Test Record No. 2, the cable jacket material on the seven-conductor No. 12 AWG cables in System Nos. 1, 2 and 3 was melted and charred but, except for the cables within the steel junction box of System No. 3, the insulation on the individual cable conductors appeared undamaged. In order to verify that no undetected faults occurred in the seven-conductor No. 12 AWG cables, nominal 4 to 5 ft long sections of the most heavily damaged seven-conductor No. 12 AWG cables were removed from each of the three cable systems. Each section of damaged cable was immersed in water, electrically loaded with 3000 V AC and tested for conductor-to-conductor and conductor-to-ground faults. No electrical faults occurred.

Prior to the construction and test of Test Assembly No. 2, a review was made of the test data to determine the critical combination of cable tray type and percentage of cable fill to be evaluated in the test assembly in order to establish coverage for alternate cable tray types and a broad range of cable fill conditions in Classified systems.

Specifically, the review addressed the use of open-ladder versus solid-bottom steel cable trays and the use of minimum fill versus 100 percent visual fill cable loading in cable trays and steel conduits. Our review indicated that, of the open-ladder and solid-bottom steel cable tray types, the open-ladder type cable tray was more critical from the standpoint of circuit integrity. This was an expected observation in that:

1. Radiant energy incident on the underside of the solid-bottom cable tray was partially reflected, thereby shielding the electrical cables within the tray. In open-ladder cable trays, the "black body" electrical cable will absorb the incident radiant energy.

2. Typically, solid-bottom steel cable trays have greater mass than open-ladder steel cable trays. As such, the solid-bottom steel cable trays provide a greater heat sink within the protective envelope than do the open-ladder steel cable trays.

3. In solid-bottom cable trays, the compressive force exerted on the bottom layer of cables by the weight of the cable fill is distributed evenly across the flat bottom of the cable trays. In open-ladder cable trays, the compressive force exerted on the bottom layer of cables by the weight of the cable fill is borne by the rungs, resulting in concentrated loading of the insulation and jacket materials in the bottom layer of cables. The force exerted on the insulation and jacket materials of the electrical cables in open-ladder cable trays is 4 to 18 times greater than that exerted on cables in solid-bottom cable trays, dependent upon the rung spacing. During thermal degradation of the electrical cable insulation and jacket materials, the point loading of the electrical cables on the rungs of open-ladder cable trays will accelerate the occurrence of a fault between the electrical conductor and cable tray.

The review also indicated that, of the minimum cable fill and the 100 percent visual cable fill in cable trays and steel conduits, the minimum cable fill is more critical from the standpoint of circuit integrity. This was an expected observation in that the greater mass of the 100 percent visual cable fill affords a greater heat sink than does the single-layer cable fill.

Based on the above, it was determined that, rather than testing four separate cable tray systems to obtain coverage for open-ladder and solid-bottom cable trays with cable fills ranging from a single-layer to a 100 percent visual fill, only an open-ladder cable tray system with a single-layer cable fill need be tested. However, by simply testing with a single-layer fill of cable in an open-ladder cable tray, the point loading of the electrical cables on the rungs of the cable tray with a 100 percent visual cable fill is not addressed. In order to address both conditions in one cable tray system, the cable tray system in System No. 1 of Test Assembly No. 2 was provided with a single-layer cable fill. In addition, a 100 percent visual cable fill was simulated in a 12 in. portion of the horizontal run of the cable tray system. The 12 in. lengths of cable were stacked atop the single layer of cables such that the weight of the cables was evenly distributed over two of the cable tray rungs.

The cable tray system in System No. 1 of Test Assembly No. 2 withstood the fire endurance and water hose stream tests without developing any electrical faults. Accordingly, it was determined that the cable tray protective system tested would be eligible for Classification as a 1 h rated system. Based on the above, the Classification coverage will be extended to include both open-ladder and solid-bottom cable trays containing a single-layer cable fill up to the maximum allowable cable fill permitted in accordance with applicable provisions of the current National Electrical Code.

In steel conduit systems, the minimum cable fill was more critical from the standpoint of circuit integrity than a maximum cable fill. This was an expected observation in that the greater mass of the maximum cable fill affords a greater heat sink than does the minimum cable fill. The compressive force exerted by the maximum cable fill would have less effect in conduits than in open-ladder cable trays as there would be no significant concentrated loading of the insulation and jacket materials on the bottom layer of cables within the conduit.

The conduit protective systems in System 4 of Test Assembly No. 1 and System Nos. 2 and 3 of Test Assembly No. 2 were tested with a minimum cable fill and, excluding the steel junction boxes, each system was determined to be eligible for Classification as a 1 h rated system. Based on the above, the Classification coverage will be extended to include the maximum allowable cable fill permitted in accordance with applicable provisions of the National Electrical Code.

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CONCLUSIONS

The following conclusions represent the judgement of Underwriters Laboratories Inc. based upon the results of the examination and tests presented in this Report as they relate to established principles and previously recorded data.

FIRE RETARDANT PROPERTIES:

The electrical circuit protective systems provided with the type of cables and protected with the types of electrical circuit protective materials described in this Report are judged to achieve a 1 h fire rating.

The 1 h fire rating of the electrical circuit protective systems was established by evaluating the performance of the system with respect to maintaining the integrity of the electrical circuits under fire exposure conditions and during a hose stream test following the fire exposure.

The electrical circuit protective systems employing the various electrical circuit protective materials will be illustrated in the Building Materials Directory, in summary form, as System Nos. 2, 3 and 4 and are illustrated at the end of this Report.

PRACTICABILITY:

The materials used in the test assembly were readily installed by qualified workers with tools and methods commonly used for construction work of this nature.

CONFORMITY:

The assemblies were tested in accordance with the standard time-temperature curve in the Standard, UL 263, specified earlier in this Report.

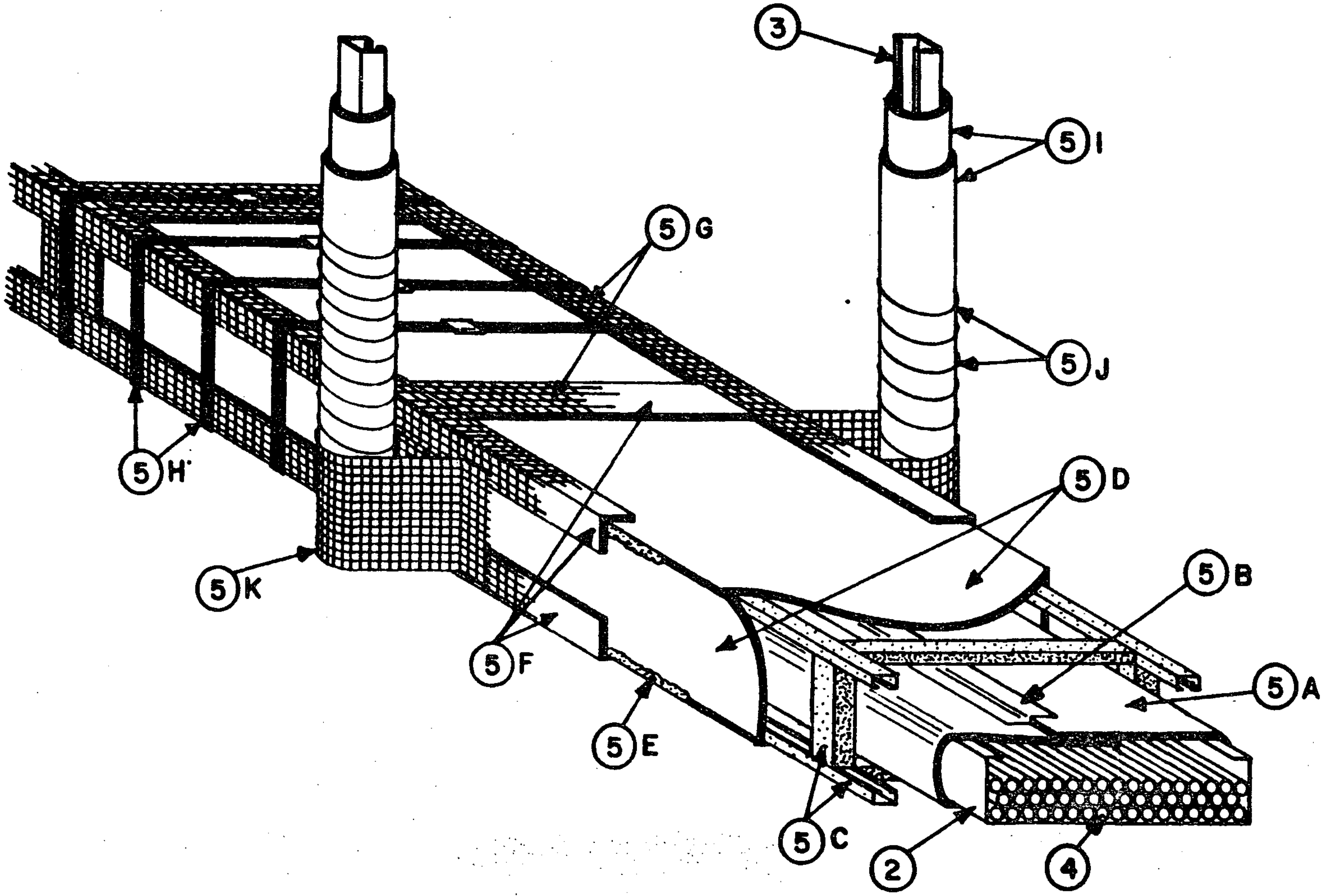
FOLLOW-UP PROGRAM:

The intumescent sheets, intumescent mat, caulk, ceramic cord and aluminum foil tape as described herein are judged to be eligible for Classification and Follow-Up Service of Underwriters Laboratories Inc. Under the Service, the manufacturer is authorized to use the Laboratories' Classification Marking on such products which comply with the Follow-Up Service Procedure and any other applicable requirements of Underwriters Laboratories Inc. Only those products which bear the Laboratories' Classification Marking are considered as Classified by Underwriters Laboratories Inc.

The Classification Marking to be used on containers of the intumescent sheets, intumescent mat, caulk, ceramic cord and aluminum foil tape is illustrated below:

ELECTRICAL CIRCUIT PROTECTIVE MATERIALS
CLASSIFIED BY
UNDERWRITERS LABORATORIES INC. (R)
FOR USE IN ELECTRICAL CIRCUIT
PROTECTIVE SYSTEM NOS. 2, 3 AND 4
SEE UL BUILDING MATERIALS DIRECTORY

System No. 2
Fire Rating - 1 Hr.



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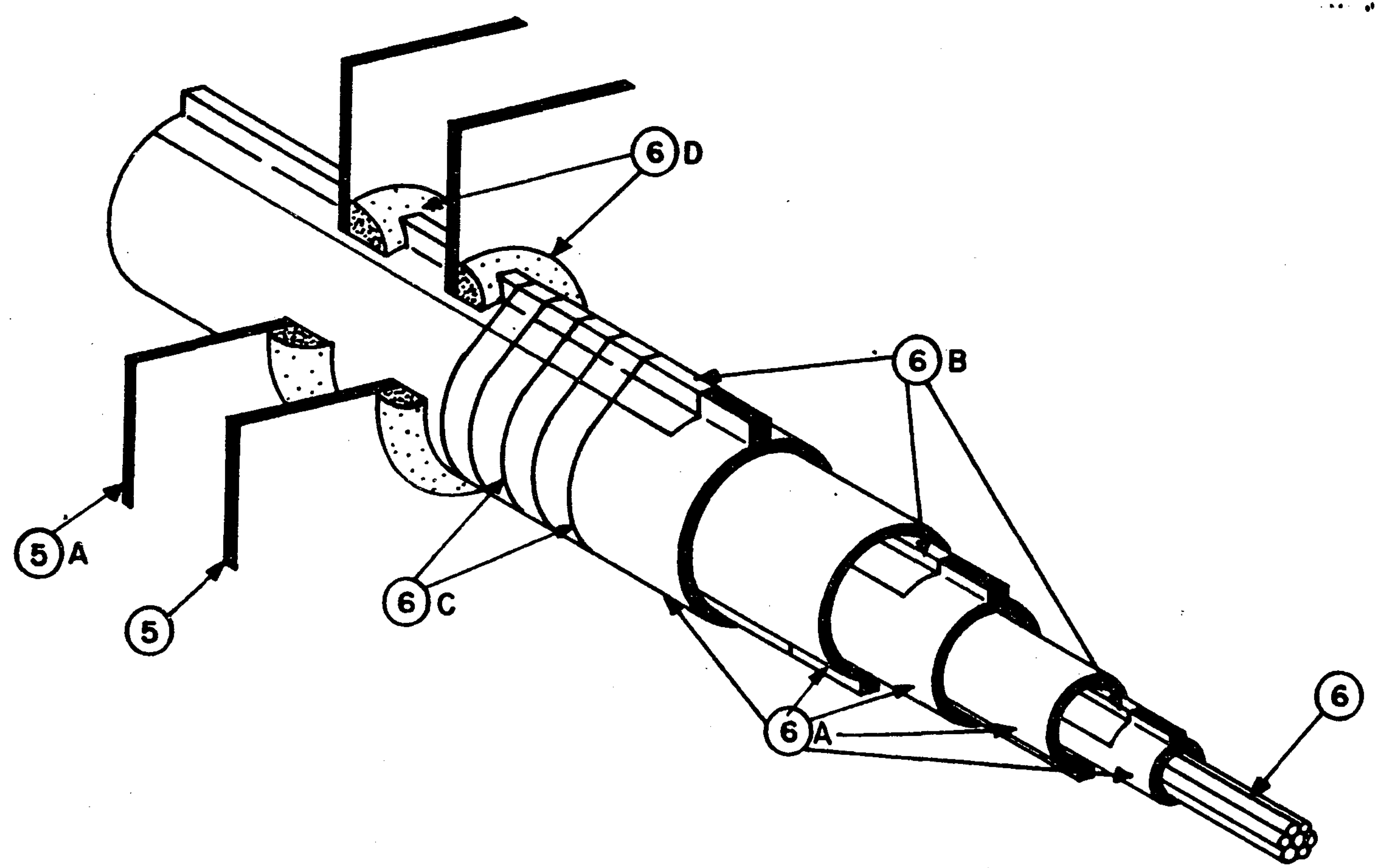

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System No. 2
Fire Rating - 1 H

1. Wall or Floor Assembly - (Not shown) - 1 h rated concrete or masonry wall or concrete floor. Through opening in wall or floor to be firestopped using a Classified firestop device or system. See Through-Penetration Firestop Devices (Guide XHCR) and Through-Penetration Firestop Systems (Guide XHEZ) categories for presently Classified firestops.

2. Cable Tray - 24 in. wide, minimum 4 in. deep, solid bottom or open-ladder cable trays. Solid bottom cable trays to be formed of minimum 0.056 in. (16 gauge) galvanized steel. Open-ladder cable trays to consist of channel-shaped siderails formed of minimum 0.056 in. (16 gauge) galvanized steel with nominal 3/4 in. wide by 1 in. deep boxed-channel rungs formed of minimum 0.029 in. (22 gauge) galvanized steel and spaced 6 in. O.C. Cable trays shall be installed as a complete system in accordance with all provisions in Article 318 of the current National Electrical Code.

3. Cable Tray Supports - The cable trays shall be supported by U-shaped welded hangers formed of minimum 0.093 in. thick (12 gauge) painted steel or minimum 0.097 in. thick (12 gauge) galvanized steel channels, 1-5/8 in. wide web with 1-5/8 in. high flanges with the flange edges hemmed for stiffness.

4. Cables - Minimum No. 16 AWG jacketed multi-conductor cables and/or minimum 250 MCM jacketed copper single-conductor power cables. Cable insulation to be cross-linked polyethylene. Cable jacket to be polyvinyl chloride. When fillers are used in the cable construction, fillers to be hemp, polyvinyl chloride or cross-linked polyethylene. Maximum allowable fill area (cross-sectional area of cables including cable insulation and jacket materials) for multi-conductor cables is 28 in.^{2} for open-ladder cable trays and 22 in.^{2} for solid bottom cable trays. The maximum allowable fill area (cross-sectional area of cables including cable insulation and jacket materials) for single-conductor cables is 26 in.^{2}. Cables to be installed in cable trays in accordance with all provisions of Article 318 of the National Electrical Code.

5. Electrical Circuit Protective System - The electrical circuit protective system consists of intumescent mat, aluminum foil tape, ceramic cord, steel framing, intumescent sheet, caulk, steel hardware cloth and steel banding straps. The system shall be installed in accordance with the manufacturer's detailed instructions accompanying the Electrical Circuit Protective Materials*. The details of the electrical circuit protective system are summarized below:

   A. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 48 in. wide rolls. Installed by cutting-to-size and wrapping around the cable tray system with each sheet lapping itself a minimum of 6 in. over the top of the cable tray. Adjacent sheets of material must overlap the preceding sheet 3 to 6 in. Sheet material installed and secured in place with aluminum foil tape (Item 5B). Caulk (Item 5E) to be applied along the edges of the intumescent mat at its interface with the cable tray supports (Item 3) and at its interface with the electrical circuit protective system on cable air drops (Item 6).

   Minnesota Mining & Manufacturing Co. - Type M20A.

   B. Electrical Circuit Protective Material* - Aluminum Foil Tape - 3 in. wide pressure-sensitive tape supplied in rolls. Used to secure intumescent mat wrap (Item 5A).

   Minnesota Mining & Manufacturing Co. - Type 425.

C. Steel Framing - Steel channels with nominal 1-1/4 in. wide web with either 1-1/4 in. or 3/4 in. high flanges with the flange edges hemmed for stiffness and to accommodate special mechanical fasteners. The channels shall be formed of minimum 0.067 in. thick (14 gauge) painted steel or minimum 0.070 in. thick (14 gauge) galvanized steel. Steel channels assembled to form a four-sided frame-work around the cable tray along the entire cable tray system. The longitudinal members along the four corners of the cable tray framing and the transverse members spanning across the top and bottom of the cable tray to be nominal 1-1/4 in. wide by 3/4 in. high channels. The framing members spanning between the longitudinal members along the cable tray siderails to be nominal 1-1/4 in. wide by 1-1/4 in. high channels. The transverse members around the four sides of the cable tray shall be spaced not more than 36 in. OC along the entire cable tray system to occur at each butted end joint of the intumescent sheets (Item 5D). The steel framing members shall be assembled by welding or through the use of special fittings in conjunction with 3/8 in. diameter steel bolts with nuts. The steel framing must be installed such that the minimum clearance between the intumescent sheets (Item 5D) and the cable tray system is 2-1/4 in. When cable air drops (Item 6) are present, additional steel framing members shall be installed to provide screw-attachment means for the intumescent sheets (Item 5D) around the perimeter of the cable air drop opening. The steel framing is to be secured to the steel cable tray supports (Item 3) and to the floor or wall and is to be installed without direct contact with the cable tray system.

D. Electrical Circuit Protective Material* - Intumescent Sheet - Rigid aluminum foil-faced sheets with galvanized steel sheet backer. Installed on steel framing, with aluminum foil facing on exterior, to completely enclose cable tray system. Sheets installed with tightly butted joints at corners of steel framing and with adjacent sheets tightly butted with joints centered over transverse framing members. Each sheet to be affixed to steel framing at corners with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws.

Minnesota Mining & Manufacturing Co. - Type CS-195.

E. Electrical Circuit Protective Material* - Caulk - Supplied in cartridges. Thick bead of caulk to be applied along the edges of the intumescent mat (Item 5A) at its interface with the cable tray supports (Item 3), over butted joints of intumescent sheet (Item 5D) and around perimeter of cable tray support (Item 3) and cable air drop protective system (Item 6) at their egress from the protective enclosure.

Minnesota Mining & Manufacturing co. - Type CP-25.

F. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 4 in. wide rolls. Installed in conjunction with steel hardware cloth (Item 5G) to cover all joints in intumescent sheet enclosure. Mat strips cut-to-length to completely cover each butted joint, centered over joint and temporarily held in position with aluminum foil tape (Item 5B).

Minnesota Mining & Manufacturing Co. - Type M20A.

G. Steel Hardware Cloth - Maximum 1/2 by 1/2 in. welded mesh of minimum 0.041 in. diameter (19 SWG) galvanized steel wire. Nominal 4 in. wide strips of hardware cloth cut-to-length and installed over each intumescent mat joint cover (Item 5F). Hardware cloth secured to intumescent sheet (Item 5D), through intumescent mat (Item 5F), with No. 10-16 by 3/4 in. long self-drilling, self-tapping, hex-washer head steel screws in conjunction with 5/8 in. diameter steel washers.

H. Steel Banding Strap - Nominal 5/8 in. wide by 0.020 in. thick steel straps used in conjunction with nominal 1 in. long channel-shaped crimp clips formed of 0.021 in. thick electrogalvanized or painted steel. The steel banding straps are used to secure the joint covers and intumescent sheets in position.

I. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 48 in. wide rolls. Minimum of two layers wrapped around steel cable tray supports (Item 3) outside of intumescent sheet enclosure. Mat secured in place using aluminum foil tape (Item 5B) at all joints. Mat additionally secured with ceramic cord (Item 5J) and/or steel hardware cloth (Item 5K).

Minnesota Mining & Manufacturing Co. - Type M20A.

J. Electrical Circuit Protective Material* - Ceramic Cord - String-like material supplied in spools. Where accessible around entire circumference of cable tray support wrap, cord is tied-off at base of wrap at interface with intumescent sheet enclosure, spiraled upward at a spacing not to exceed 2 in. OC, and tied-off at interface with wall or floor. Cord tie-off at top and base of cable tray support wrap covered with aluminum foil tape (Item 5B).

Minnesota Mining & Manufacturing Co. - Type 34.

K. Steel Hardware Cloth - Maximum 1/2 by 1/2 in. welded mesh of minimum 0.041 in. diameter (19 SWG) galvanized steel wire. Strips of hardware cloth cut-to-size to cover intumescent mat wrap (Item 5I) on cable tray supports (Item 3) where 360° access to the wrap is not present. Hardware cloth secured to intumescent sheet enclosure with No. 10-16 by 3/4 in. long self-drilling, self-tapping, hex-washer head steel screws in conjunction with 5/8 in. diameter steel washers.

6. Cable Air Drop - Cables passing from one cable tray protective system to another cable tray protective system, through the air, to be protected with an electrical circuit protective system consisting of intumescent mat, aluminum foil tape, ceramic cord, caulk and steel hardware cloth. Minimum aggregate area of cables in air drop (cross-sectional area of cables including cable insulation and jacket materials) is 1.88 in.^{2}. The system shall be installed in accordance with the manufacturer's detailed instructions accompanying the Electrical Circuit Protective Materials*. The details of the cable air drop protective system are summarized below:

A. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 48 in. wide rolls. Installed by cutting-to-size and folding around tightly-bundled cables of cable air drop with the edges of the mat sheet secured together with steel staples and aluminum foil tape (Item 6B) along the longitudinal standing seam. Adjacent sheets of material must overlap the preceding sheet 3 to 6 in. Successive layers of intumescent mat installed in the same manner with the stapled and taped longitudinal seam of each layer diametrically opposed from that of the preceding layer and with the overlap locations for each layer offset a minimum of 6 in. from the overlap of the preceding layer. A total of five layers of intumescent mat are required. Intumescent mat wrap on cable air drop to extend a minimum of 9 in. into intumescent mat wrap (Item 5A) of cable tray protective system at each end. Opening in cable tray protective systems to accommodate cable air drop shall conform to contours of mat-wrapped cable air drop.

Minnesota Mining & Manufacturing Co. - Type M20A.

B. Electrical Circuit Protective Material* - Aluminum Foil Tape - 3 in. wide pressure-sensitive supplied in rolls. Used to secure intumescent mat wrap (Item 6A).

Minnesota Mining & Manufacturing Co. - Type 425.

C. Electrical Circuit Protective Material* - Ceramic Cord - String-like material supplied in spools used for supplemental securement of outer layer of intumescent mat wrap after aluminum foil tape application. Cord is tied-off at base of wrap at interfaces with cable tray protective systems, spiraled around intumescent mat wrap in both directions in a criss-cross pattern and spaced 2 in. OC.

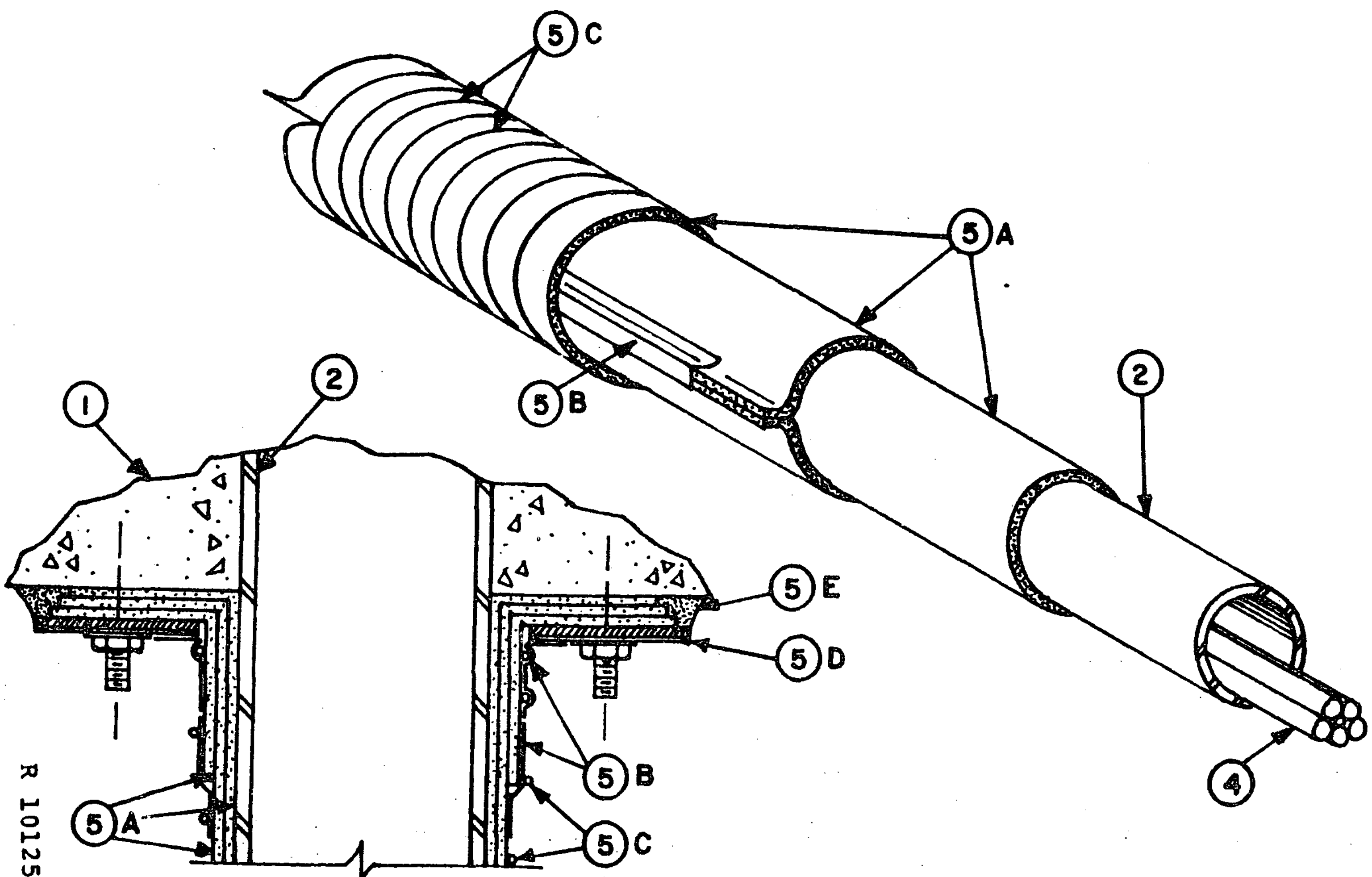
Minnesota Mining & Manufacturing Co. - Type 34.

D. Electrical Circuit Protective Material* - Caulk - Supplied in cartridges. Thick bead of caulk to be applied around the perimeter of the intumescent mat wrap on the cable air drop at each interface with the cable tray protective system.

Minnesota Mining & Manufacturing Co. - Type CP-25.

* Bearing the UL Classification Marking.

System No. 3
Fire Rating - 1 Hr.



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System No. 3
Fire Rating - 1 h

1. Wall Or Floor Assembly - 1 h rated concrete or masonry wall or concrete floor. Through opening in wall or floor to be firestopped using a Classified firestop device or system. See Through-Penetration Firestop Devices (Guide XHCR) and Through-Penetration Firestop Systems (Guide XHEZ) categories for presently Classified firestops.

2. Steel Conduit - Nominal 2 in. diameter (or larger) Trade Size rigid steel conduit. Conduits shall be installed as a complete system in accordance with all provisions in Article 346 of the current National Electrical Code.

3. Conduit Support - (Not Shown) - The conduits shall be supported by U-shaped welded hangers formed of minimum 0.093 in. thick (12 gauge) painted steel or minimum 0.097 in. thick (12 gauge) galvanized steel channels, 1-5/8 in. wide web with 1-5/8 in. high flanges with the flange edges hemmed for stiffness.

4. Cables - Minimum No. 16 AWG jacketed multi-conductor cable and/or minimum 250 MCM jacketed copper single-conductor power cables. Cable insulation to be cross-linked polyethylene. Cable jacket to be polyvinyl chloride. When fillers are used in the cable construction, fillers to be hemp, polyvinyl chloride or cross-linked polyethylene. Cables to be installed in conduits in accordance with all provisions of Article 346 of the National Electrical Code.

5. Electrical Circuit Protective System - The electrical circuit protective system consists of intumescent mat, aluminum tape, ceramic cord, intumescent sheet, caulk and steel hardware cloth. The system must be installed in accordance with the manufacturer's detailed instructions accompanying the Electrical Circuit Protective Materials*. The details of the electrical circuit protective system are summarized below:

A. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 48 in. wide rolls. Installed by cutting-to-size and folding around conduit with the edges of the mat sheet secured together with aluminum foil tape (Item 5B) along the longitudinal standing seam. Adjacent sheets of material must overlap the preceding sheet 3 to 6 in. Successive layers of intumescent mat installed in the same manner with the taped longitudinal seam of each layer diametrically opposed from that of the preceding layer and with the overlap locations for each layer offset a minimum of 6 in. from the overlap of the preceding layer. A minimum of five layers of intumescent mat are required on nominal 2 in. to nominal 4-1/2 in. diameter Trade Size rigid steel conduit. A minimum of two layers of intumescent mat are required on nominal 5 and 6 in. diameter Trade Size rigid steel conduit. Minimum of two layers of intumescent mat wrapped around steel conduit supports (Item 3). Mat secured in place using aluminum foil tape (Item 5B) at all joints.

Minnesota Mining & Manufacturing Co. - Type M20A.

B. Electrical Circuit Protective Material* - Aluminum Foil Tape - 3 in. wide pressure-sensitive tape supplied in rolls. Used to secure intumescent mat wrap (Item 5A).

Minnesota Mining & Manufacturing Co. - Type 425.

C. Electrical Circuit Protective Material* - Ceramic Cord - String-like material supplied in spools. Cord is tied-off at base of wrap at interface with wall and/or floor, spiraled around outer layer of mat at a spacing not to exceed 2 in. OC. Cord tie-off at interface with wall and/or floor covered with aluminum foil tape (Item 5B).

Minnesota Mining & Manufacturing Co. - Type 34.

D. Electrical Circuit Protective Material* - Intumescent Sheet - Rigid aluminum foil-faced sheets with galvanized steel sheet backer. Installed around intumescent mat wrapped conduit and conduit supports at the interface with the wall and/or floor. Secured to wall and/or floor with steel anchors.

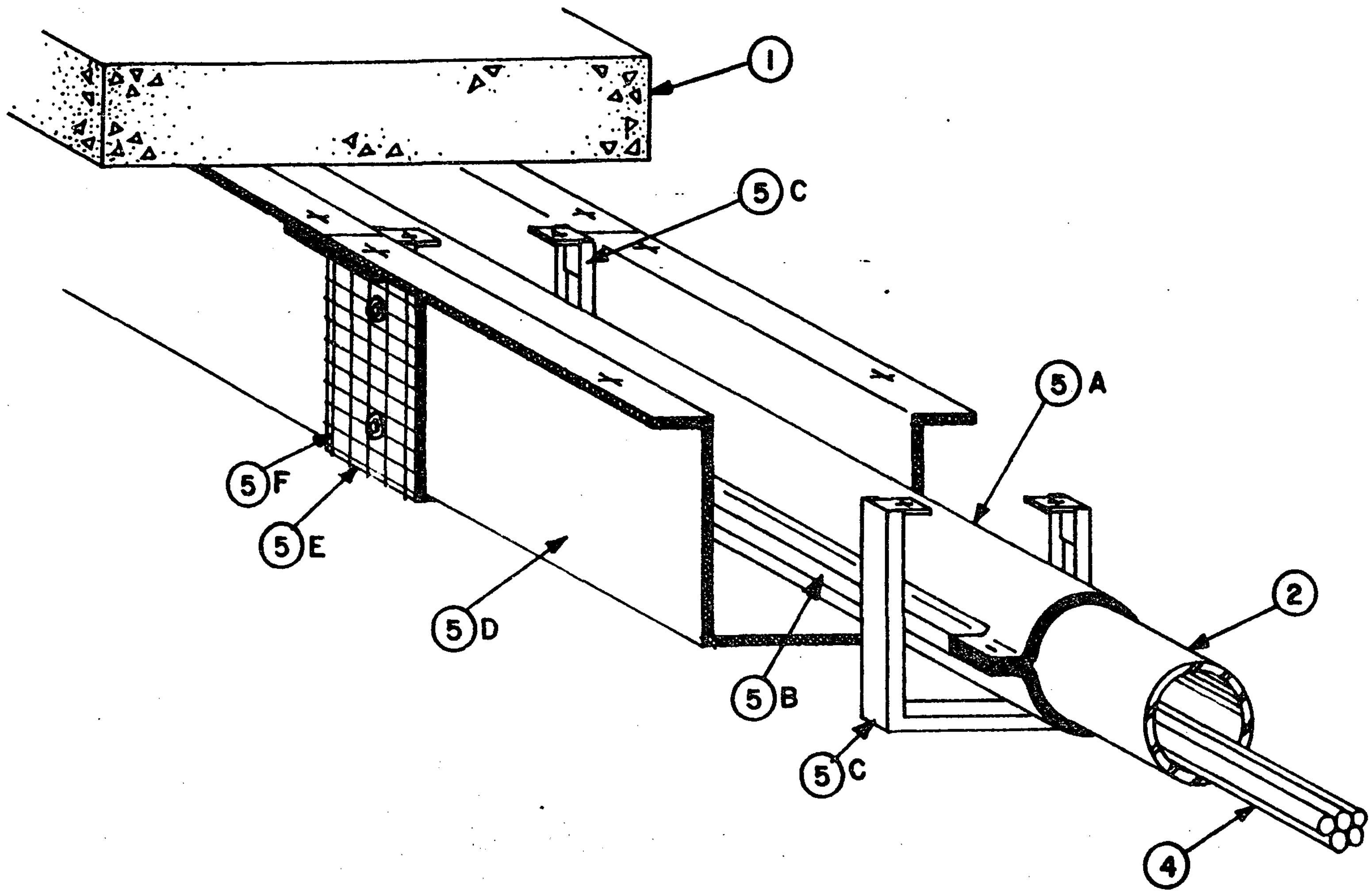
Minnesota Mining & Manufacturing Co. - Type CS-195.

E. Electrical Circuit Protective Material* - Caulk - Supplied in cartridges. Thick bead of caulk to be applied as a gasket between intumescent sheet (Item 5D) and the wall and/or floor.

Minnesota Mining & Manufacturing Co. - Type CP-25.

*Bearing the UL Classification Marking.

System No. 4
Fire Rating - 1 Hr.



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System No. 4
Fire Rating - 1 h

1. Wall Or Floor Assembly - - 1 h rated concrete or masonry wall or concrete floor. Through opening in wall or floor to be firestopped using a Classified firestop device or system. See Through-Penetration Firestop Devices (Guide XHCR) and Through-Penetration Firestop Systems (Guide XHEZ) categories for presently Classified firestops.

2. Steel Conduit - Nominal 2 in. diameter (or larger) Trade Size rigid steel conduit. Conduits installed parallel with and maximum 2 in. from wall or floor. Conduits shall be installed as a complete system in accordance with all provisions in Article 346 of the current National Electrical Code.

3. Conduit Supports - (Not Shown) - Conduits shall be supported in accordance with all provisions in Article 346 of the current National Electrical Code. The supports used shall be completely within the three-sided intumescent sheet enclosure (Item 5D).

4. Cables - Minimum No. 16 AWG jacketed multi-conductor cables and/or minimum 250 MCM jacketed copper single-conductor power cables. Cable insulation to be cross-linked polyethylene. Cable jacket to be polyvinyl chloride. When fillers are used in the cable construction, fillers to be hemp, polyvinyl chloride or cross-linked polyethylene. Cables to be installed in conduit in accordance with all provisions of Article 346 of the National Electrical Code.

5. Electrical Circuit Protective System - The electrical circuit protective system consists of intumescent mat, aluminum foil tape, steel framing, intumescent sheet, caulk and steel hardware cloth. The system must be installed in accordance with the manufacturer's detailed instructions accompanying the Electrical Circuit Protective Materials*. The details of the electrical circuit protective system are summarized below:

A. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 48 in. wide rolls. Installed by cutting-to-size and folding around steel conduit with the edges of the mat sheet secured together with steel staples and aluminum foil tape (Item 5B) along the longitudinal standing seam. Adjacent sheets of material must overlap the preceding sheet 3 to 6 in.

Minnesota Mining & Manufacturing Co. - Type M20A.

B. Electrical Circuit Protective Material* - Aluminum Foil Tape - 3 in. wide pressure-sensitive tape supplied in rolls. Used to secure intumescent mat wrap (Item 5A).

Minnesota Mining & Manufacturing Co. - Type 425.

C. Steel Framing - Steel channels with nominal 1-1/4 in. wide web with 3/4 in. high flanges with the flange edges hemmed for stiffness and to accommodate special mechanical fasteners. The channels shall be formed of minimum 0.067 in. thick (14 gauge) painted steel or minimum 0.070 in. thick (14 gauge) galvanized steel. Steel channels assembled to form a U-shaped bracket around three sides of the conduit and secured to the wall or floor with steel anchors. The U-shaped brackets must be formed such that the minimum clearance between the intumescent sheets (Item 5D) and the conduit is 2 in. The U-shaped brackets shall be assembled by welding or through the use of special fittings in conjunction with 3/8 in. diameter steel bolts with nuts. Brackets installed at the interface with the wall or floor at each end of the conduit system and along the entire length of the conduit system with a maximum spacing of 36 in. OC (bracket required at each butted joint of the intumescent sheet enclosure).

D. Electrical Circuit Protective Material* - Intumescent Sheet - Rigid aluminum foil-faced sheets with galvanized steel sheet backer. Intumescent sheet formed around U-shaped brackets with nominal 2 in. wide flanges along both side edges against wall or floor. Adjacent lengths of formed intumescent sheets to be tightly butted and to be centered over U-shaped brackets. Intumescent sheet secured to wall or floor with steel anchors spaced maximum 12 in. OC. Sheets secured to U-shaped brackets with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws.

Minnesota Mining & Manufacturing Co. - Type CS-195.

E. Electrical Circuit Protective Material* - Intumescent Mat - Flexible sheet material, supplied in nominal 4 in. wide rolls. Installed in conjunction with steel hardware cloth (Item 5F) to cover all joints in intumescent sheet enclosure. Mat strips cut-to-length to completely cover each butted joint, centered over joint and temporarily held in position with aluminum foil tape (Item 5B).

Minnesota Mining & Manufacturing Co. - Type M20A.

F. Steel Hardware Cloth - Maximum 1/2 by 1/2 in. welded mesh of minimum 0.041 in. diameter (19 SWG) galvanized steel wire. Nominal 4 in. wide strips of hardware cloth cut-to-length and installed over each intumescent mat joint cover (Item 5E). Hardware cloth secured to intumescent sheet (Item 5D), through intumescent mat (Item 5E), with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws in conjunction with 5/8 in. diameter steel washers.

*Bearing the UL Classification Marking.

Report by:

C. J. Johnson

C. J. JOHNSON
Engineering Associate
Fire Protection Department

Reviewed by:

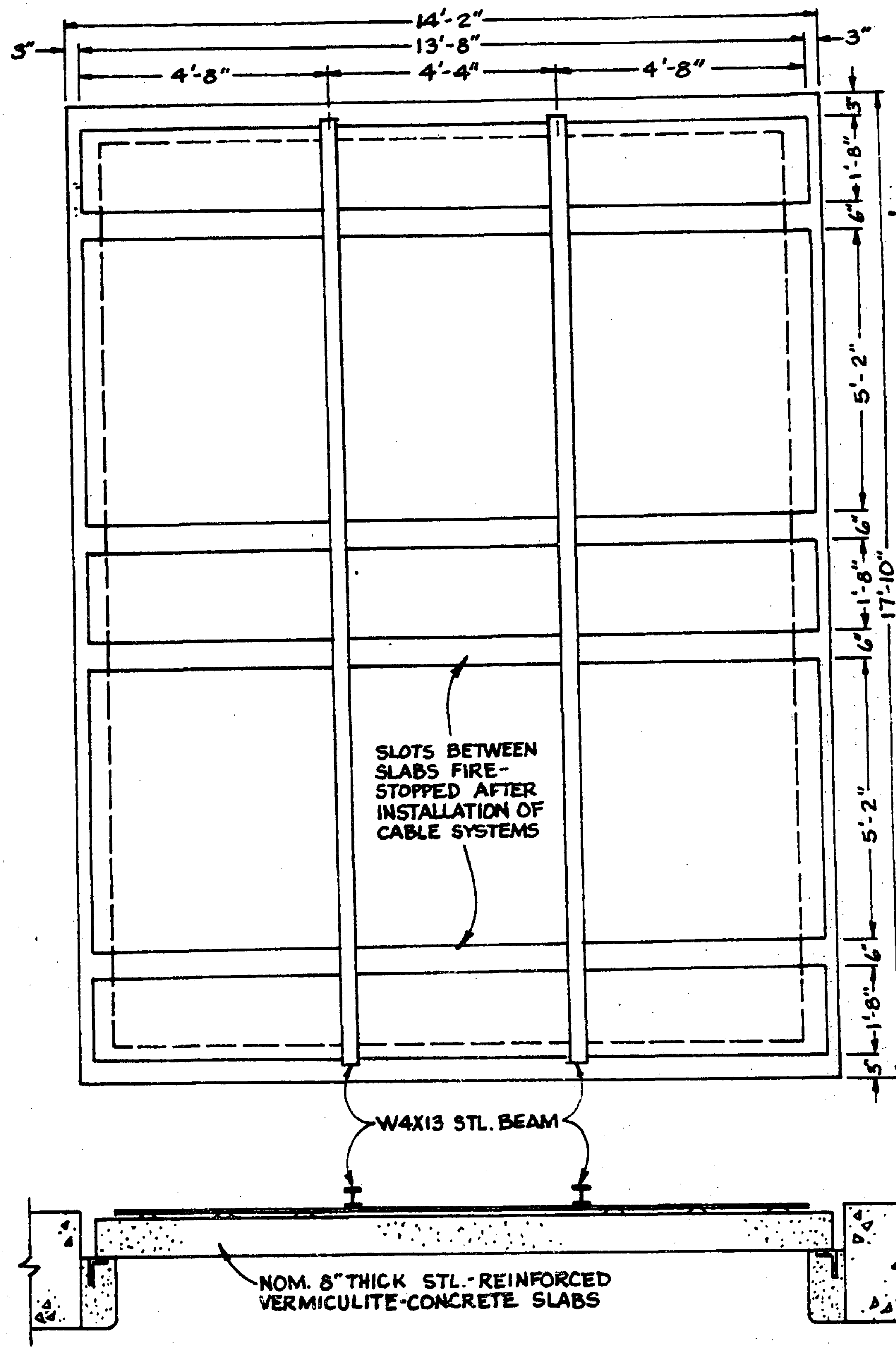
R. M. Berhinig

R. M. BERHINIG
Engineering Group Leader
Fire Protection Department

J. R. Beyreis

J. R. BEYREIS
Managing Engineer
Fire Protection Department

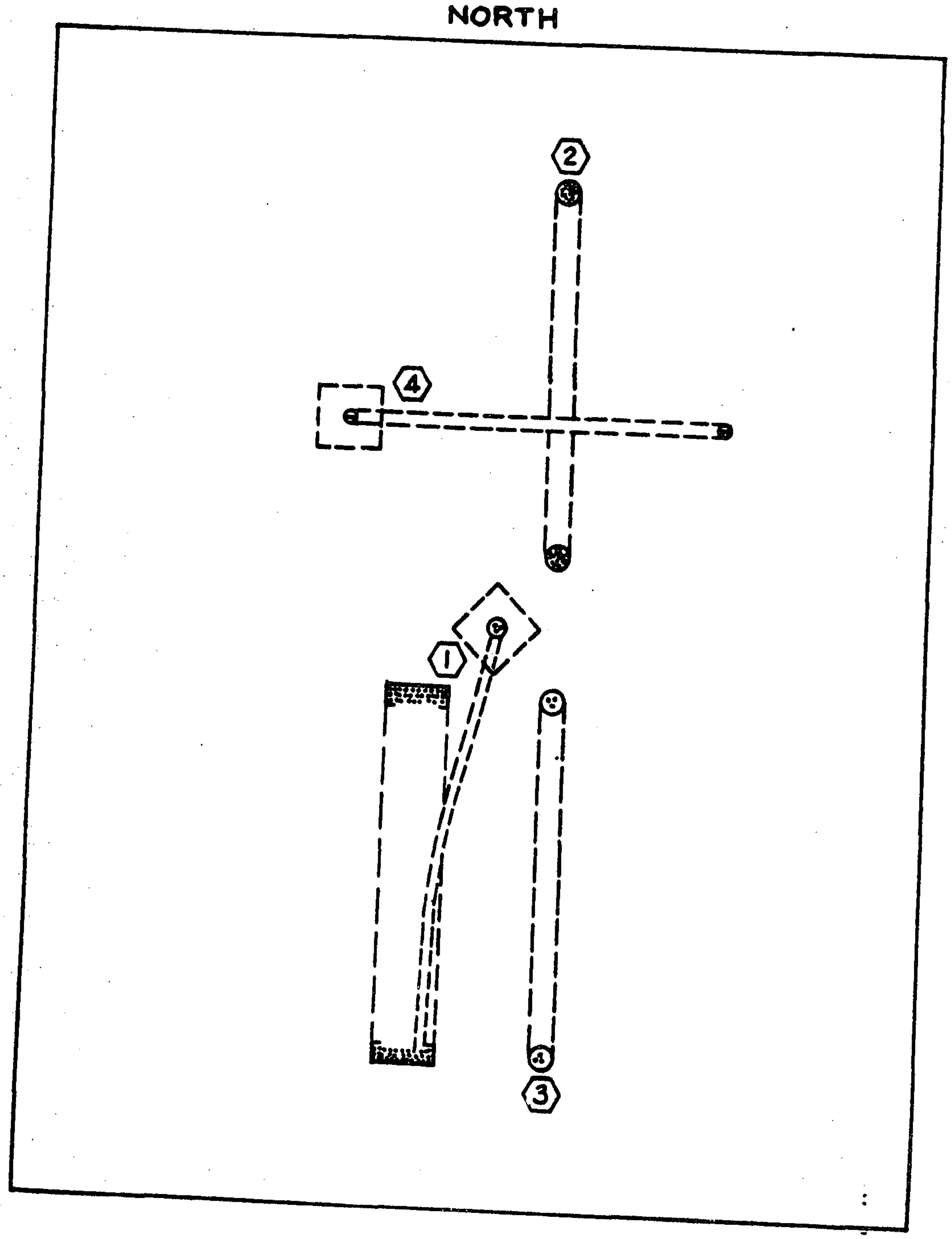
CJJ/RMB/JRB:jmd



FLOOR ASSEMBLY

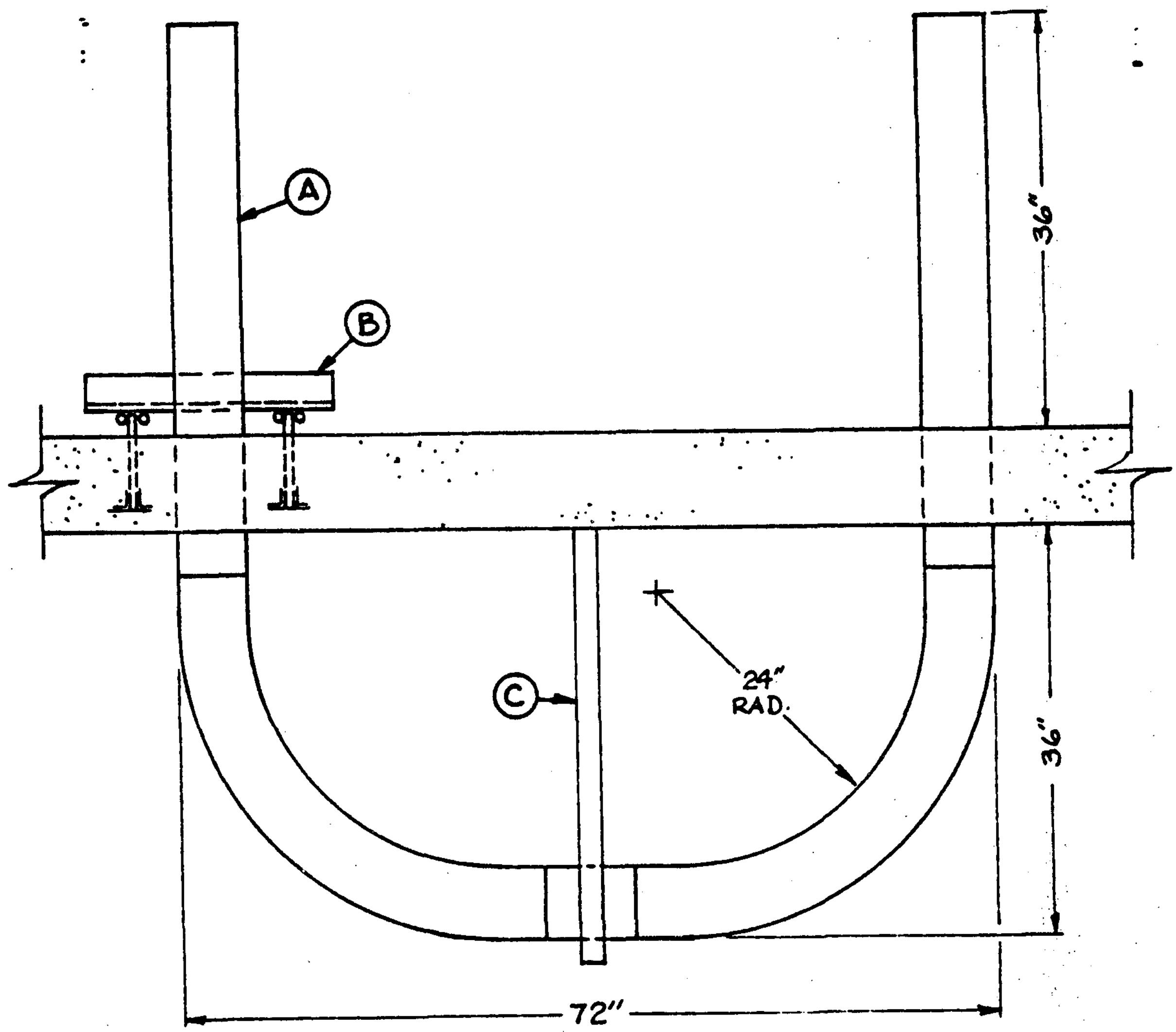
R10125-1,-2
ILL. 1

1- 12"x12"x6" STL. JUNCTION BOX W/CABLE DROP-OUT TO 12" CABLE TRAY
2- NOM. 5"ø RIGID STL. CONDUIT W/40% CABLE FILL
3- NOM. 5"ø RIGID STL. CONDUIT W/ MINIMUM CABLE FILL
4- 12"x12"x6" STL. JUNCTION BOX W/ NOM. 2"ø RIGID STL. CONDUIT W/ MINIMUM CABLE FILL



TEST ASSEMBLY NO. 1

R10125-1
ILL. 2



Ⓐ NOM. 12" WIDE x 6" DEEP OPEN-LADDER CABLE TRAY SYSTEM FOR SYSTEM NO. 1.

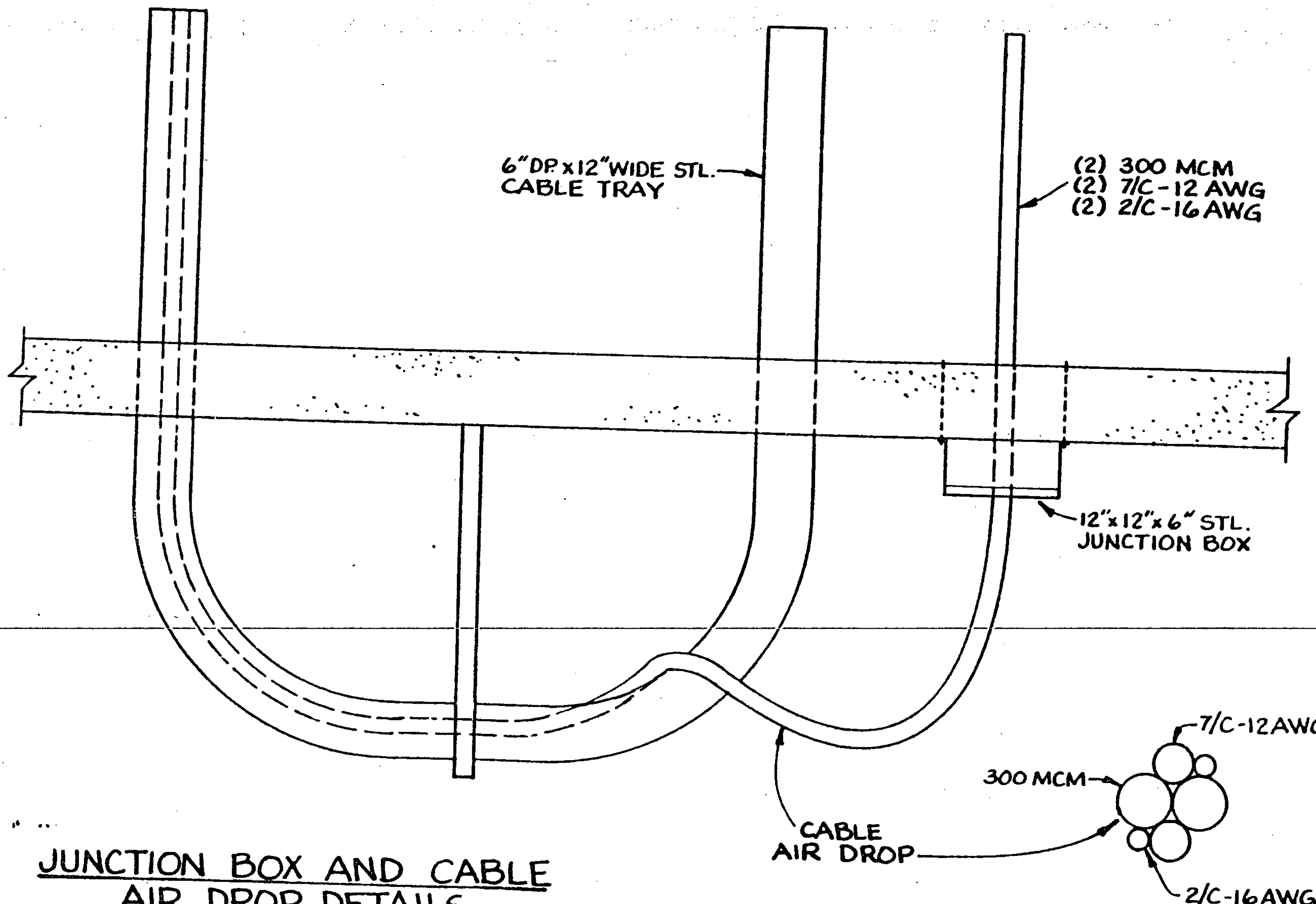
Ⓑ NOM. 3"x3"x¼" STEEL ANGLES RESTING ON STEEL REINFORCEMENT OF FLOOR SLABS (INVERTED TYPE 8H2 STEEL JOISTS) AND WELDED TO CABLE TRAY SIDERAILS ON BOTH SIDES OF CABLE TRAY AT BOTH ENDS OF CABLE TRAY SYSTEM.

Ⓒ WELDED TRAPEZE SUPPORT SECURED TO FLOOR SLAB.

CABLE TRAY SYSTEM DETAILS-
SYSTEM NO. 1

(TEST ASSEMBLY NO. 1)

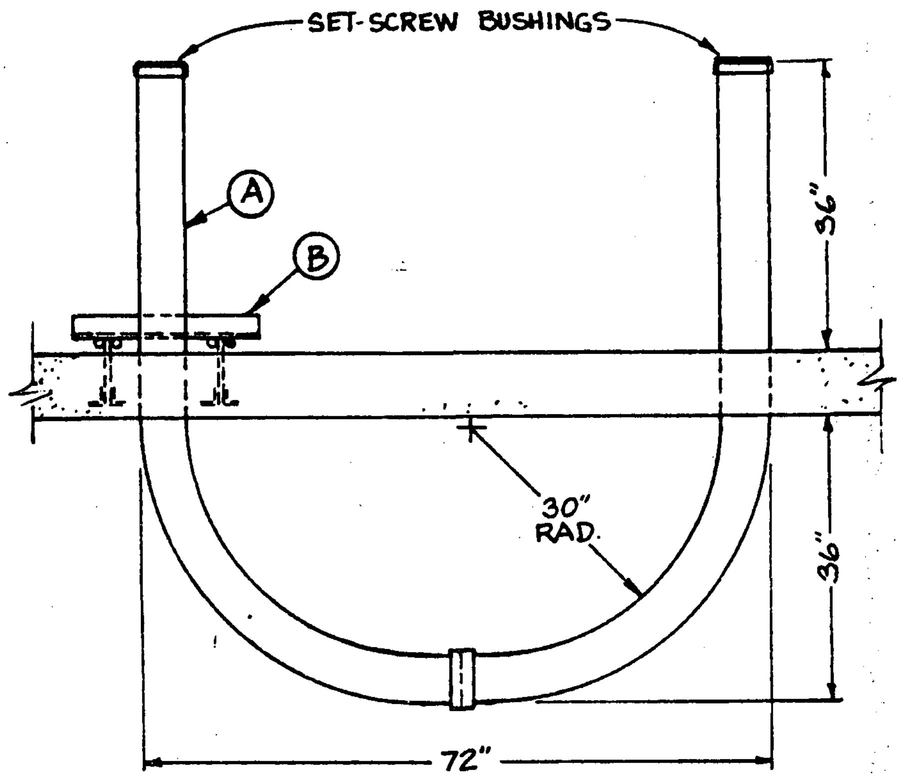
R10125-1
ILL. 3



JUNCTION BOX AND CABLE AIR DROP DETAILS - SYSTEM NO. 1

(TEST ASSEMBLY NO. 1)

R10125-1
ILL. 4

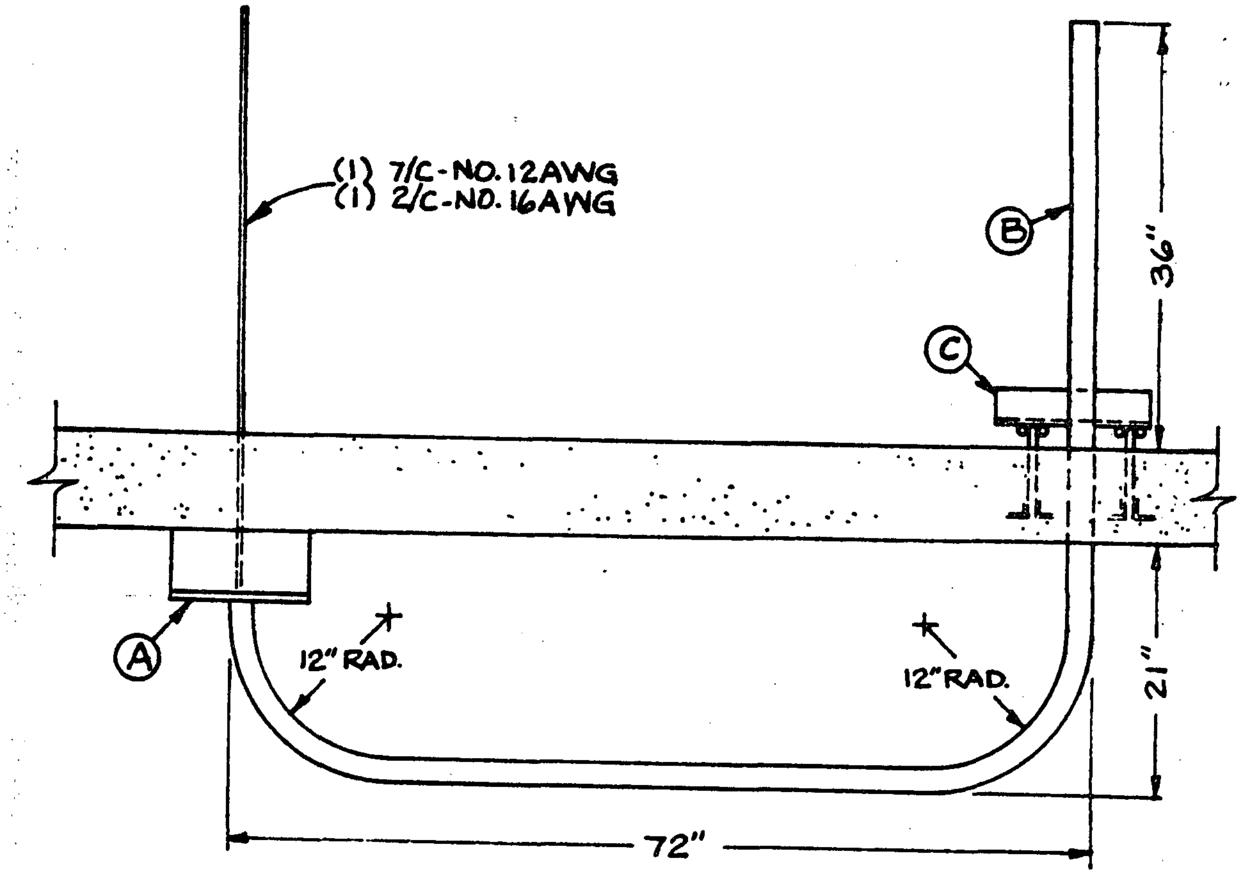


Ⓐ NOM. 5"ϕ RIGID STEEL CONDUIT SYSTEM FOR SYSTEM NOS. 2 AND 3.

Ⓑ NOM. 3"x3"x$\frac{1}{4}$" STEEL ANGLES RESTING ON STEEL REINFORCEMENT OF FLOOR SLABS (INVERTED TYPE 8H2 STEEL JOISTS) AND WELDED TO BOTH SIDES OF CONDUIT AT BOTH ENDS OF CONDUIT.

CONDUIT SYSTEM DETAILS - SYSTEM NOS. 2 & 3

(TEST ASSEMBLY NO. 1)



Ⓐ NOM. 12"x12"x6" STEEL JUNCTION BOX SECURED W/ 3/8"ϕ THREADED STEEL RODS, W/NUTS & WASHERS, INSTALLED THROUGH FLOOR SLAB.

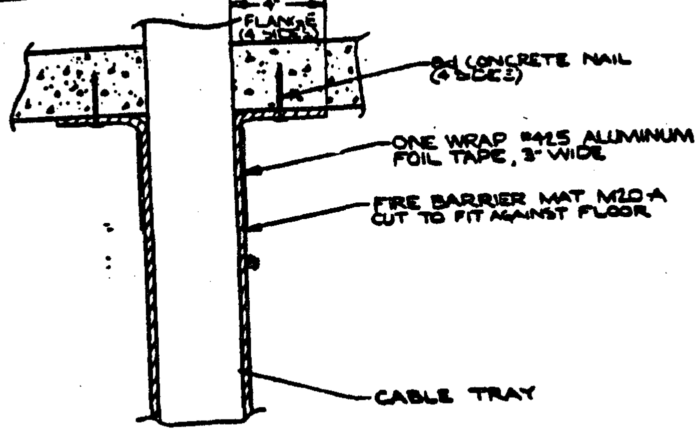
Ⓑ NOM. 2"ϕ RIGID STEEL CONDUIT SYSTEM.

Ⓒ NOM. 3"x3"x1/4" STEEL ANGLES RESTING ON STEEL REINFORCEMENT OF FLOOR SLABS (INVERTED TYPE 8H2 STEEL JOISTS) AND WELDED TO BOTH SIDES OF CONDUIT.

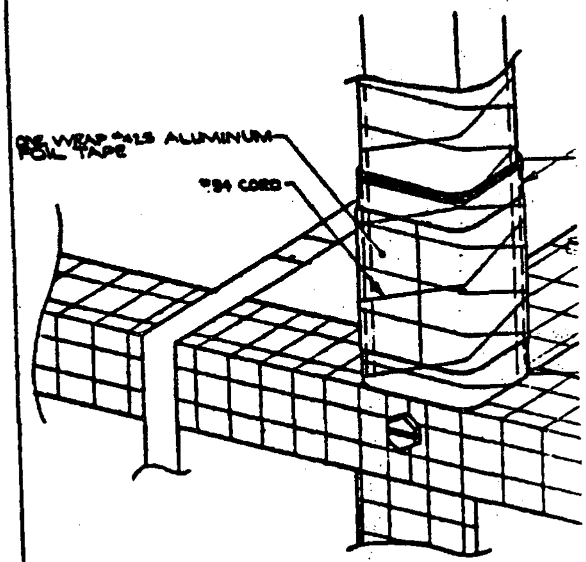
JUNCTION BOX AND CONDUIT DETAILS - SYSTEM NO. 4

(TEST ASSEMBLY NO. 1)

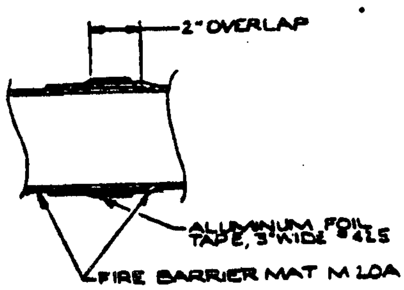
R10125-1
ILL. 6



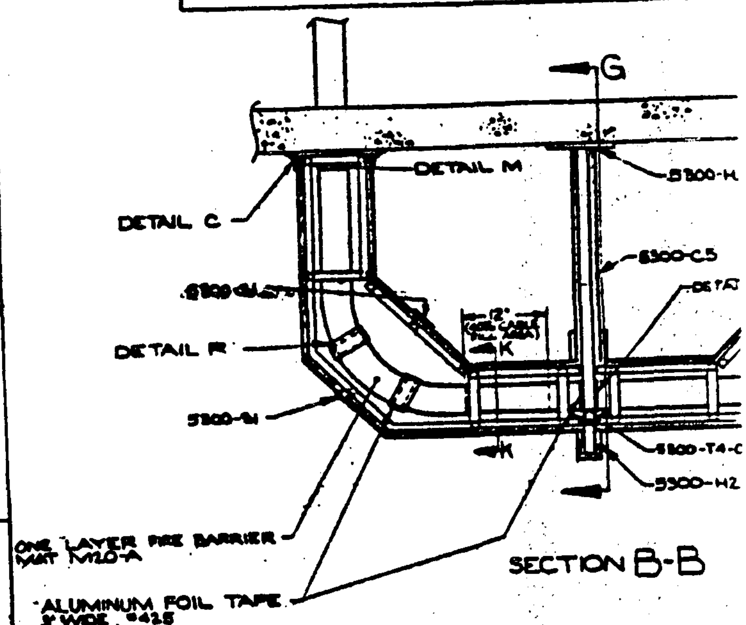
DETAIL M
FIRE BARRIER MAT M20-A TO FLOOR INTERFACE



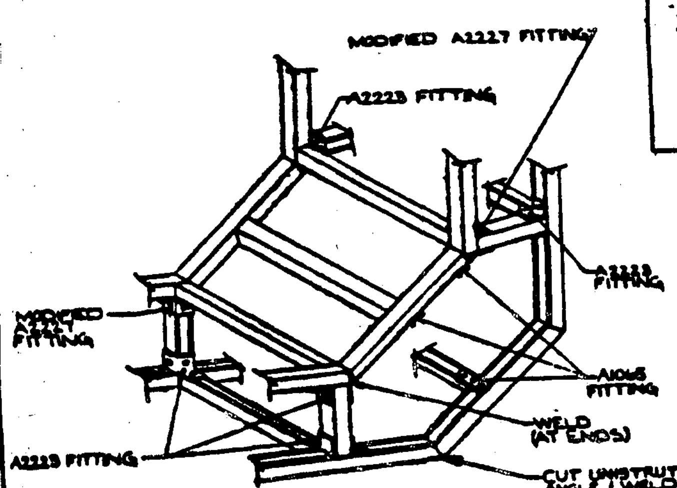
DETAIL L
(TRAY #1 SHOWN)



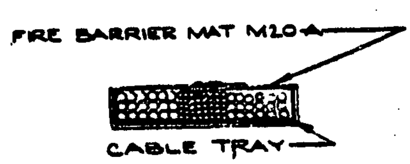
DETAIL R



SECTION B-B

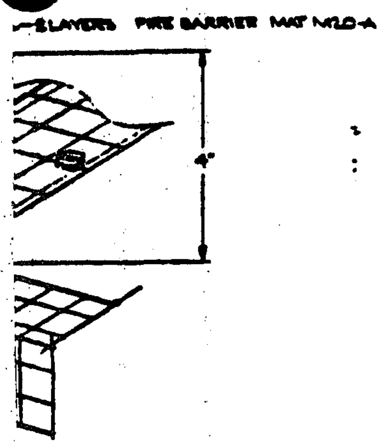


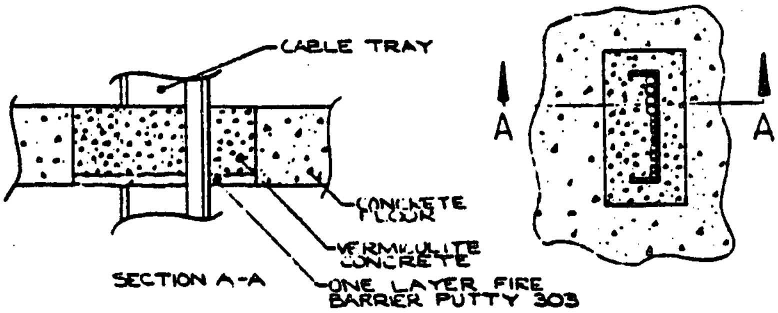
DETAIL E
UNISTRUT & FITTING CONSTRUCTION



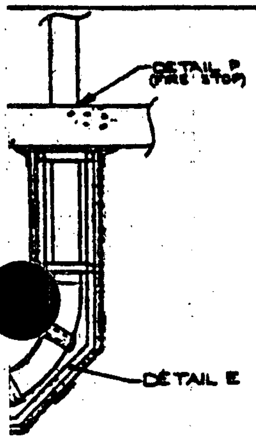
SECTION K-K
40% CABLE FILL AREA, 12" LONG

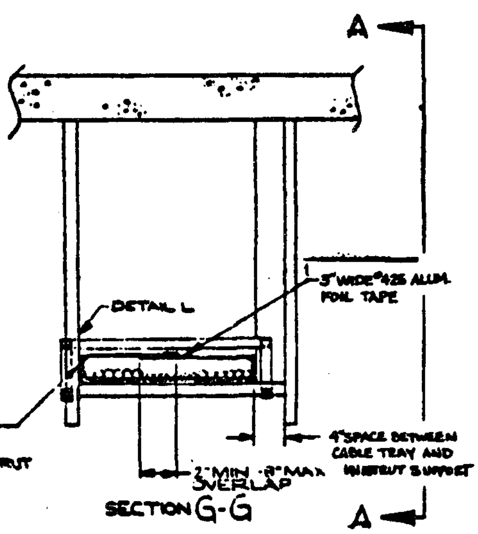
NOTES:



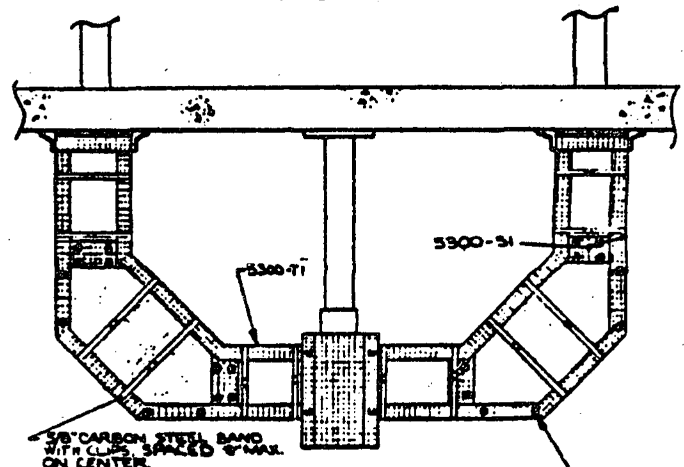


DETAIL P
(FIRESTOP)



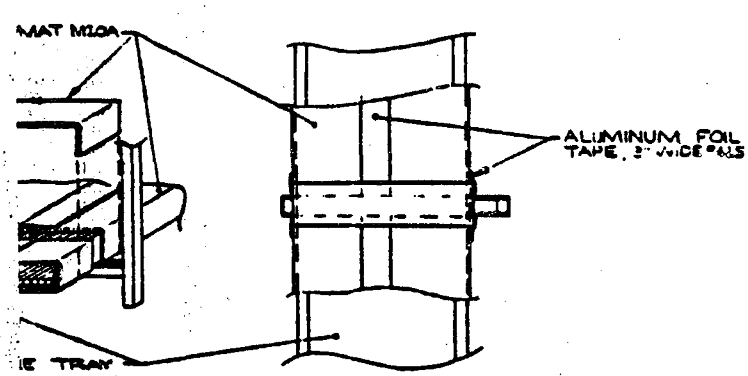


SECTION G-G



SECTION A-A
BANDING AND SEAMING SYSTEM

USE BIT TIP SELF-DRILLING SCREWS ON CORNER SEAMING ONLY WHERE BANDING DOES NOT HOLD SEAMING SYSTEM IN PLACE/WHERE STEEL BANDING CANNOT MAINTAIN 8" MAX SPACING



TOP VIEW

DETAIL N

NOTE: FIRE BARRIER MAT M20A WRAP AROUND CABLE TRAY NOT USED IN SYSTEM NO. 1 OF TEST ASSEMBLY NO. 1.

R10125-1,-2
ILL. 8

ISSUE	ISSUE DATE AND CHANGE RECORD	REV	CH
D	3-21-83	SLT	
C	3-16-83	SLT	
B	3-7-83	SLT	
A	2-7-83	SLT	

USED ON

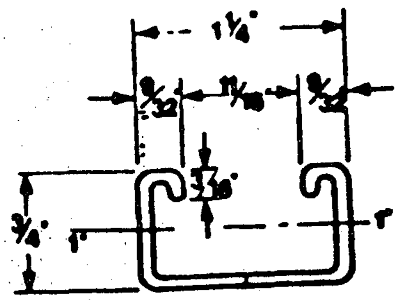
3M

TITLE FIRE BARRIER U.L. TEST SET-UP

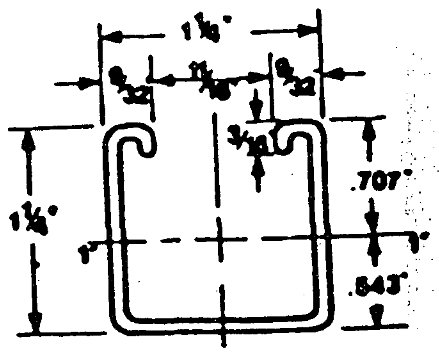
PAGE 2 of 3

D

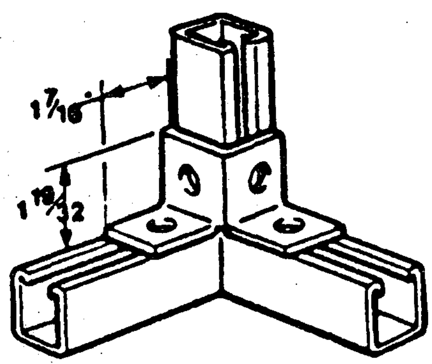
PART NO. PP83-007



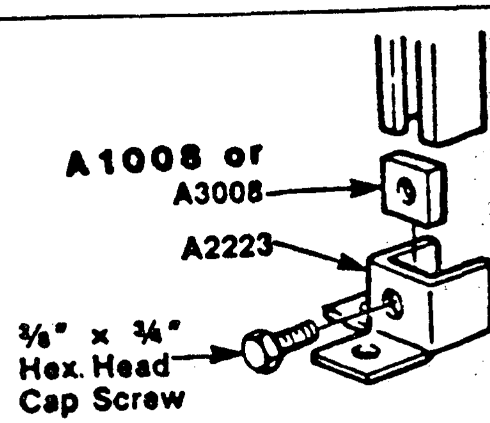
A3300 Unistrut



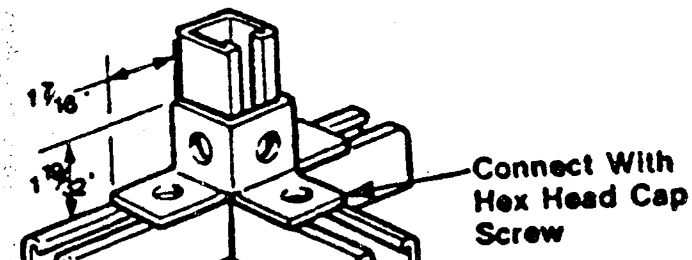
A1000 Unistrut



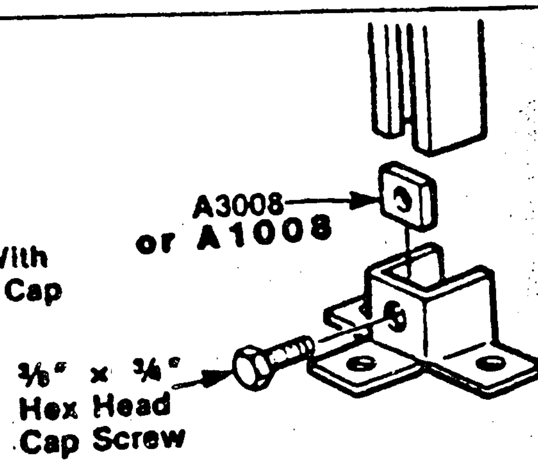
A2223 Fitting



A2223 and Bolting



A2227 Fitting



A2227 and Bolting

ISSUE	DATE	REV	CH
3	6/AUG/82		

NOT TO SCALE — CH: SAT

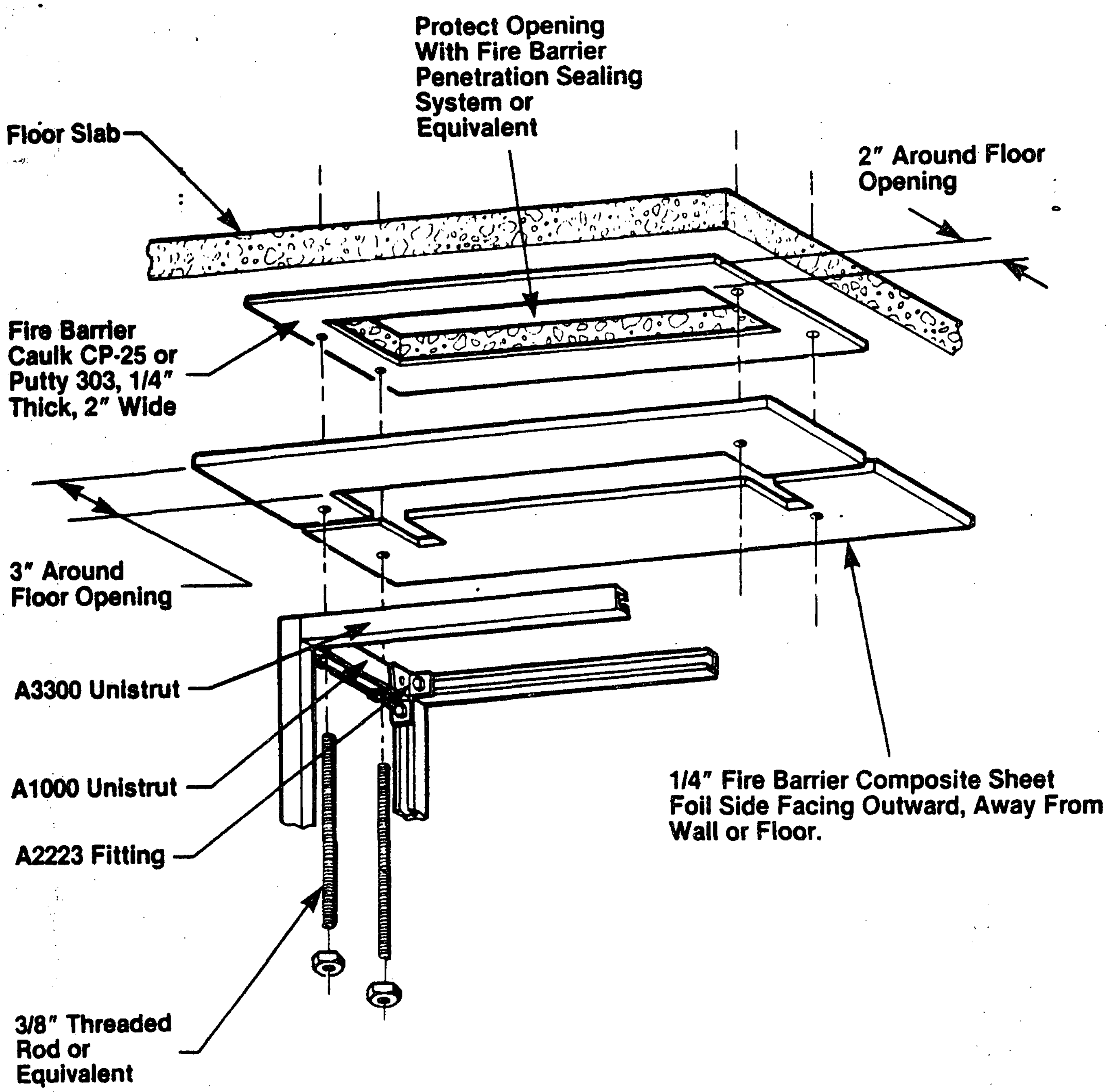
DR: J F FRENIK — APP: [signature]

Electro-Products Division/3M 3M

5300 U1

TYPICAL UNISTRUT FITTINGS

R10125-1,-2
ILL. 7



Unistrut Assembly
(1st of 2 Drawings - See 5300-T-12B)

R10125-1,-2
ILL. 9

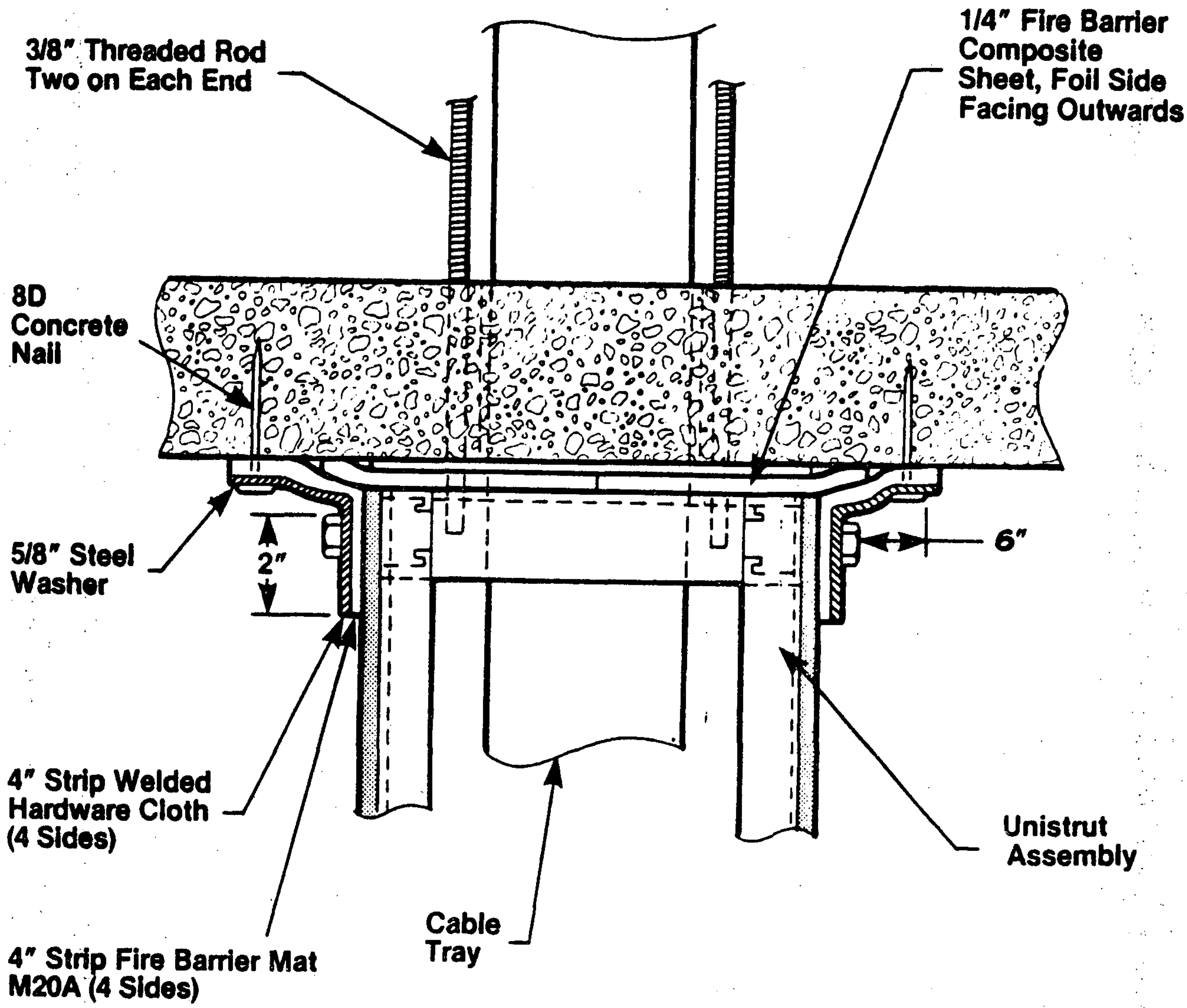
ISSUE	DATE	REV	CH
1	4/13/83		

NOT TO SCALE — CH J.R. Tuzinski
DR J.F. Krenik — APP M.A. O'Hara

Electro-Products Division/3M — 3M

5300-T-12A

Fire Barrier Cable Tray Protection System Interfacing Floor/ Wall Opening



Composite Sheet Assembly
(2nd of Two Drawings - See 5300-12A)

R10125-1,-2
ILL. 10

ISSUE	DATE	REV	CH
1	4/13/83		

NOT TO SCALE

CH J.R. Tuzinski

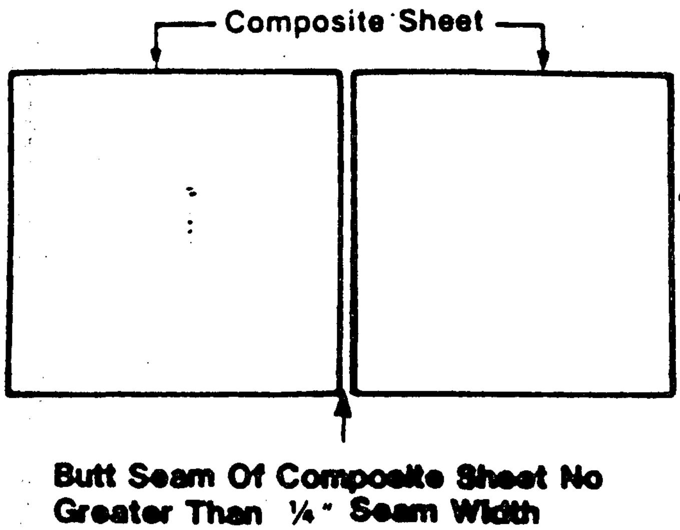
DR J.F. Krenik

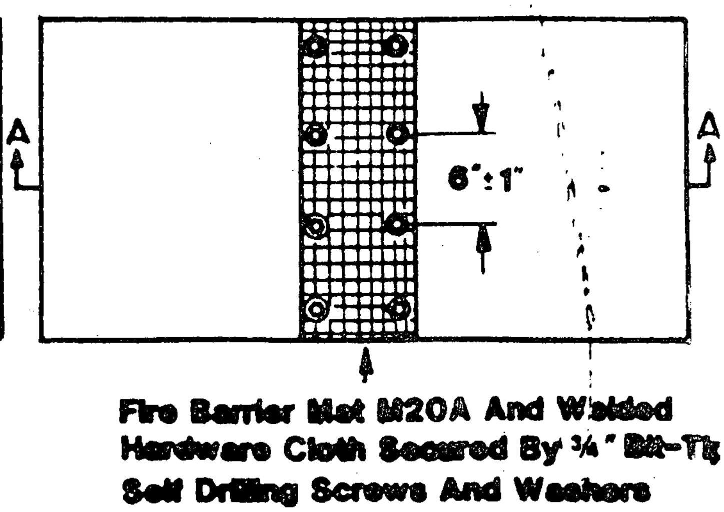
APP M.A. O'Hara

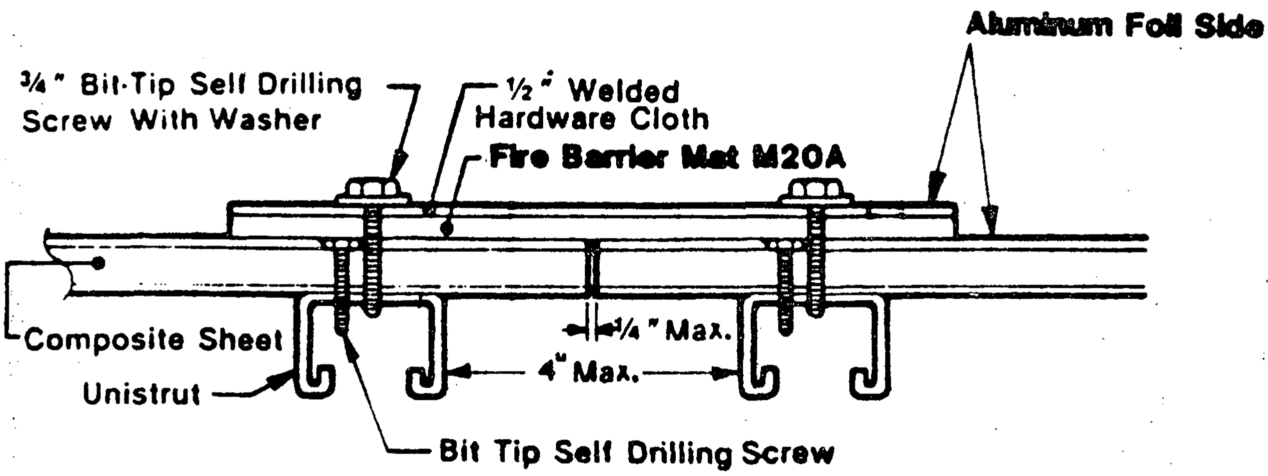
Electro-Products Division/3M 3M

5300-T-12B

Fire Barrier Cable Tray Protection System Interfacing Floor/Wall Opening







Detail A

R10125-1,-2
ILL. 11

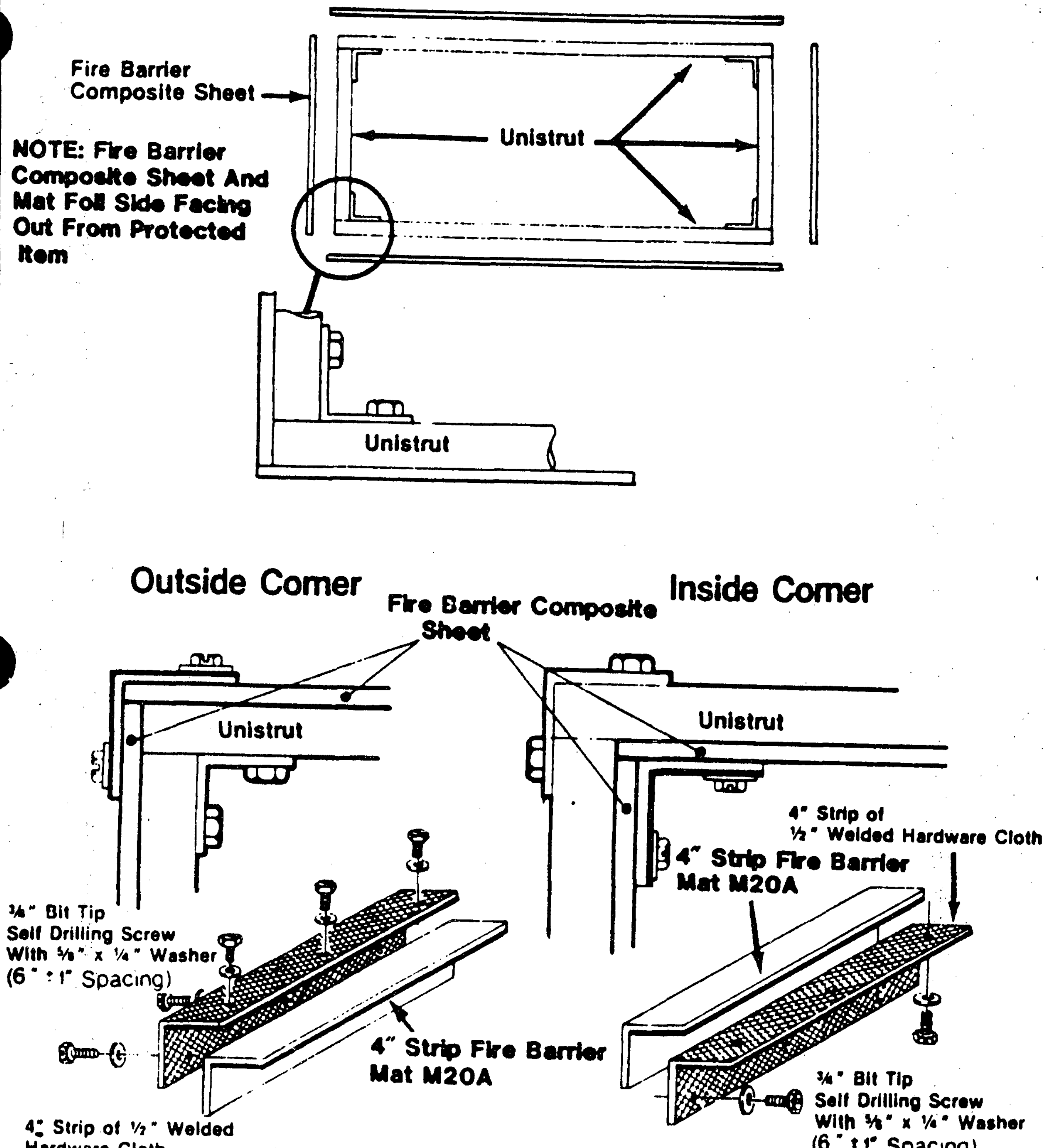
Issue	Date	Rev	CH
1	6/AUG/82		

Electro-Products Division/3M 3M

5300-S1-A

Fire Barrier 3M

Joining Technique
Flat Seam Protection



ISSUE	DATE	REV	CH
3	24/AUG/82		

NOT TO SCALE

DR J.F.KRENIK

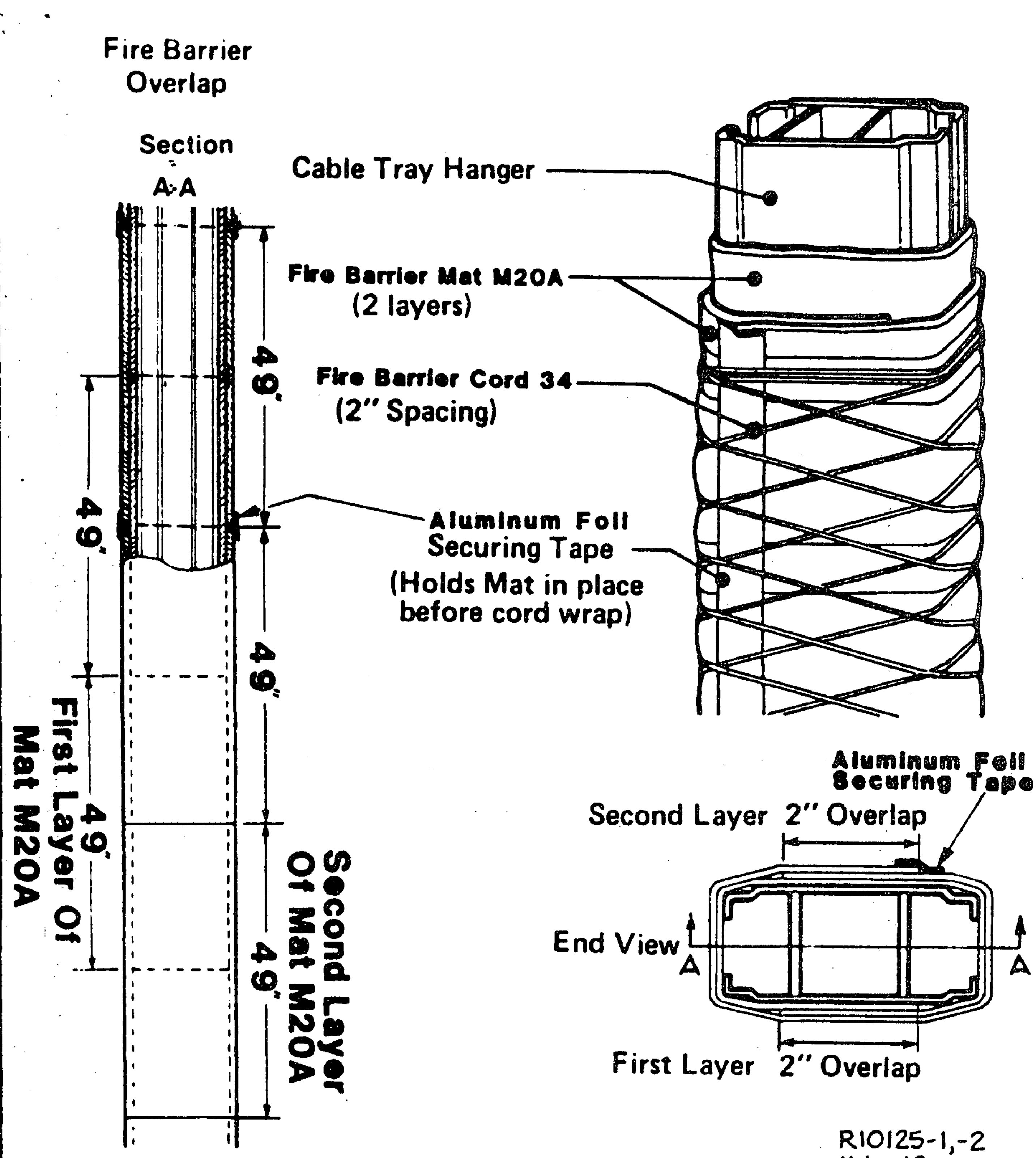
Electro-Products Division/3M 3M

5300-S2

R10125-1,-2
ILL. 12

3M

Fire Barrier Corner Seams Protection System



R10125-1,-2
ILL. 13

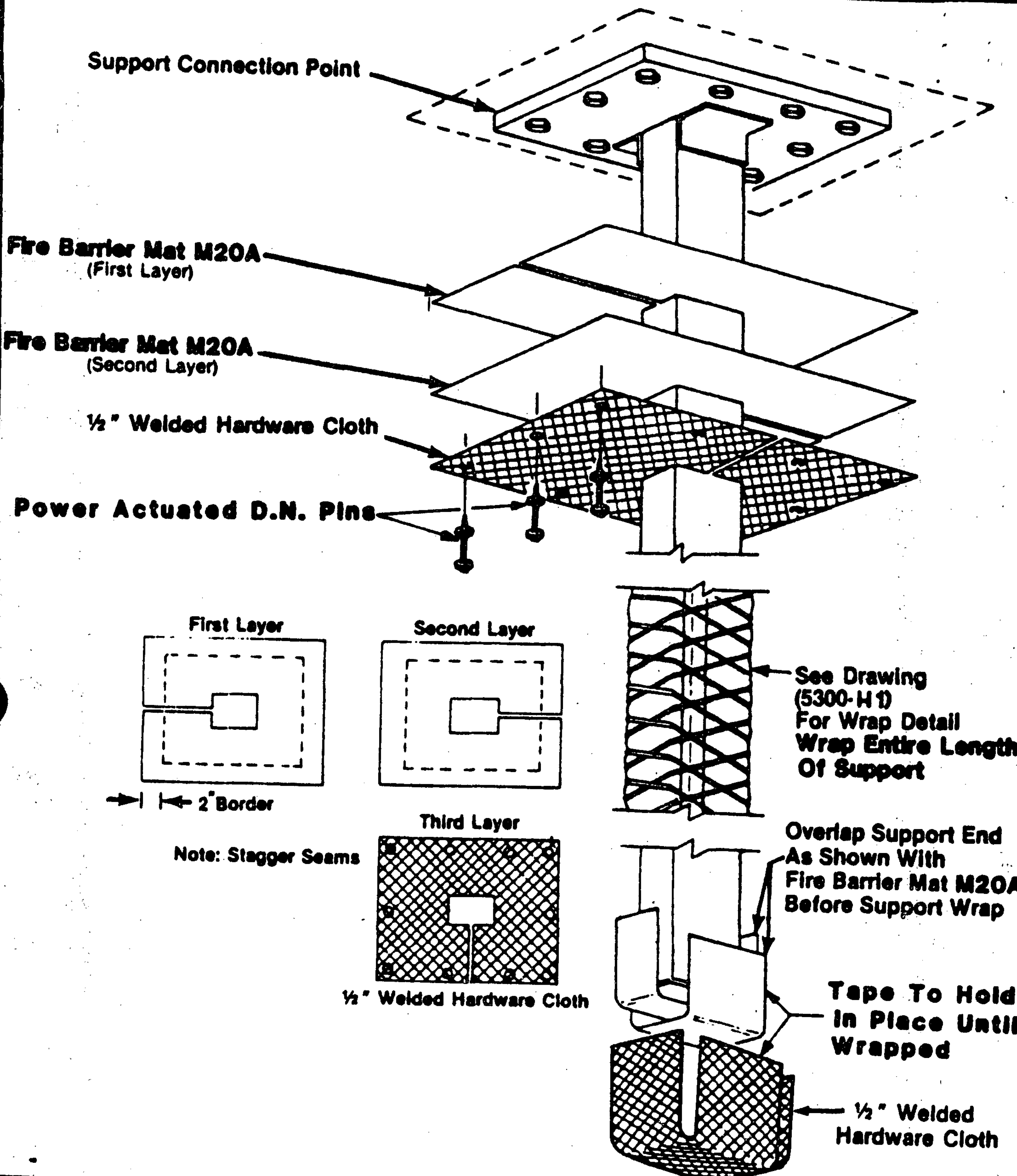
ISSUE	DATE	REV	CH
3	24/AUG/82		
NOT TO SCALE			
DR J.F.KRENIK			

Electro-Products Division/3M 3M

5300-H1

Fire Barrier Cable Tray Hanger System

3M



All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, however, since the conditions of use and application are beyond our control 3M shall not be liable for any [illegible] direct or consequential resulting from the use of material or design. 3M's only warranty shall be to [illegible] any of our products found to be defective

ISSUE	DATE	REV	CH.
3	24/AUG/82		

NOT TO SCALE

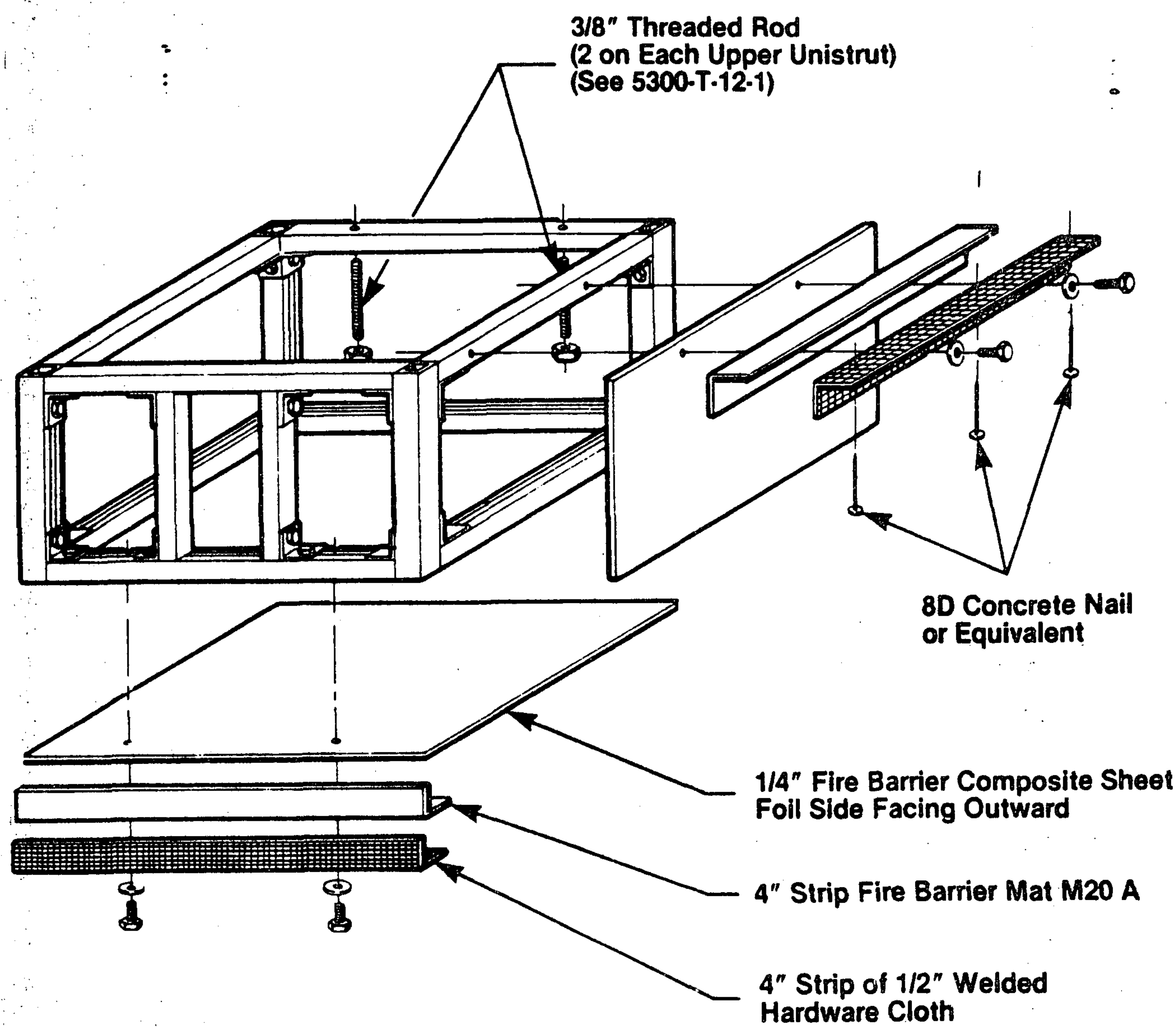
DR J.F.KRENIK

Electro-Products Division/3M 3M

5300-H2

Fire Barrier Raceway Support Connection Point Protection System 3M

R10125-1,-2
ILL. 14



See 5300-T1 For Construction Details

R10125-1,-2
ILL. 15

ISSUE	DATE	REV	CH.
1	4/13/83		

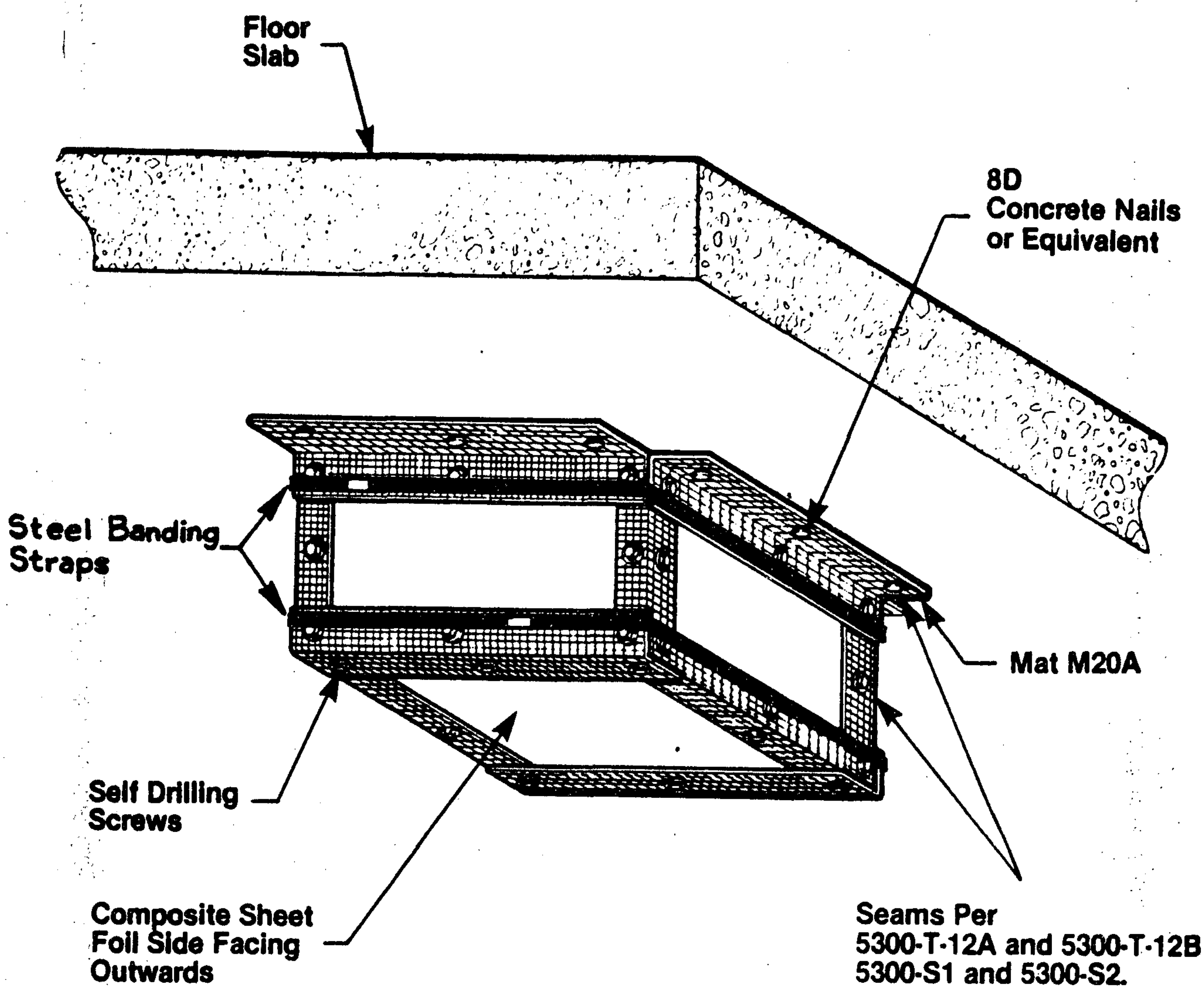
NOT TO SCALE — CH J.R. Tuzinski

DR J.F. Krenik — APP M.A. O'Hara

Fire Barrier Junction Box Protection System

Electro-Products Division/3M — 3M

5300-J1



R10125-1,-2
ILL. 16

ISSUE	DATE	REV	CH
1	4/13/83		

NOT TO SCALE

CH J.R. Tuzinski

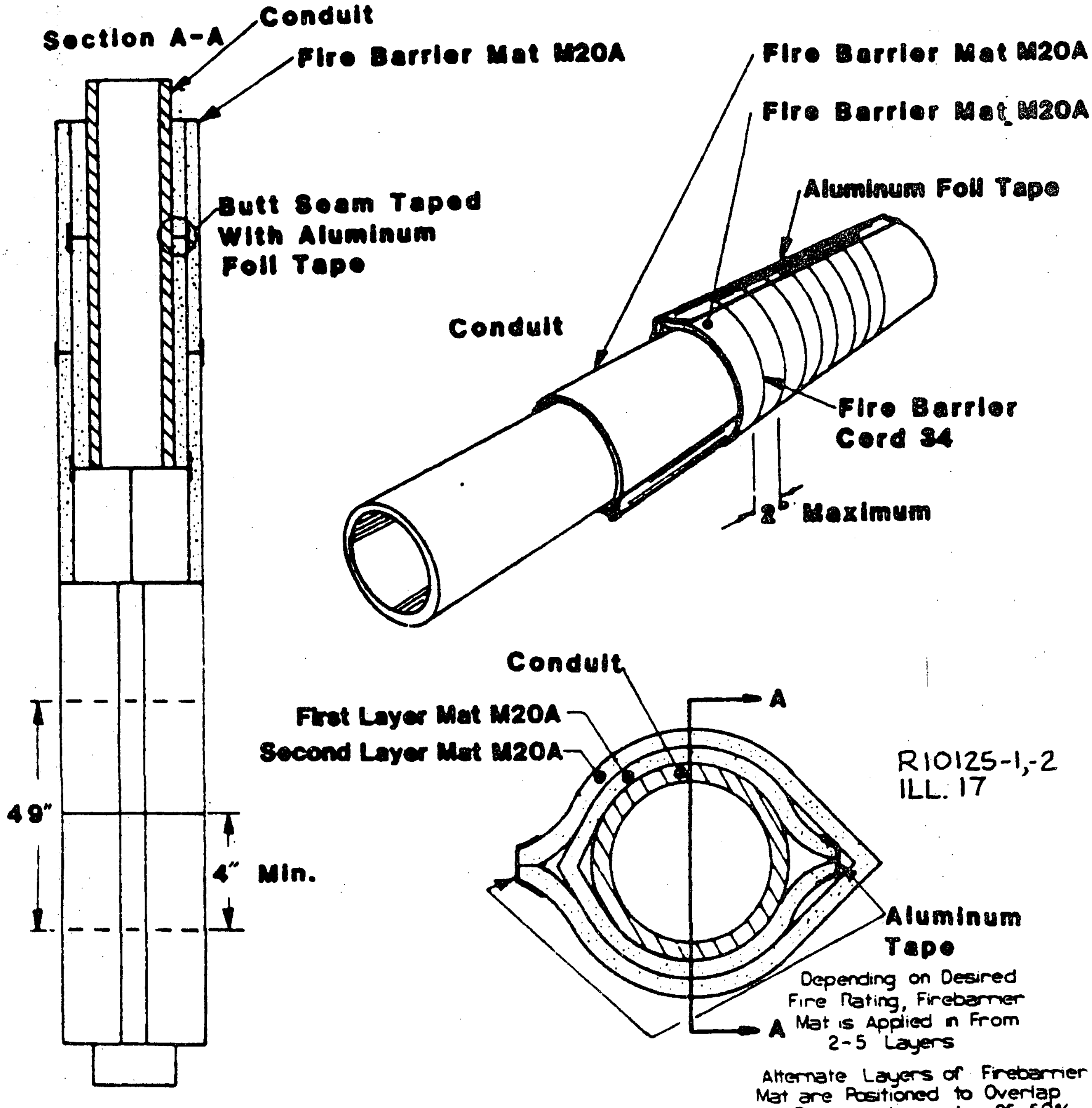
DR J.F. Krenik

APP M.A. O'Hara

Electro-Products Division/3M 3M

5300-J2

Fire Barrier Junction Box Protection System



Depending on Desired Fire Rating, Firebarrier Mat is Applied in From 2-5 Layers

Alternate Layers of Firebarrier Mat are Positioned to Overlap the Previous Layer by 25-50% of Mat Length and Taped Edges are Rotated 180°

NOTE: Install Fire Barrier Mat With Aluminum Foil Out

ISSUE	DATE	REV	CH
3	24/AUG/82		

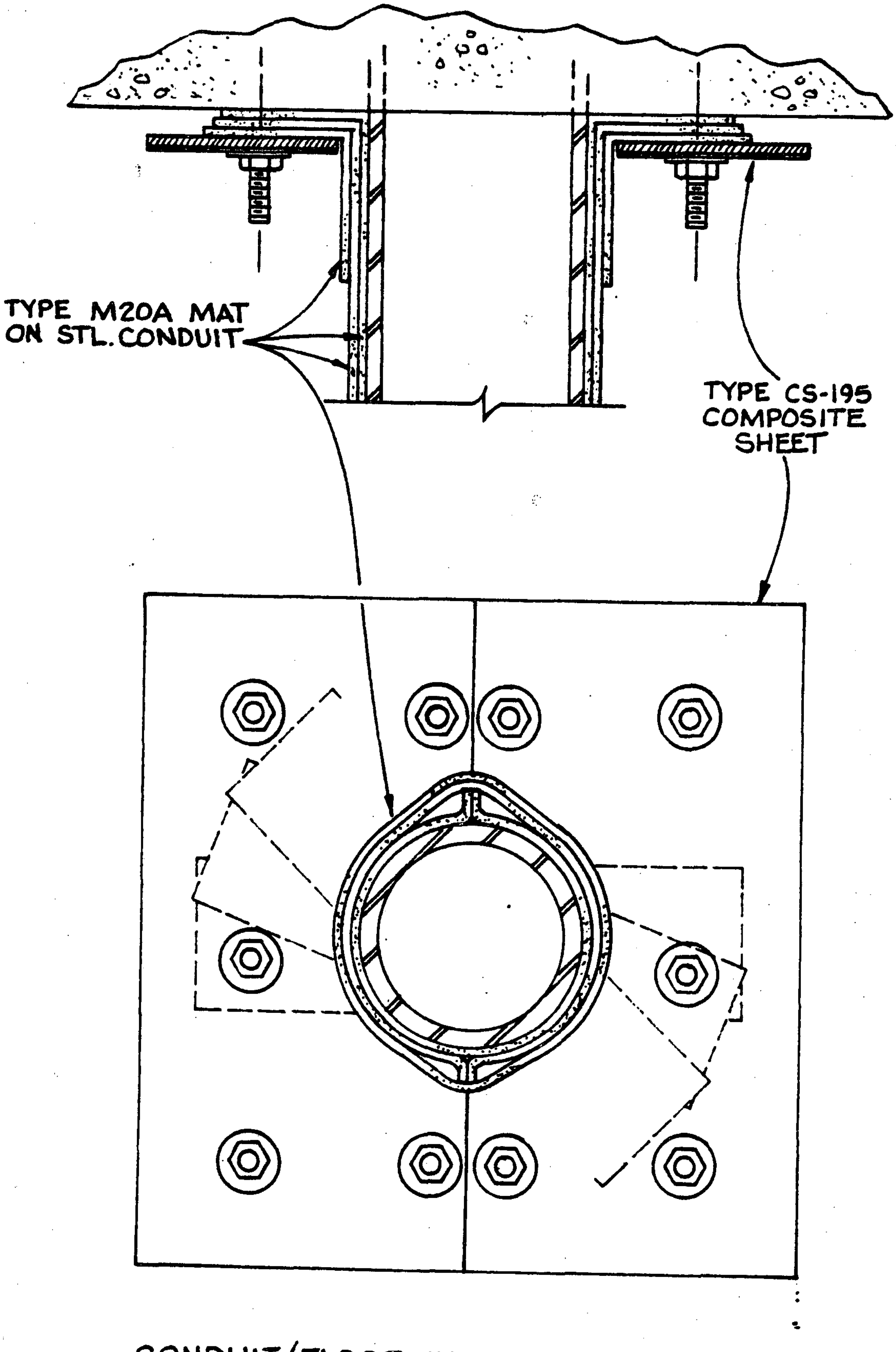
NOT TO SCALE

3M

Fire Barrier Conduit Protection System

Electro Products Division 3M — 3M

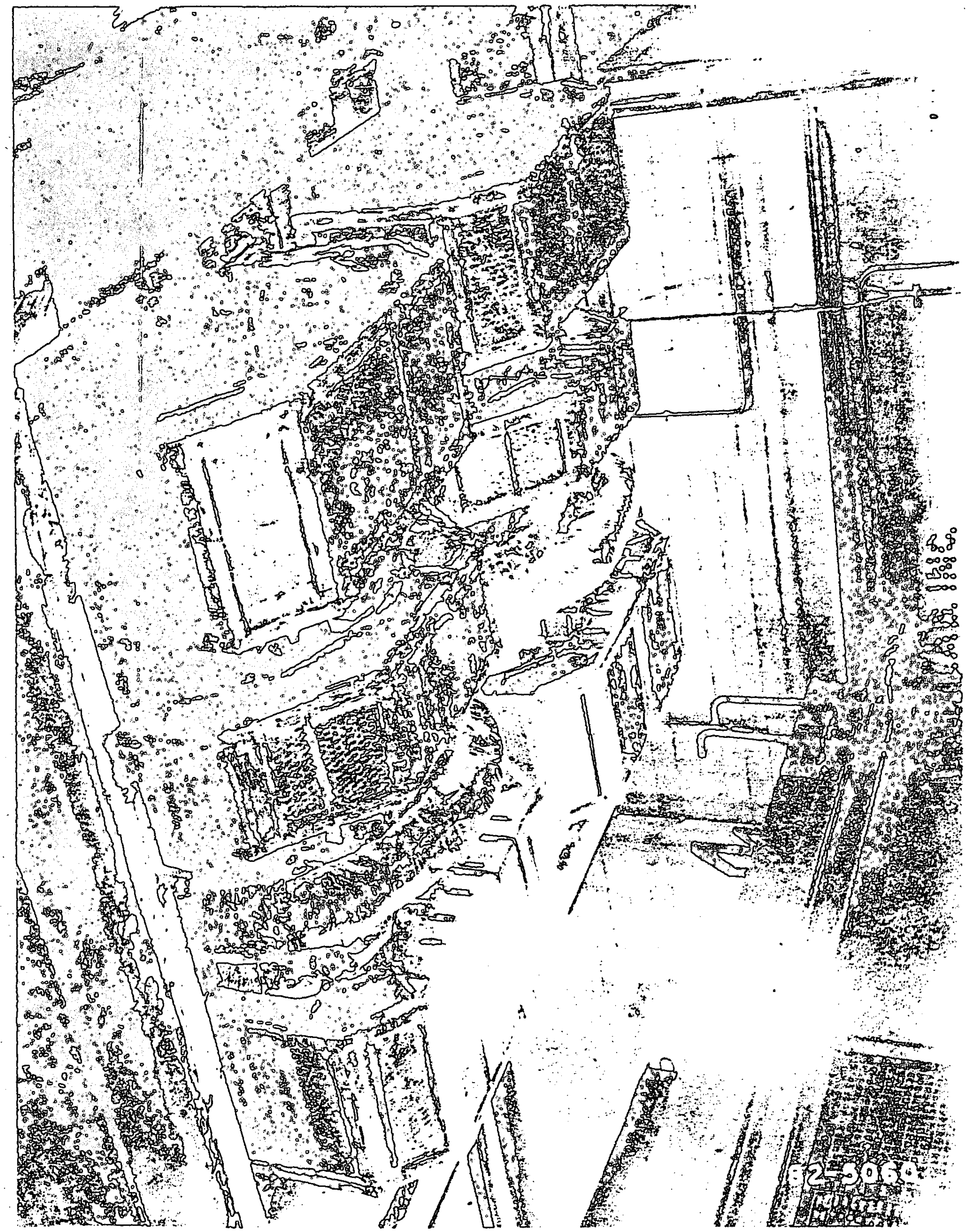
5300-C5



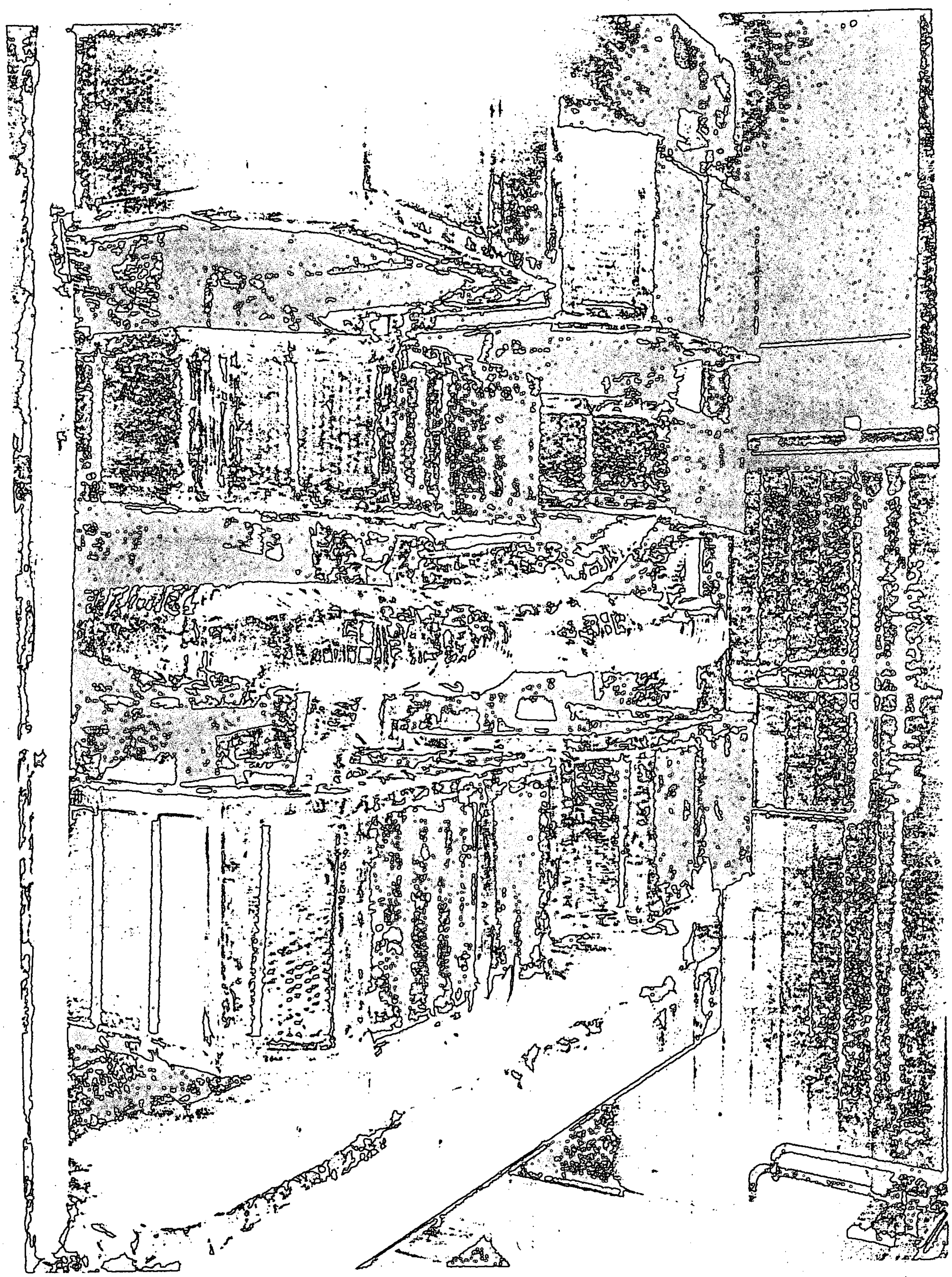
CONDUIT/FLOOR INTERFACE DETAIL

R10125-1,-2
ILL. 18

EXPOSED SURFACE BEFORE FIRE TEST - TEST ASSEMBLY NO. 1

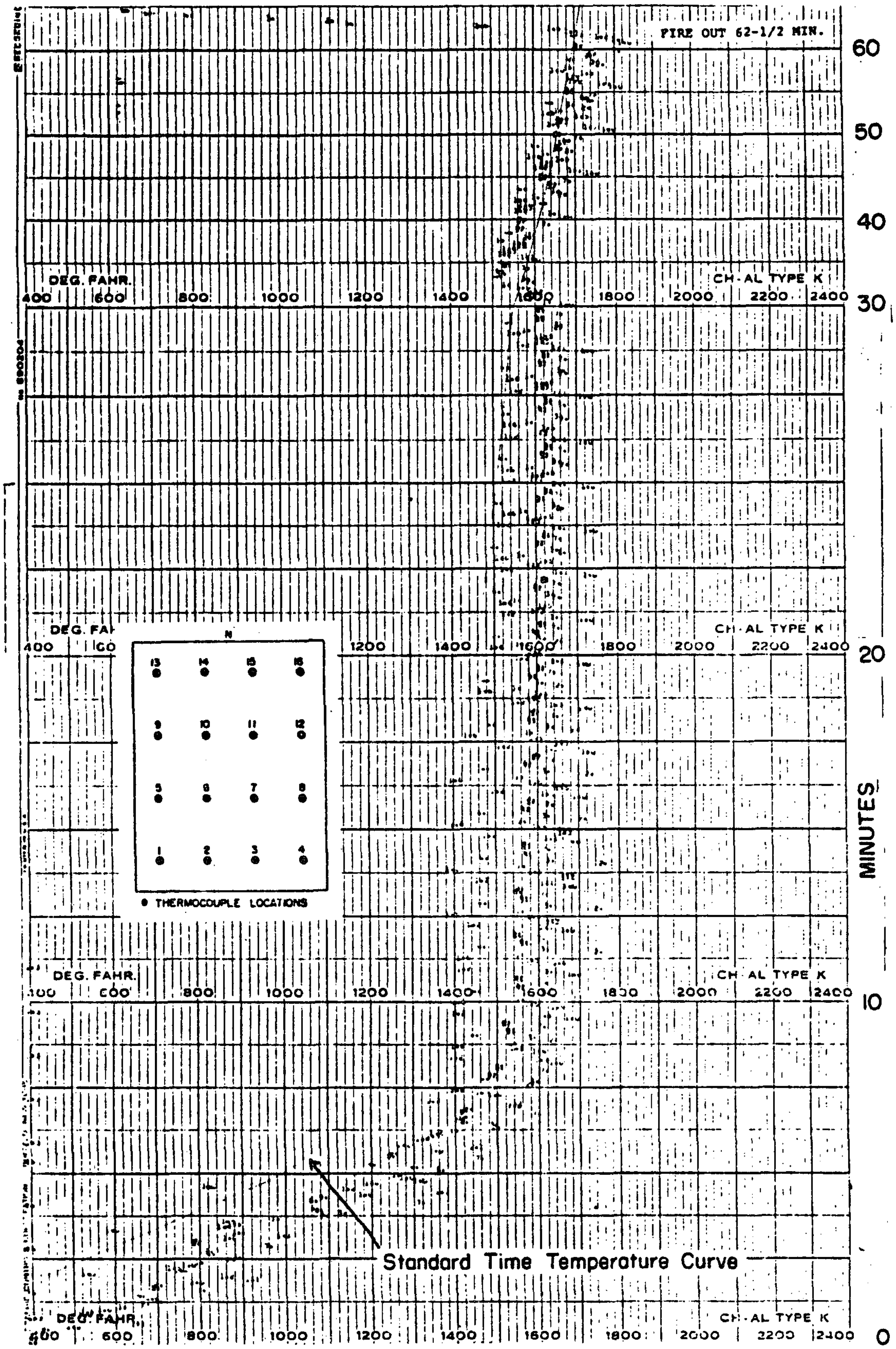


EXPOSED SURFACE BEFORE FIRE TEST - TEST ASSEMBLY NO. 1

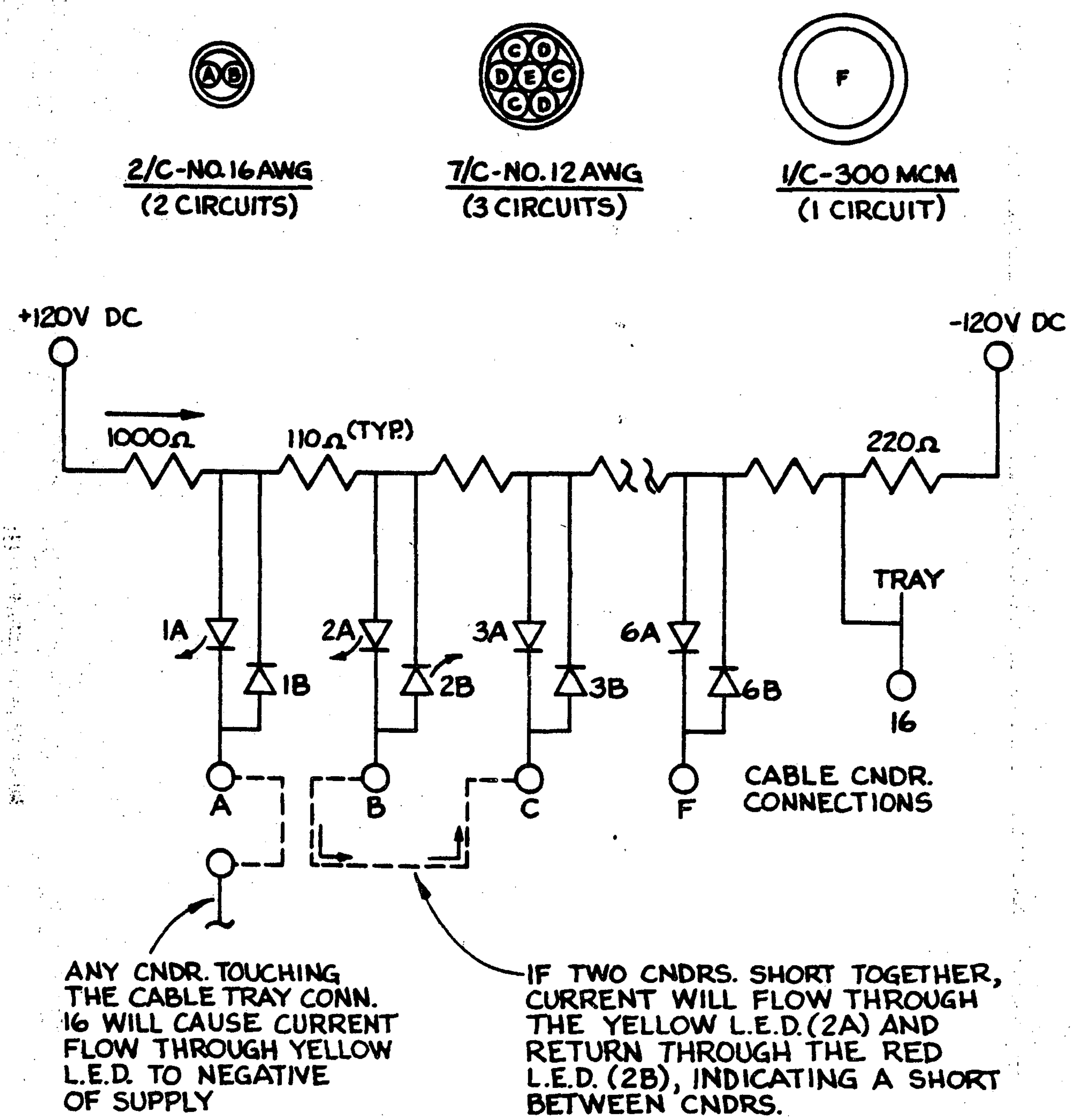


FURNACE TEMPERATURES
R 10125-1
December 21, 1982

Underwriters Laboratories Inc.
Fire Endurance Test



ILL. 21



ELECTRICAL CIRCUIT INTEGRITY

(TYPICAL-EACH SYSTEM)

R10125-1,-2
ILL. 22

EXPOSED SURFACE AFTER FIRE AND HOSE STREAM TESTS - TEST ASSEMBLY NO. 1

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	90	91	92	93
TIME(MIN.)				
2	72.7	70.5	70.5	141.3
4	78.8	71.9	70.8	171.7
6	85.5	75.4	71.8	200.1
8	91.4	80.6	74.2	193.2
10	98.2	85.6	78.2	188.9
12	105.8	91.1	84.7	193.5
14	113.6	99	93.8	214.4
16	125.5	109.2	107.5	302.7
18	143.6	121.2	120.8	358.4
20	150.8	134.8	132.5	404
22	178.6	149.9	147.9	441.5
24	206.4	167.5	172.7	475.8
26	205.2	197.3	199.6	507.2
28	203.3	209.3	207.4	541.6
30	269.9	209.6	208.6	572.6
32	286.7	212.9	214.1	605.6
34	304.9	236.5	220.2	644.5
36	322.4	269.7	233.4	677.8
38	341.7	291.3	245.1	710.5
40	361.3	309.5	263.8	748.5
42	380.6	327.4	283.2	778.6
44	400.2	343.8	300.2	805.1
46	419.5	359.2	317.3	828
48	439.1	373.8	334.4	850.1
50	459.1	387.9	350.6	875.7
52	478 8	401	366.2	911.4
54	498.6	413.5	382	963.1
56	518.3	426.2	397.9	1028.9
58	538	439.2	413.9	1096.9
60	557.5	452	429.4	1151.5

R10125-2
ILL. B19

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	94	95	96	97
TIME(MIN.)				
2	84.6	101.9	131.5	198.2
4	118.8	162.6	220.7	234.3
6	195	200.9	373.2	341
8	204	197.5	477.5	432.6
10	203.9	196.1	571.1	502.7
12	204.8	197.5	651.7	563.7
14	209.2	197.9	719.9	590.7
16	233.8	196	788.6	627.3
18	278.7	196.3	831.6	667.6
20	334.4	286.8	847.3	701.7
22	383.8	329.5	870	737.2
24	420.5	354.7	907.4	780.6
26	463.9	368.9	942.9	817.5
28	493.3	405.4	987.5	844.9
30	521	454.5	1032.4	865.3
32	548.4	502.4	1063.6	885.6
34	576.4	547.1	1089.2	898.8
36	603	585.9	1119.6	912.4
38	627.3	618.2	1147.1	933
40	651.6	646.9	1172.3	965.4
42	676.6	675.6	1192.5	986.8
44	704.9	704.5	1210.2	1002.6
46	734	734.2	1225.6	1019.3
48	767.4	765.5	1232.9	1041.8
50	813.8	802.1	1240.6	1077.7
52	885.7	853.4	1266.8	1147
54	990.6	924.5	1294.4	1237.2
56	1109.4	1016.3	1312.5	1292.9
58	1199.1	110[illegible]	1317.2	1307.7
60	1246.4	1171.2	[illegible]6.8	1308.4

R10125-2
ILL. B20

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	90	91	92	93
TIME(MIN.)				
2	72.7	70.5	70.5	141.3
4	78.8	71.9	70.8	171.7
6	85.5	75.4	71.8	200.1
8	91.4	80.6	74.2	193.2
10	98.2	85.6	78.2	188.9
12	105.8	91.1	84.7	193.5
14	113.6	99	93.8	214.4
16	125.5	109.2	107.5	302.7
18	143.6	121.2	120.8	358.4
20	150.8	134.8	132.5	404
22	178.6	149.9	147.9	441.5
24	206.4	167.5	172.7	475.8
26	205.2	197.3	199.6	507.2
28	203.3	209.3	207.4	541.6
30	269.9	209.6	208.6	572.6
32	286.7	212.9	214.1	605.6
34	304.9	236.5	220.2	644.5
36	322.4	269.7	233.4	677.8
38	341.7	291.3	245.1	710.5
40	361.3	309.5	263.8	748.5
42	380.6	327.4	283.2	778.6
44	400.2	343.8	300.2	805.1
[illegible]	419.5	359.2	317.3	828
48	439.1	373.8	334.4	850.1
50	459.1	387.9	350.6	875.7
52	478.8	401	366.2	911.4
54	498.6	413.5	382	963.1
56	518.3	426.2	397.9	1028.9
58	538	439.2	413.9	1096.9
60	557.5	452	429.4	1151.5

R10125-2
ILL. B19

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	110	111	112	113
TIME(MIN.)				
2	71	71	70.9	71
4	71.2	71.3	71.2	71.2
6	71.9	71.8	72	71.9
8	73.5	72.9	73.9	73.4
10	76.1	74.5	77.2	76
12	79.5	76.8	82.1	79.7
14	83.6	79.6	88.2	84.8
16	88.5	83.3	95.8	91.2
18	94.4	87.9	104.9	99.1
20	101.6	93.8	116.1	108.3
22	110.7	101	129.3	118.6
24	121.3	109.7	143.6	129.6
26	133.3	120.2	157.4	140.8
28	146.2	131.5	169.3	152.3
30	156.9	141.6	179	163.8
32	166.7	151.1	188.6	175
34	177.6	161.1	201.1	186.8
36	189.8	171.7	215.2	201.5
38	202.8	183	230.4	217.1
40	216.7	194.7	245.5	233.2
42	231.4	206.4	260.5	249.5
44	246.2	222.5	277	264.1
46	262.2	241.3	295.3	281.6
48	281.7	261.1	315.8	301.7
50	302.6	281.9	337.8	324.3
52	323.7	303.4	360.9	346.4
54	344.9	325.6	384.7	368.6
56	364.4	348.4	408.5	390.9
58	381	371.7	432.1	412.6
60	397.1	396.4	455	434.6

R10125-2
ILL. B24

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	106	107	108	109
TIME(MIN.)				
2	68.6	68.5	68.2	68.3
4	68.7	69.3	68.4	68.5
6	69.1	70.7	69.2	69.2
8	70.1	73.1	71.3	70.5
10	71.9	77.4	74.9	72.7
12	74.4	83.2	79.7	75.8
14	77.6	90.3	86	79.6
16	81.9	98.8	93.7	84.4
18	87	108.8	102.9	89.9
20	93.1	119.5	113.5	97.1
22	99.8	130.6	125.6	105.8
24	106.7	141.9	139.8	116.2
26	114.1	153.8	153.3	127.6
28	121.7	166.4	166	139.4
30	129.6	180.3	176.9	150
32	137.8	193.5	188.9	160.3
34	146.9	210.9	203.2	171.1
36	156.7	229.6	218.6	182.8
38	167.4	245.1	234.1	196.3
40	178.9	262.6	250	211.2
42	192.6	280.4	267.6	226.9
44	203.1	301	285.9	243.1
46	216.2	321.5	305.8	260.2
48	230.3	342.1	326.2	278.2
50	245.8	363.5	347.2	298
52	262	386.1	369.2	319.2
54	278.3	409.9	391.1	341.4
56	294.6	437.6	411.7	364.4
58	311.1	463.7	433.7	387.9
60	327.5	483.2	456.1	411.1

R10125-2
ILL. B23

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	118	119	120	121
TIME(MIN.)				
2	71	71.3	71.3	102.6
4	71.9	71.7	71.4	138.1
6	73.5	72.7	71.8	185.1
8	77.6	74.6	72.8	219.6
10	83.5	78.9	74.5	239.9
12	91.1	83.6	76.9	254.9
14	99.7	89.5	80.5	264
16	110.3	97.5	84.5	269.4
18	120.8	105.9	89.8	275.4
20	133.7	115.8	94.4	280.1
22	146.9	125.9	100.4	284.9
24	160.6	138.2	109.8	292
26	173.6	150.7	117.2	305.4
28	188.1	164.1	126	327.1
30	202.9	177.6	136.6	360.3
32	218.9	190.5	147	410.8
34	237.9	208.1	156.6	462.7
36	255.6	227.4	166.1	510.1
38	275.4	246.6	174	551.6
40	294	264.5	182.7	594
42	313.1	283.8	196.2	637.2
44	331.3	305.2	222.5	671.5
46	356.5	326.6	229.8	702.5
48	377.8	349.5	236.5	733
50	402.3	369.9	242.5	762.7
52	425.7	390.5	252.5	789.4
54	448.4	411.5	264.7	814.4
56	470.9	432.7	278.7	837.2
58	492.9	451.5	295.9	858.4
60	520.9	471.6	307.2	879.6

R10125-2
ILL. B26

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	114	115	116	117
TIME(MIN.)				
2		70.9	70.7	71.1
4	71.2	71.1	70.9	71.3
6	72	71.6	71.3	71.9
8	73.5	72.6	72.2	73.3
10	76	74.3	73.8	75.7
12	79.6	76.9	76.3	79.6
14	84.3	80.6	79.5	84.5
16	90.3	85.5	83.7	90.6
18	97.6	91.5	89	98.1
20	106.5	98.6	95.8	108.1
22	116.6	106.6	104.1	119.1
24	127.4	115.3	113.7	130.1
26	138.9	124.6	125.3	142.1
28	150	133.8	136.3	152.5
30	160.4	143.3	146.1	161.5
32	171.8	153.4	155.6	171.5
34	184.6	164.1	165.8	181.4
36	198.6	175.6	176.7	193.9
38	213.5	186.9	188.5	209.3
40	228.9	198.3	202.7	226.1
42	244.2	211.3	218.2	243
44	259.8	228.1	234.1	260.3
46	277.4	245.8	254.1	278
48	297.4	265	268.8	296.8
50	317.9	286.1	284.5	315.5
52	338.1	307.1	302.6	336.6
54	358.5	328.7	322.5	358.2
56	378.7	351.2	343.7	381
58	400.6	374	365.8	404.5
60	436.5	397.3	387.5	426.9

R10125-2
ILL. B25

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	126	127	128	129
TIME(MIN.)				
2	84.5	140.4	98.5	128.4
4	109.8	175.8	135.2	165.4
6	145.3	205.6	171.3	193.9
8	199.6	222	208.2	211.8
10	241.2	217.6	228.8	223.5
12	267.2	217.6	237.6	230
14	279.2	221.9	236.3	229.1
16	290.3	220.5	236.5	228.6
18	299.9	226.6	233.5	230.1
20	309.8	233.9	237.5	232.3
22	314	272.1	250.3	243
24	325.9	339.2	302.9	275.1
26	340.4	432.1	428.5	343
28	360.7	543.2	556.2	459.3
30	402	764.9	587.1	430.6
32	448.6	763.8	625.8	417.9
34	505	796	672	456
36	569.7	832.6	693.8	499.4
38	632.7	866.5	740.3	611.6
40	682.6	898.8	768.2	702.7
42	726.3	937.7	798.7	736
44	765.5	915.8	797.8	779.2
46	796.9	929	825.9	807.5
48	825.5	948.4	855.4	830.5
50	852.7	967.7	880.5	848.8
52	878.8	988.8	901.3	866.4
54	904.6	1005.4	926.7	891.5
56	930	1037.3	952	912.2
58	954.9	1061.3	975.6	936.4
60	979.2	1091.6	999.4	963.1

R10125-2
ILL. B28

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	122	123	124	125
TIME(MIN.)				
2	77.7	75.8	79	95.4
4	92	83	93.4	136.2
6	118.4	92.3	109.7	172.4
8	149.2	101.5	130.8	209.1
10	166.3	112.9	147.9	232
12	177	134.5	163.8	246.3
14	197.9	148.8	174.7	255.1
16	204	160.3	182.7	263.2
18	209.9	172.4	190.5	267.8
20	217	192.2	201.8	274.8
22	234.8	209.9	213	281.8
24	242	232.9	226.8	294.3
26	252.4	276.1	245.6	312.6
28	264.2	338.5	275.4	345.7
30	288.2	382.3	338	416.2
32	316.4	410.2	394.5	493.4
34	353.4	464.1	464.1	568.4
36	397.8	519.3	522	617
38	442.7	579.2	574.8	652.8
40	488.3	638.2	624.5	685.7
42	533.4	695.7	671	713.3
44	580.5	749	713.8	739.5
46	629.3	799.6	752.4	768.1
48	673.9	847.4	784.9	797.3
50	706.6	887.8	815.4	828.1
52	731.2	924.3	844.7	858.4
54	754.1	957.3	872.7	888.7
56	775.5	987.1	899	918.3
58	797.3	1015.2	923.7	945.5
60	819.9	1043.5	947.9	975.1

R10125-2
ILL. B27

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	134	135	136	137
TIME(MIN.)				
2	76.8	86.5	75.4	72.1
4	89.9	109.4	88.4	78.1
6	106.3	137.5	108.3	85.5
8	124.6	169.2	135.1	93.3
10	142.8	208.8	156.4	100.9
12	157.4	237.4	182	109.1
14	169.2	261.8	202.4	117.4
16	174.3	277	208.9	125.3
18	185.2	285.4	233.2	131.8
20	194.5	281.1	239.9	137.1
22	204.3	279.5	250.3	142.3
24	215.5	277.4	262.2	149.4
26	232.8	280.1	275.1	156.3
28	261.1	288.5	291.4	168.1
30	324	311.2	323.4	194.1
32	372.4	346.6	359.4	228.7
34	436.7	390.4	404.6	265.1
36	494.7	436.7	458.8	302.4
38	546.9	486.7	507	335.7
40	599.2	534.6	556.2	370
42	652.2	584.9	603.5	409.5
44	699.3	641.9	647.8	453.7
46	738.7	685.7	674.7	496.8
48	771.4	719.4	699	541.5
50	802	749.9	721.7	580
52	830.5	779.9	739.6	612.2
54	858.4	808.1	757.4	640.1
56	885.2	834.5	776.7	667.2
58	911.9	860.4	795.3	695.2
60	937.8	884.8	813.7	720.8

R10125-2
ILL. B30

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	130	131	132	133
TIME(MIN.)				
2	97.7	93.5	87.3	77.2
4	137.1	125.7	114.3	87.6
6	169.8	166.3	147.6	99.7
8	201.2	191.1	199.8	111.2
10	217	202.6	226	124.1
12	225.9	211.3	247.5	137.6
14	218.6	217.9	263.4	154.5
16	215.2	221.8	276.2	165.8
18	188.9	229.6	284.6	181.9
20	192.2	233.3	293	199.6
22	202.6	242	301.7	210.9
24	234.5	247.4	315.1	217.4
26	269.7	263.4	331.2	255.9
28	326.3	284.3	352.7	307.7
30	475.2	468.7	396.6	347
32	498.8	554.4	452.5	380.7
34	614.7	648	516.6	456.2
36	657.4	709.6	580.4	514.1
38	744	677.4	634.8	575.3
40	761.2	688.3	683.3	627.4
42	800.7	713.3	722.4	674.9
44	824.6	736.4	755.5	722.4
46	846.4	761.2	784.4	768.2
48	868	795.6	810.6	810.1
50	889.7	828.2	836.1	849.4
52	911.3	854.4	861.6	885.7
54	932.9	883.3	886.9	919.7
56	953.8	912.3	911.8	950.6
58	973.9	941.5	936.3	980.1
60	993.5	968.6	960.1	1009.8

R10125-2
ILL. B29

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	142
TIME(MIN.)	
2	81.2
4	121.8
6	155.6
8	183.5
10	207.9
12	217.7
14	255
16	299.7
18	343.6
20	391.5
22	436.6
24	482.2
26	521.5
28	560.3
30	598.7
32	634.7
34	671.7
36	708.7
38	745.9
40	781.4
42	815.8
44	848.6
46	879.5
48	909.2
50	938.8
52	967
54	993.9
56	1019
58	1043
60	1066.2

R10125-2
ILL. B32

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	138	139	140	141
TIME(MIN.)				
2	72.4	79.9	81.2	84.2
4	79.7	94.2	97.5	104.1
6	92.3	113.2	115.8	133.2
8	108.8	144.7	151	173.4
10	124.8	179.6	189.8	203
12	136.9	216.4	218.1	218.6
14	169.3	250.6	247.8	255.2
16	179.7	308.9	289.4	320.5
18	197.5	349.8	341.3	371.7
20	217.7	392.5	395	424.8
22	235.7	437.7	449.4	476.9
24	251.8	482.1	501.9	523.2
26	269	525.3	553.1	566.1
28	290.3	566.9	601.3	612.5
30	324.2	606.9	646.8	657.4
32	351.8	645.5	691.4	701.1
34	386.5	683.6	738.4	746.8
36	424.3	721.1	786.1	792.5
38	468.5	758.8	831.8	836.1
40	510.8	797	875.4	877.2
42	550.8	835.3	916.6	915.7
44	597.7	872.3	954.3	951.6
46	646	908.1	990.1	987.4
48	690.4	941.5	1026	1022.7
50	726.5	974	1060.5	1056.5
52	759.3	1006	1092.2	1088.3
54	789.9	1037.4	1123.8	1118.3
56	819.2	1067.1	1152.3	1146.3
58	846.9	1095	1178.7	1172.6
60	872.9	1121.8	1204.1	1197.9

R10125-2
ILL. B31

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	162	163	164	165
TIME(MIN.)				
2	72.7	73	71	70.1
4	77.5	78.7	74.6	71.3
6	84.7	86.3	80.2	75.1
8	94.7	98.2	86.6	82.2
10	105	112.5	96.2	92.7
12	116.3	127.5	106.6	103.9
14	130.5	145	117.3	116.8
16	148	159.6	131.4	131.2
18	163.4	170.3	144.6	140.4
20	175.1	178.9	156.3	146.4
22	184.6	187.9	166.8	157.5
24	191.5	202.6	178	166.5
26	201.1	224	192.5	182.3
28	224.5	253.5	208.3	195.6
30	254	289.8	232.3	210.8
32	289.5	338.3	260.8	229.4
34	332	382.2	291.7	255.6
36	364.9	413.6	327.9	286.5
38	393.5	441.4	368.2	320.8
40	425.9	474.2	410.3	358.4
42	458.1	504.5	464	399.5
44	499.6	547	520.8	441.1
46	541.7	588.4	563.1	480.5
48	581.4	628.3	617.4	512.5
50	623.6	666.3	651.4	532.6
52	663.9	703	693.5	591.6
54	699.1	736.9	727.2	631.4
56	732.3	768.2	753.5	670.4
58	763	797.9	799	698.5
60	792.1	825.3	820	735.5

R10125-2
ILL. B34

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	159	160	161
TIME(MIN.)			
2	70.7	70.8	72.6
4	72.3	72.5	77.8
6	74.8	74.9	85.8
8	78.6	78.6	94.2
10	84.2	83.7	103.7
12	91.1	90.3	114.7
14	99.3	98.2	127.2
16	109.5	108.3	142.1
18	122.5	121.5	158.2
20	136.8	135.9	172.5
22	151.7	149.7	184
24	164.9	162	194.5
26	177.1	173.7	214
28	187.4	184.2	241.4
30	196	192.5	285.3
32	201.3	199.2	335.9
34	206.5	205	372.9
36	211.5	208.2	403.6
38	217.9	214.9	431.6
40	224.9	233.5	472
42	237.8	249.3	523.2
44	282.8	268.3	576
46	310.8	292.9	627.7
48	336.2	317.9	676.5
50	363.1	342.1	721.7
52	390.3	367	753.6
54	418.8	393.4	785.6
56	447.2	420.8	818.3
58	476.5	448.7	852.9
60	505.3	476.8	878.3

R10125-2
ILL. B33

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	170	171	172	173
TIME(MIN.)				
2	71.3	70.9	94.6	111.7
4	72.7	71.6	120.1	136.9
6	75	73.1	144.5	158.5
8	77.5	75.3	156	169.7
10	80.2	78.2	168.8	180.6
12	83.3	81.4	176.9	189.8
14	86.8	84.7	185	193.8
16	90.7	88.3	194.2	203
18	95.4	92.5	205.1	215.3
20	101.1	97.8	222.4	239.2
22	108.5	104.8	237.4	273.3
24	118.3	114.3	278.6	317.4
26	128.9	126.2	313.8	372.2
28	140.2	140.4	355.1	415.4
30	154.3	156.3	380.2	460.1
32	173.4	177.7	408.9	500.7
34	196	202.8	438.7	536
36	210.2	210.1	483.4	572.1
38	210.5	211.6	522.8	593.3
40	210.7	216	546.4	626.6
42	210.7	230.1	559.5	652.5
44	228.7	242.3	570.9	676.8
46	268.8	258.2	584	698.4
48	292.1	276.2	597.4	724.9
50	313.9	295.7	611.3	752.7
52	337.4	316.6	628.3	775
54	361.3	338.5	641.9	793.6
56	382	361.3	654.9	806
58	404.6	384.3	662.8	822.3
60	429.2	407.5		

R10125-2
ILL. B36

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	166	167	168	169
TIME(MIN.) :				
2	71	70.3	71.1	85.2
4	72.9	71.9	72.5	83.2
6	75.6	74.3	75.3	80.3
8	78.7	77.3	78.9	76.8
10	82.3	81	83	73
12	86.4	85.2	87.4	68.9
14	90.9	90.1	92.1	64.6
16	96.4	96.7	97	59.9
18	102.8	103.7	102.4	55
20	110.6	111.8	108.7	106.1
22	119.7	120.7	116.3	115.6
24	130.6	130.8	125.9	127
26	143.2	143.5	138.1	140.8
28	155.9	158.4	151	157.2
30	171.1	174.8	165.8	174.8
32	179.8	187.4	182.4	191.9
34	192.1	199.8	198.1	208.6
36	200	209.3	217.2	223.9
38	209.3	214	219.7	234.3
40	210	222.8	221.2	253.6
42	210.4	233.8	235	273.8
44	248.2	251.5	301.7	297.5
46	277.7	268.7	328	322.6
48	300.4	287.9	355.4	347.1
50	320.6	308.9	381.3	370
52	337.9	330.4	406.2	394.3
54	358.6	352	430.2	418.5
56	380.7	374	454.9	443.4
58	403.2	396.4	479.2	468
60	427	418.7	503.7	491.7

R10125-2
ILL. B35

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	178	179	180	181
TIME(MIN.)				
2	70.5	70.1	70.5	70.3
4	70.6	70.3	70.6	70.4
6	70.9	70.9	70.9	70.6
8	71.6	72.1	71.8	71.1
10	72.9	73.8	73	72.1
12	75	76	74.8	73.4
14	78.1	78.9	77	75.2
16	82.6	82.2	79.6	77.3
18	88.6	86.2	82.4	79.7
20	96.4	91.3	85.7	82.6
22	105.1	97.5	89.6	86.1
24	114.4	105.1	94.6	90.3
26	123.5	114.8	101.4	96.2
28	131.6	126.2	109.9	104.4
30	140.1	138.8	120.7	115
32	148.5	152.4	132.3	126.8
34	156.8	167.1	145	139.5
36	165.2	183.2	156	150.7
38	174	201.1	166.3	159.4
40	186.2	205.5	177	170.4
42	206.8	210.9	189.6	183.2
44	219.2	[illegible]	207.7	191.3
46	234.1	[illegible]	227.8	196.8
48	256	250.7	[illegible]	201.3
50	283.1	270.2		237.8
52	315.1	290.1	[illegible]	263.4
54	347.7	310.5	[illegible]	289.7
56	384.2	331.3	348.5	317.7
58	418.2	353.1	378	348.1
60				

R10125-2
ILL. B38

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	174	175	176	177
TIME(MIN.)				
2	110.8	70.2	70.6	70.1
4	137.2	70.9	70.9	70.4
6	150.4	72.6	71.6	71.1
8	161	75.7	73	72.7
10	166.2	80.6	75.5	75.5
12	171.1	87.2	79	79.8
14	174.4	95.8	83.8	85.5
16	182.3	106.1	90.2	93.4
18	202.1	116.2	98.1	103.5
20	233.5	128.3	107.7	115
22	272.9	139	117.8	126.1
24	319.5	149.1	127.6	135.9
26	359.3	157.6	134.2	145.2
28	394.8	168	142	153.9
30	433.8	180.1	150.6	162
32	438.8	196.6	162.1	170.4
34	459.7	220.2	177.6	179.2
36	500.3	244.6	196.3	188.9
38	516.5	272.2	217.1	200.8
40	538.9	306.7	239	216.2
42	558.3	344.8	267.6	235.9
44	592.3	387.2	302.6	250.9
46	610.9	432.9	340.2	271.9
48	630	478.9	378	299.3
50	644.3	550.5	424.3	339.8
52	666	608.8	515.3	381
54	690.2	649.1	557.9	415.9
56	713.4	686.7	597.6	444.6
58	738.7	720.8	643.4	475.5
60				

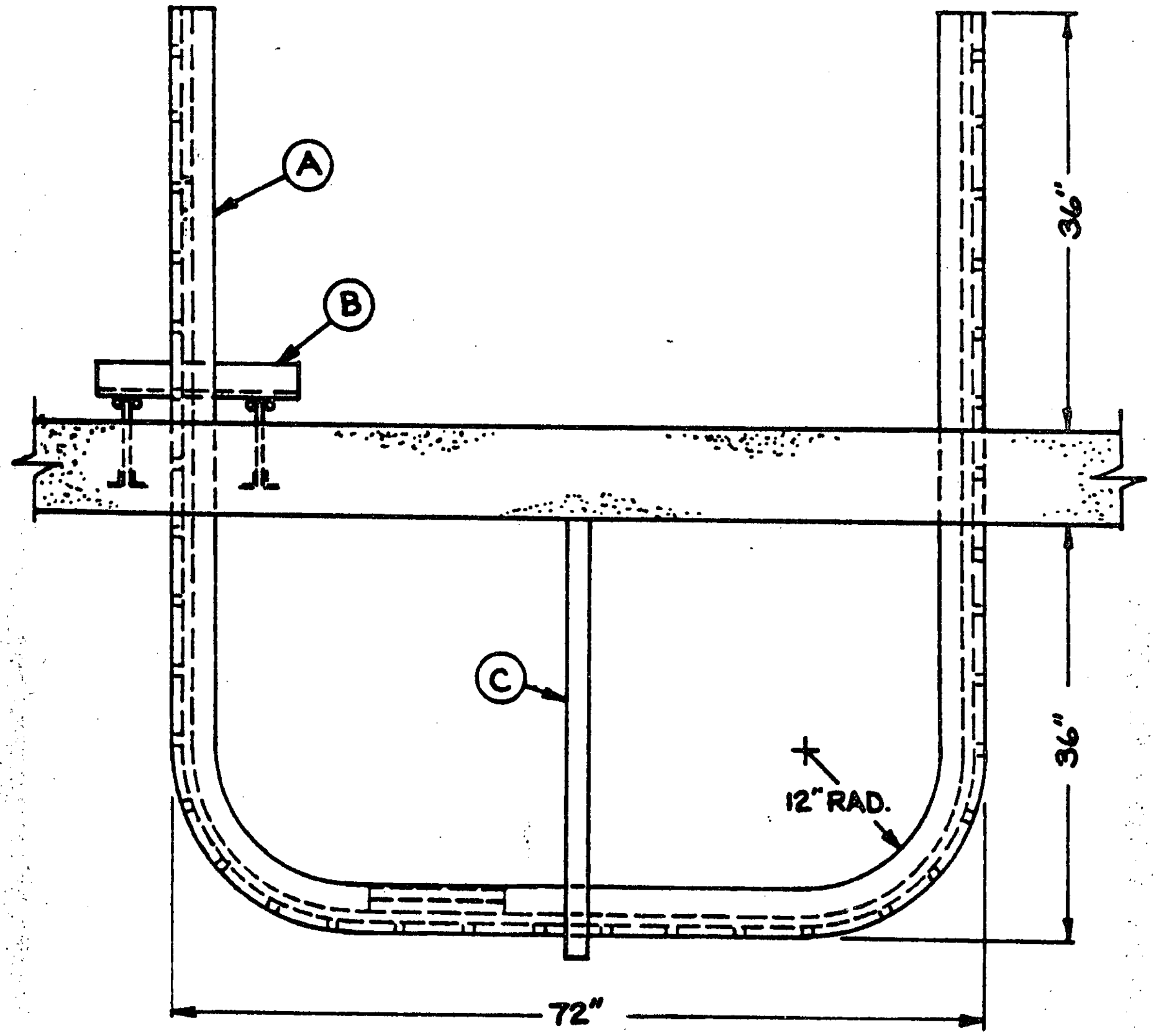
R10125-2
ILL. B37

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	186	187
TIME(MIN.)		
2	1075.8	1173.7
4	1198.5	1284.2
6	1390.4	1365.9
8	1475.5	1344.5
10	1463.9	1324.7
12	1440	1401.6
14	1462.8	1447
16	1479.6	1464.4
18	1463	1447.4
20	1470.6	1454.1
22	1485.9	1514
24	1497.7	1490.5
26	1531	1508.9
28	1538.2	1510.3
30	1533.3	1523.9
32	1536.7	1527.9
34	1535.4	1517.3
36	1548.7	1572.2
38	1577.9	1605.7
40	1565.7	1617
42	1569.5	1614
44	1585.7	1628.8
46	1579.7	1640.9
48	1604.6	1651.7
50	1601.2	1665.6
52	1601.9	1676.7
54	1622.9	1684.8
56	1628.6	1693.4
58	1637.9	1692.5
60		

R10125-2
ILL. B40

EXPOSED SURFACE AFTER FIRE AND HOSE STREAM TESTS - TEST ASSEMBLY NO. 1



(A) NOM. 24" WIDE x 4" DEEP (3" CABLE LOADING DEPTH) OPEN-LADDER CABLE TRAY SYSTEM.

(B) NOM. 3" x 3" x 1/4" STEEL ANGLES RESTING ON STEEL REINFORCEMENT OF FLOOR SLABS (INVERTED TYPE 8H2 STEEL JOISTS) AND WELDED TO CABLE TRAY SIDERAILS ON BOTH SIDES OF CABLE TRAY AT BOTH ENDS OF CABLE TRAY SYSTEM.

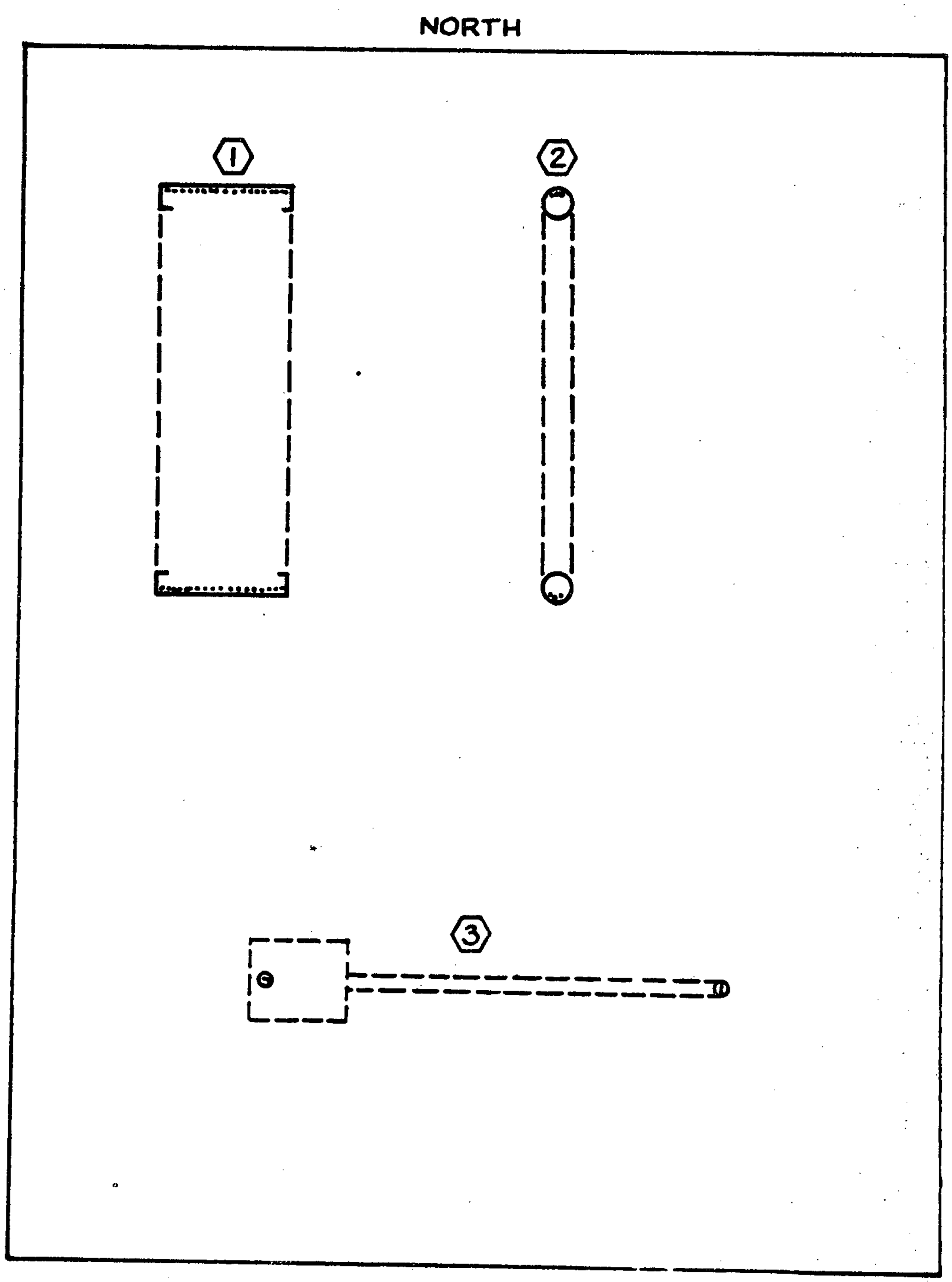
(C) WELDED TRAPEZE SUPPORT SECURED TO FLOOR SLAB.

CABLE TRAY SYSTEM DETAILS - SYSTEM NO. 1

(TEST ASSEMBLY NO. 2)

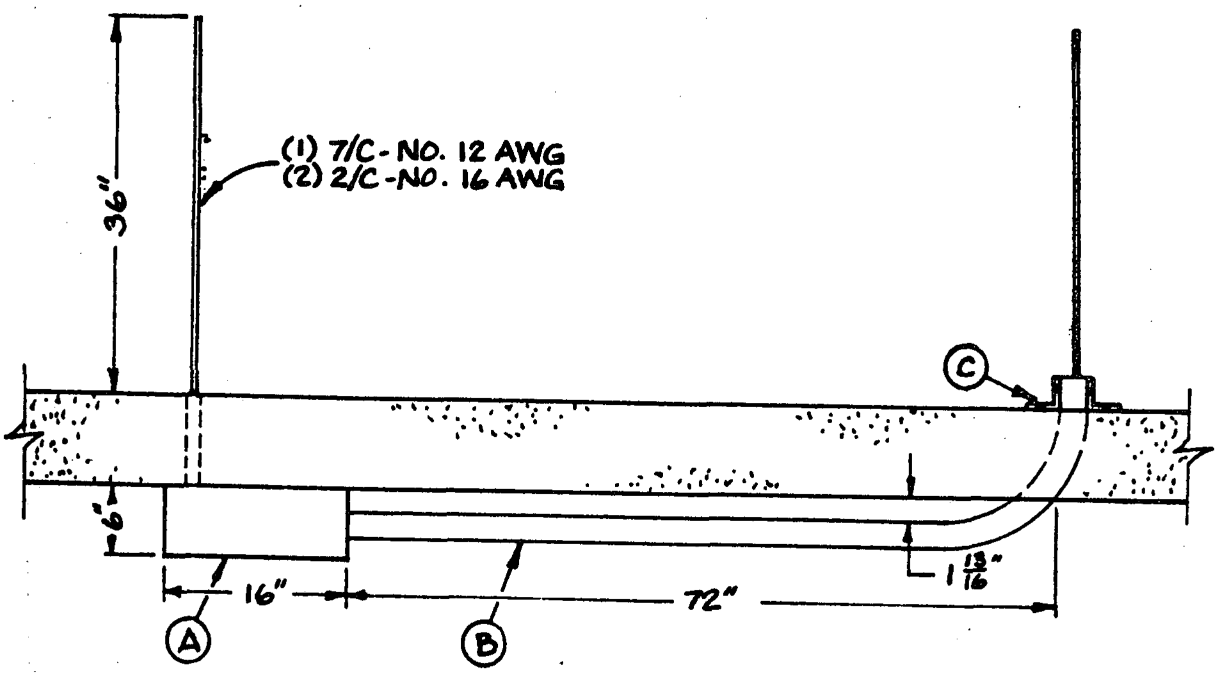
R10125-2
ILL. 26

1-NOM. 4"x24" OPEN-LADDER STL. CABLE TRAY W/MINIMUM CABLE FILL.
2-NOM. 5"ø RIGID STL. CONDUIT W/ MINIMUM CABLE FILL.
3-12"x12"x6" STL. JUNCTION BOX W/NOM. 2"ø RIGID STL. CONDUIT W/MINIMUM CABLE FILL.



TEST ASSEMBLY NO. 2

R10125-2
ILL. 25



Ⓐ NOM. 12"x16"x6" STEEL JUNCTION BOX SECURED W/ 3/8" ⌀ THREADED STEEL RODS, W/ NUTS & WASHERS, INSTALLED THROUGH FLOOR SLAB.

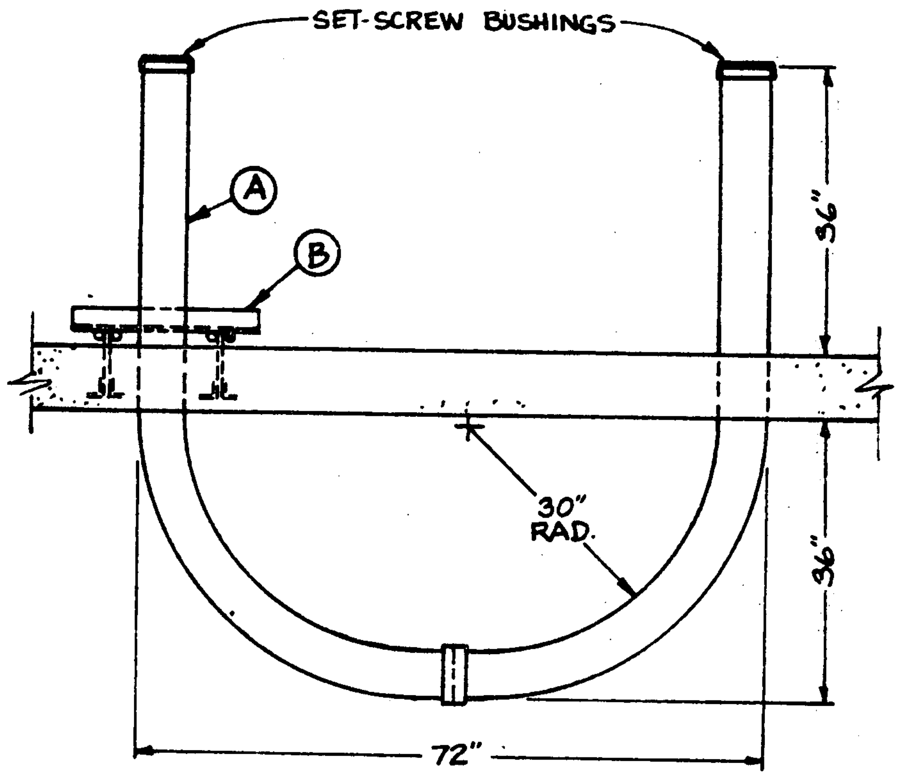
Ⓑ NOM. 2" ⌀ RIGID STEEL CONDUIT SYSTEM.

Ⓒ NOM. 3"x3"x 1/4" STEEL ANGLES RESTING ON FLOOR SLAB AND WELDED TO BOTH SIDES OF CONDUIT.

JUNCTION BOX AND CONDUIT DETAILS- SYSTEM NO. 3

(TEST ASSEMBLY NO. 2)

R10125-2
ILL. 28

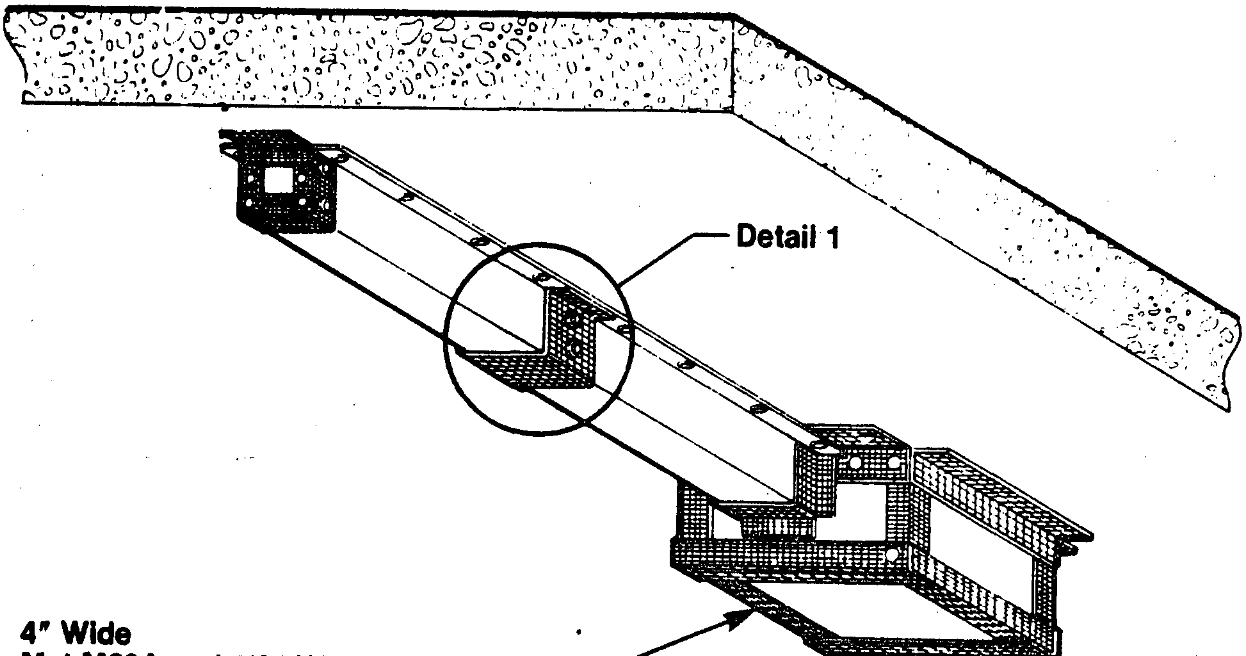


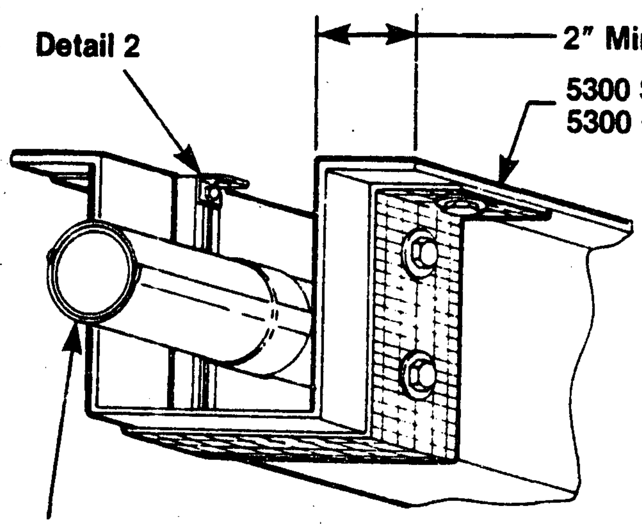
(A) NOM. 5"ø RIGID STEEL CONDUIT SYSTEM FOR SYSTEM NO. 2

(B) NOM. 3"x3"x¼" STEEL ANGLES RESTING ON STEEL REINFORCEMENT OF FLOOR SLABS (INVERTED TYPE 8H2 STEEL JOISTS) AND WELDED TO BOTH SIDES OF CONDUIT AT BOTH ENDS OF CONDUIT.

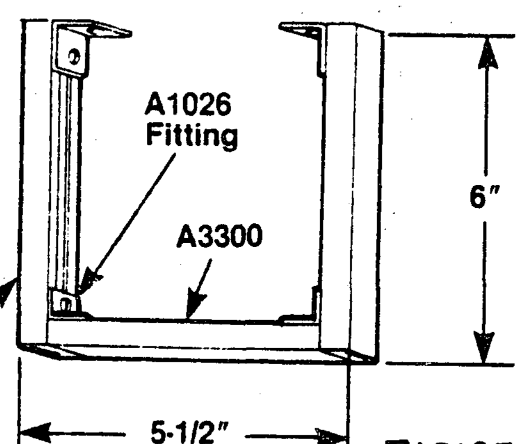
CONDUIT SYSTEM DETAILS - SYSTEM NO. 2

(TEST ASSEMBLY NO. 2)





Detail 1



Detail 2

R10125-2
ILL. 29

ISSUE	DATE	REV	CH.
1	4/13/83		

NOT TO SCALE

CH J.R. Tuzinski

DP J.F. Krenik

APP M.A. O'Hara

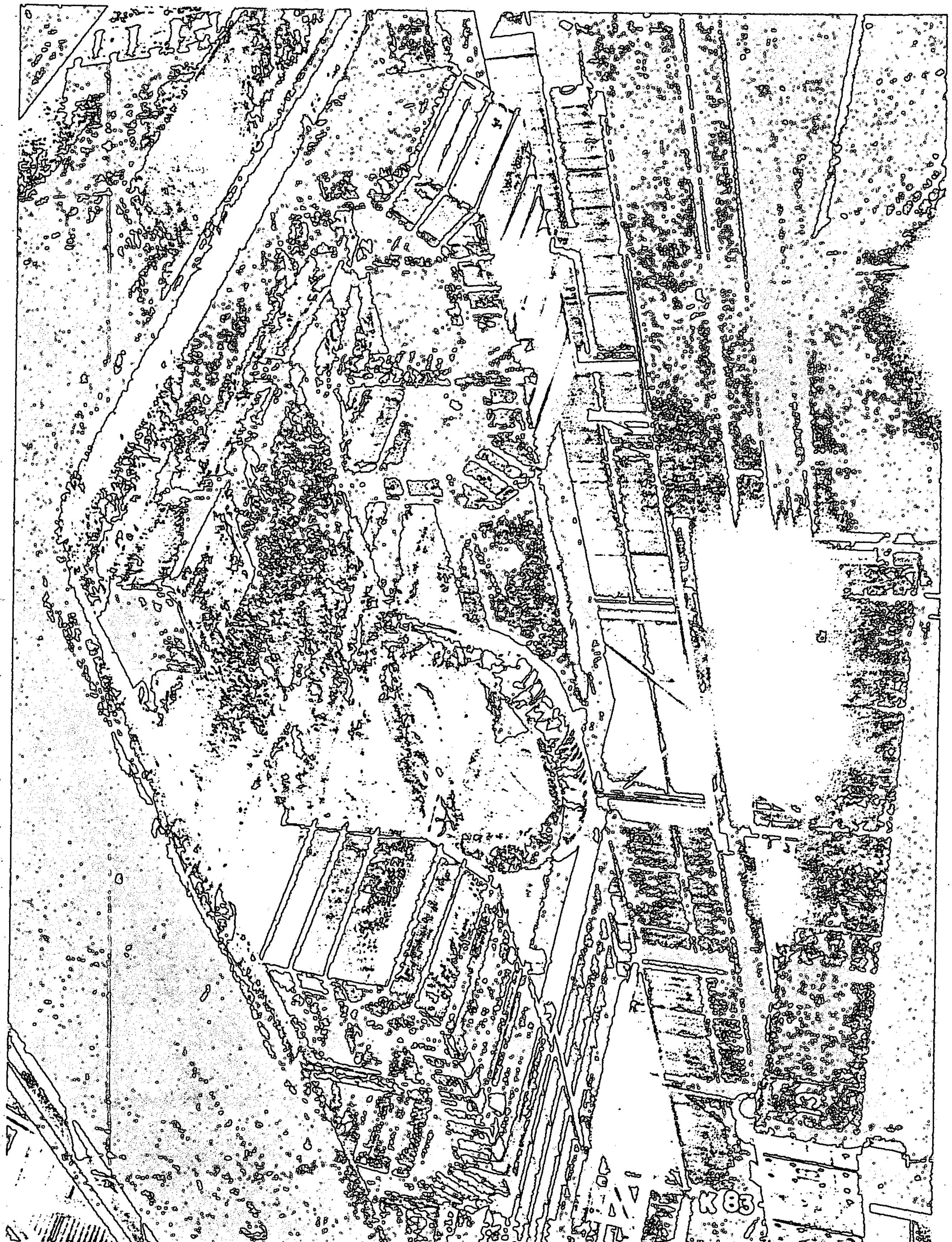
Electro-Products Division/3M

3M

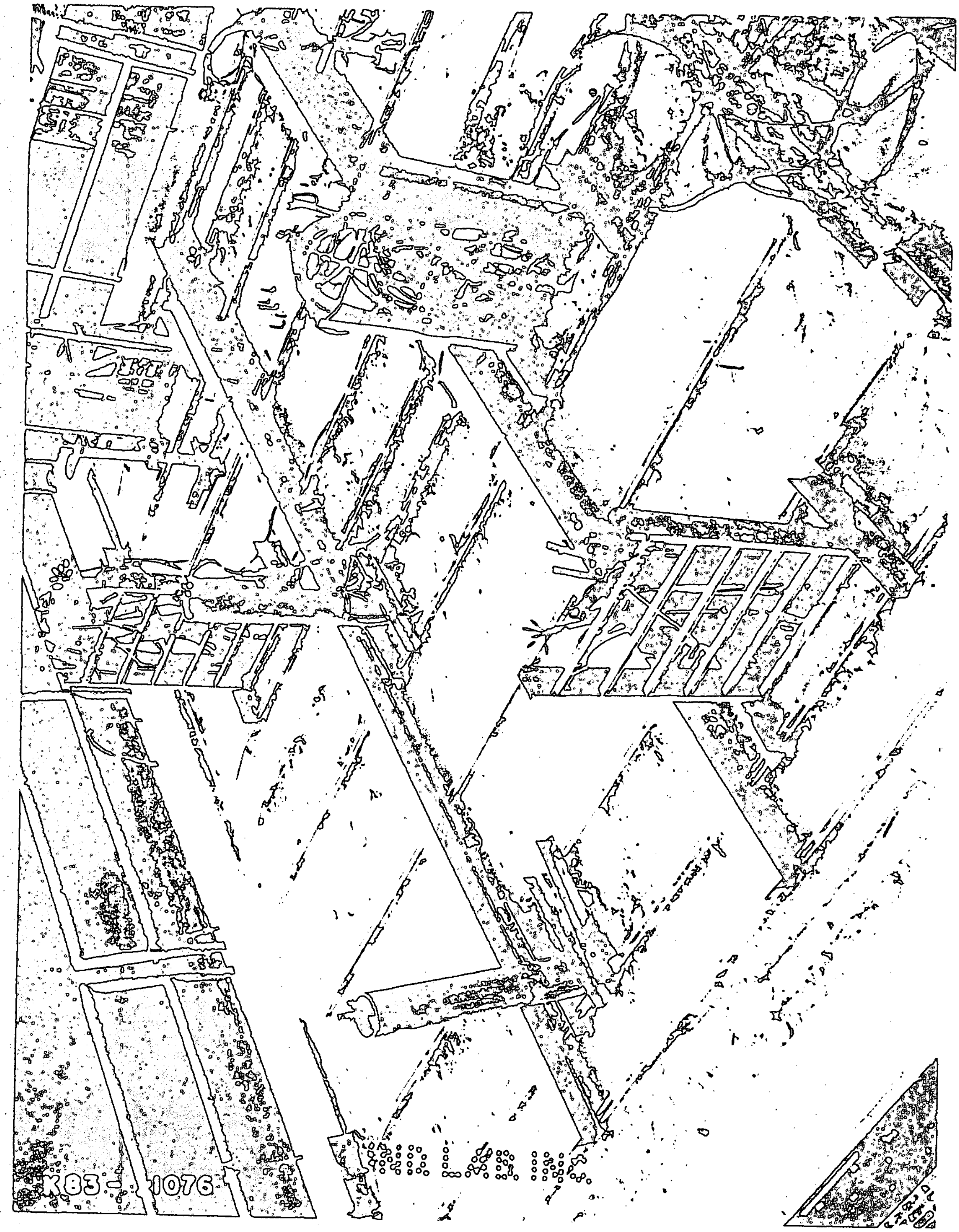
5300-C6

Conduit - Junction Box Protection System

EXPOSED SURFACE BEFORE FIRE TEST - TEST ASSEMBLY NO. 2



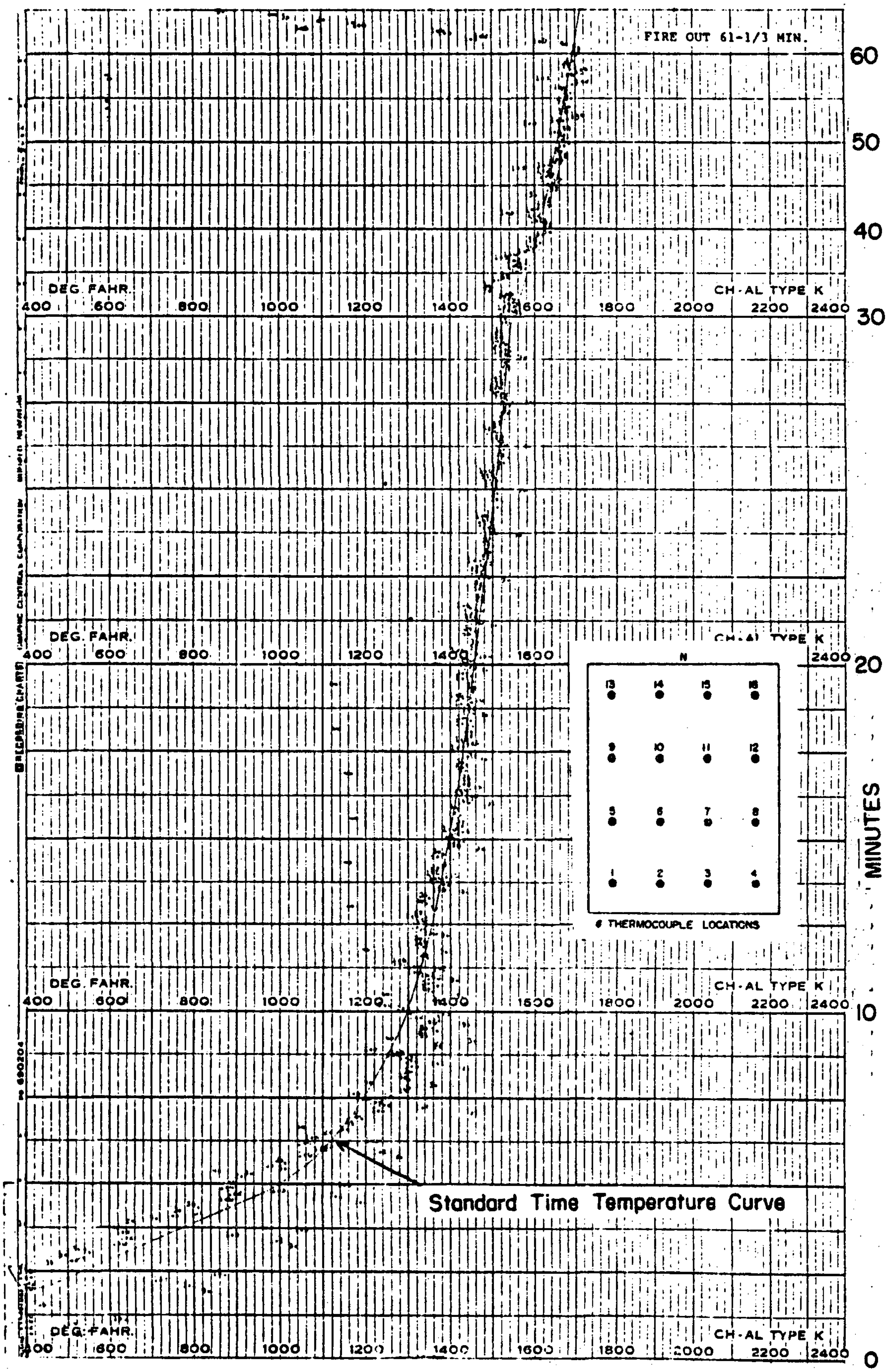
UNEXPOSED SURFACE BEFORE FIRE TEST - TEST ASSEMBLY NO. 2



FURNACE TEMPERATURES

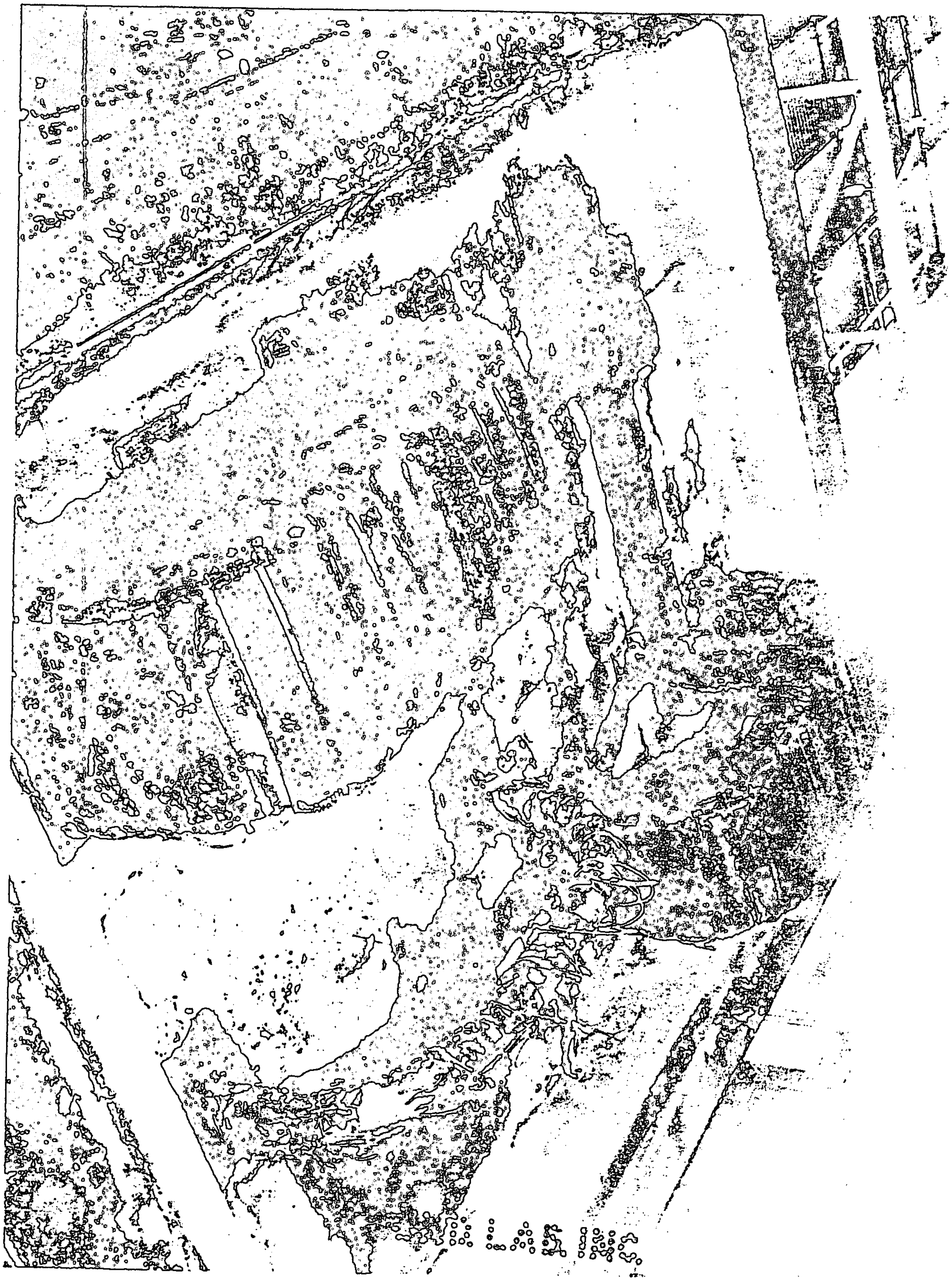
R 10125-2
March 3, 1983

Underwriters Laboratories Inc.
Fire Endurance Test



ILL. 32

EXPOSED SURFACE AFTER FIRE AND HOSE STREAM TESTS - TEST ASSEMBLY NO. 2



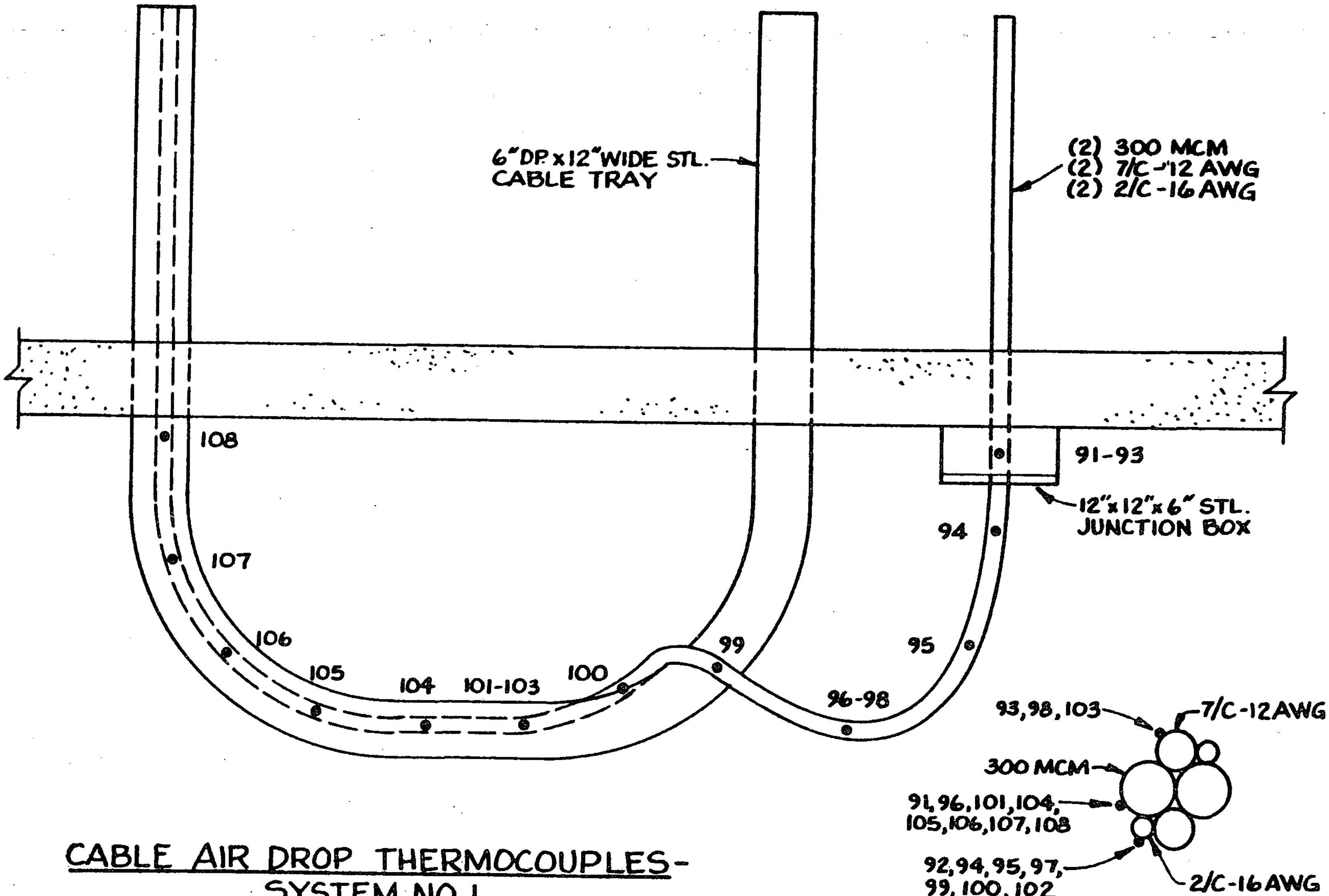
APPENDIX A
TEMPERATURES OF THE ASSEMBLY - TEST ASSEMBLY NO. 1

LOCATION OF THERMOCOUPLES:

The temperatures on the cables, steel conduits, steel junction boxes and within the electrical protective systems on the exposed side of Test Assembly No. 1 were measured by 108 thermocouples located as shown in ILLS. A1 through A6. The temperatures of the furnace chamber in the "U" of System Nos. 2 and 3 and in the "U" of the cable tray receiving the cable air drop of System No. 1 were measured by three thermocouples placed 12 in. from the bottom surface of the floor at the center of each system, as shown in ILL. A1.

TEMPERATURES OF THE ASSEMBLY:

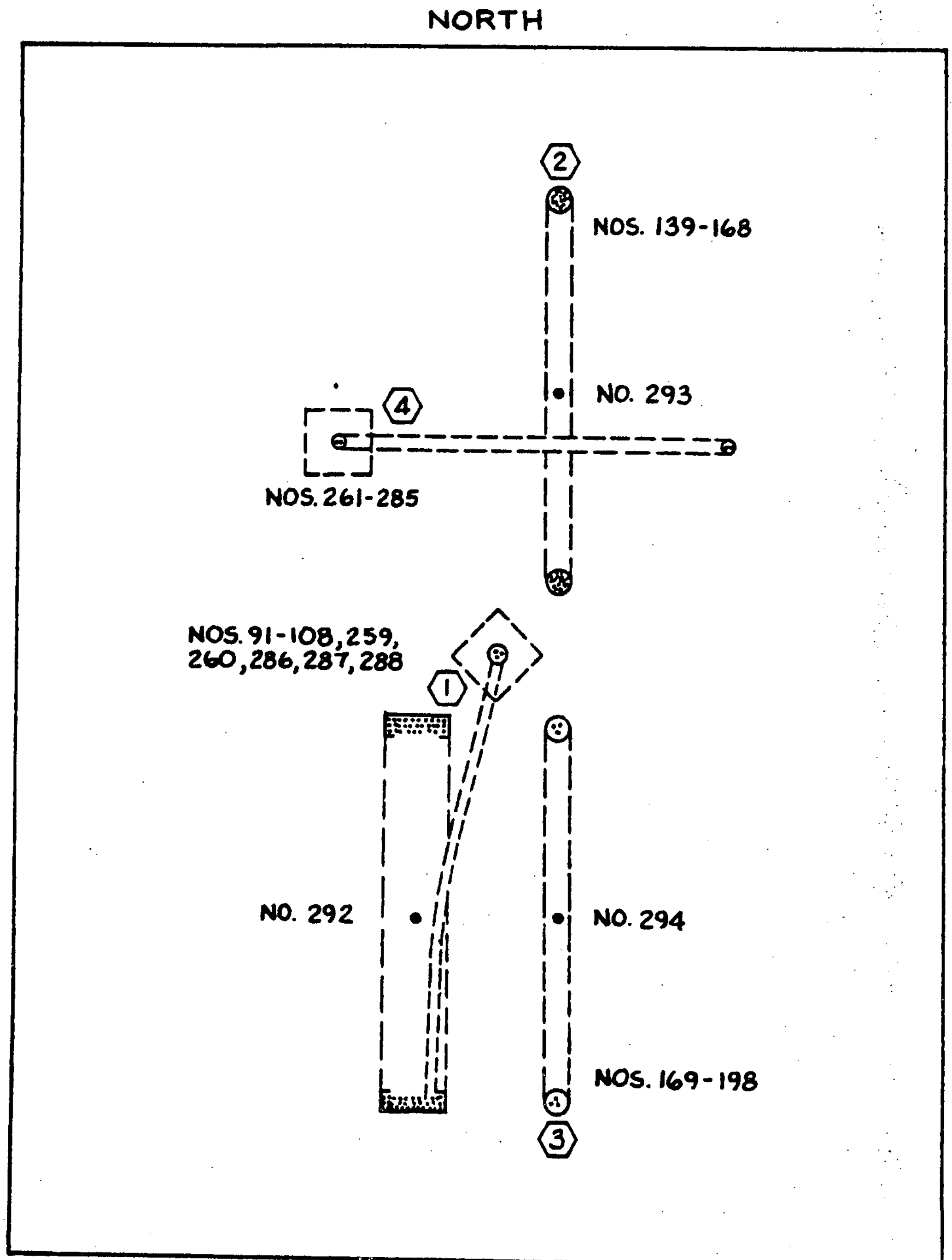
The temperatures on the cables, steel conduits, steel junction boxes and within the electrical circuit protective systems on the exposed side of Test Assembly are shown on the tables in. ILLS. A7 through A35. The temperature of the furnace chamber measured in the "U" System Nos. 1, 2 and 3 are shown on the tables in ILL. A36 and A37.



CABLE AIR DROP THERMOCOUPLES-
SYSTEM NO. 1

R10125-1
ILL. A2

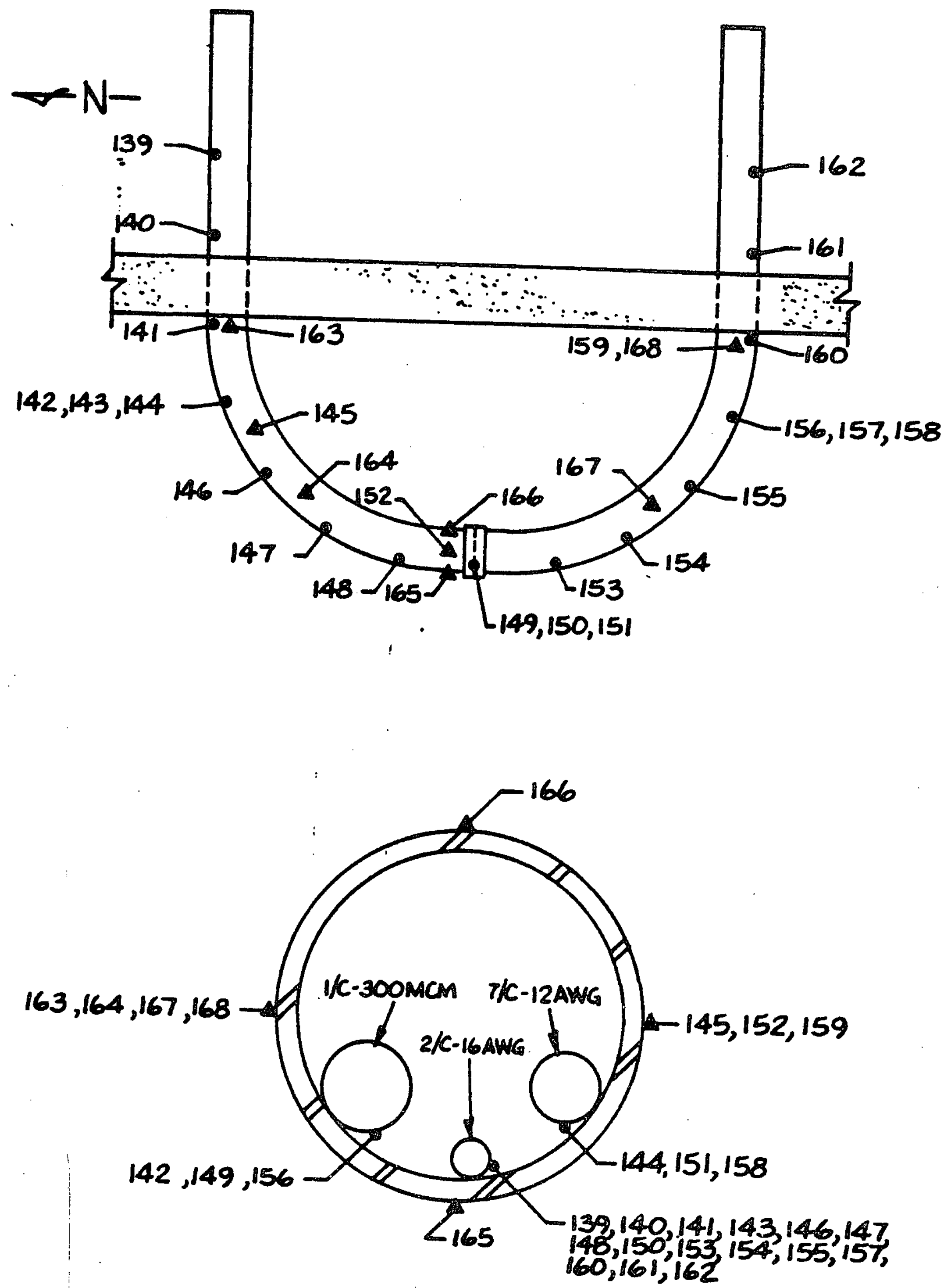
1- 12"x12"x6" STL. JUNCTION BOX W/ CABLE DROP-OUT TO 12" CABLE TRAY
2- NOM. 5"ø RIGID STL. CONDUIT W/ 40% CABLE FILL
3- NOM. 5"ø RIGID STL. CONDUIT W/ MINIMUM CABLE FILL
4- 12"x12"x6" STL. JUNCTION BOX W/ NOM. 2"ø RIGID STL. CONDUIT W/ MINIMUM CABLE FILL



(T.C. NOS. 292-294 LOCATED 12" BELOW FLOOR IN "U" OF SYSTEM)

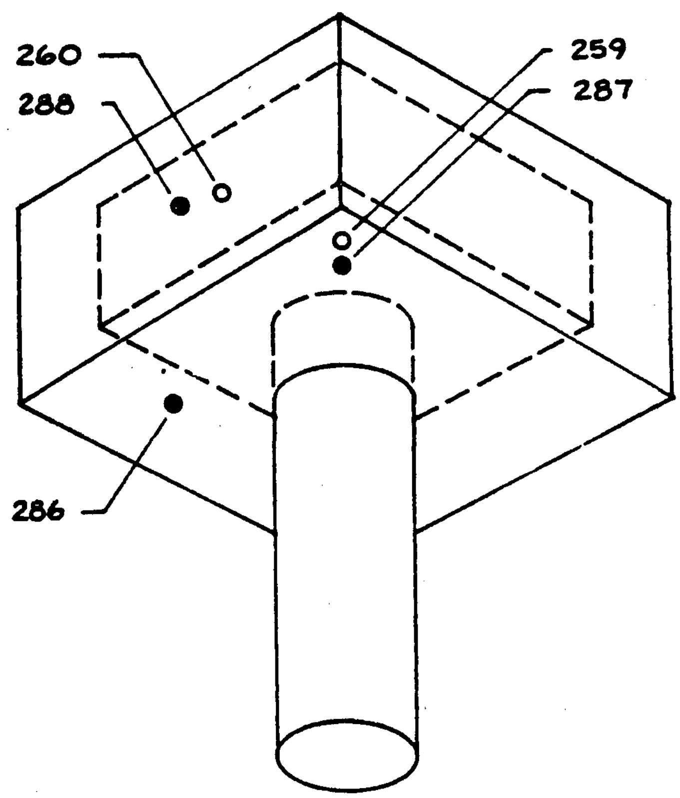
THERMOCOUPLE LOCATIONS

R10125-1
ILL. A1



CONDUIT AND CABLE THERMOCOUPLES - SYSTEM NO. 2

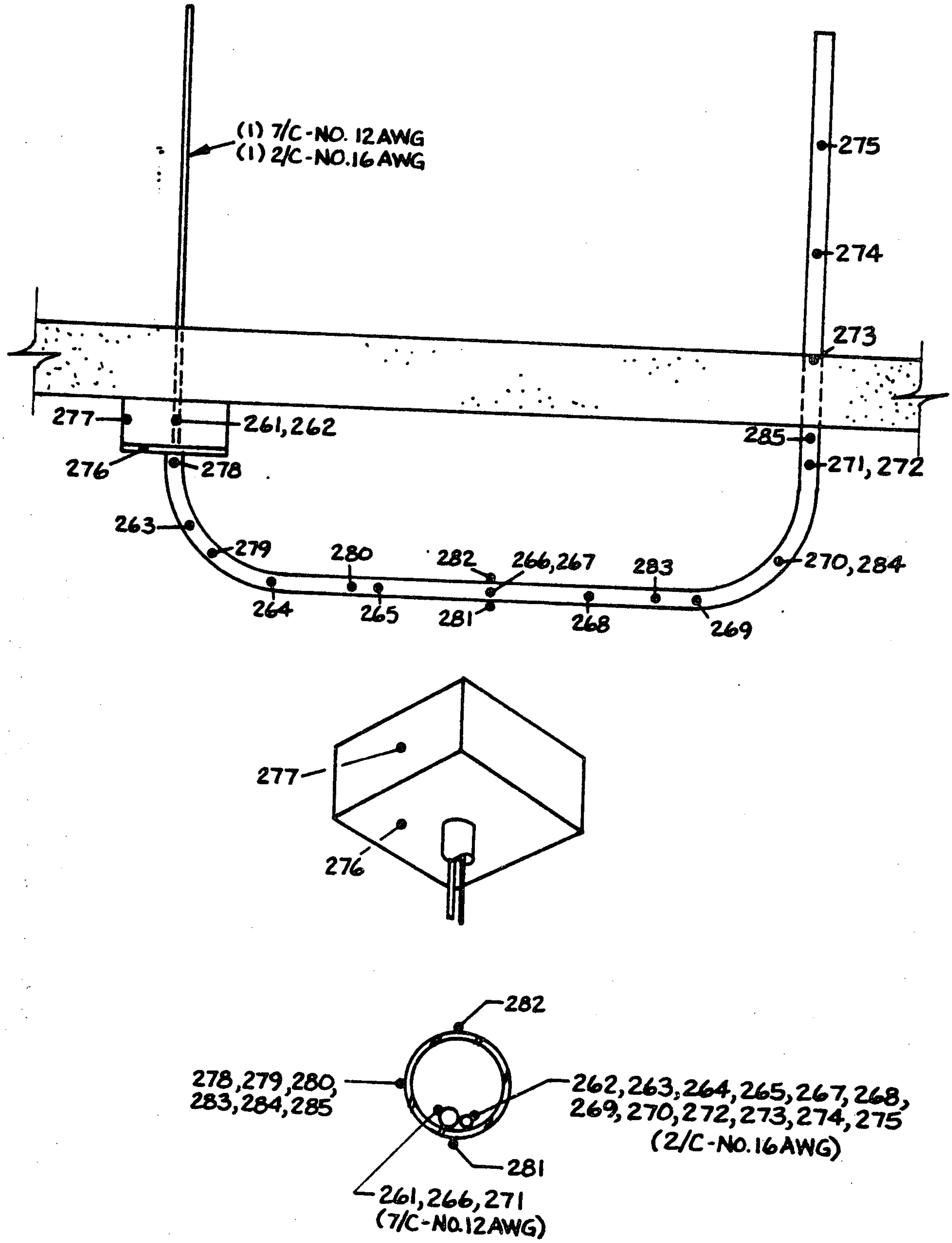
R10125-1
ILL. A4



TC	LOCATION
259	INSIDE STL. JUNCTION BOX, SECURED TO BOX COVER W/STL. RIVET
260	INSIDE STL. JUNCTION BOX, SECURED TO BOX SIDE W/STL. RIVET
286	INSIDE PROT. ENCLOSURE, IN CONTACT W/ BACK OF COMPOSITE FIRE BARRIER SHEET BENEATH JUNCTION BOX
287	INSIDE PROT. ENCLOSURE, MIDWAY BETWEEN COMPOSITE FIRE BARRIER SHEET AND COVER OF JUNCTION BOX
288	INSIDE PROT. ENCLOSURE, MIDWAY BETWEEN COMPOSITE FIRE BARRIER SHEET AND SIDE OF JUNCTION BOX

JUNCTION BOX AND
ENCLOSURE THERMOCOUPLES-
SYSTEM NO. 1

R10125-1
ILL. A3



CONDUIT, CABLE AND JUNCTION BOX THERMOCOUPLES-SYSTEM NO.4

R10125-1
ILL. A6

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	101	102	103	104
TIME(MIN.)				
2	65.8	66.1	67.1	66.1
4	65.9	67.2	68	66.2
6	66.4	70	69.8	67
8	67.8	75.6	73.9	68.3
10	70.8	87.7	83.2	70.3
12	74.9	103.6	96.5	72.5
14	81.6	112.8	105.2	75.3
16	85.9	121.3	111.1	79.2
18	91.1	129.8	112.2	83.1
20	94.5	138.5	120.3	87.5
22	98.4	149	126.9	92
24	101.9	161.7	134.1	96.7
26	105.8	171.8	140.9	102.2
28	110.5	184.1	150.4	108.4
30	116.1	201.9	163.3	115.3
32	120.3	216.6	173	123.2
34	124.6	232.2	183.1	131.8
36	128.6	251.6	196	142.2
38	134.5	275.8	211.9	153.5
40	142.6	289.7	223.8	166.4
42	147.9	307.4	241.5	182.7
44	158.4	338.8	260.1	201.2
46	169	379.2	280.8	223
48	184.6	406.7	302.5	244.2
50	201.3	434	324.7	265.2
52	216.1	467.3	356.1	284.3
54	244.4	503.6	385.9	305.2
56	277.1	529.8	406.4	328.9
58	299.6	554.6	429.8	349.5
60	320.7	577.1	454.8	369.9

R10125-1
ILL. A10

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	93	94	95	96
TIME(MIN.)				
2	75 *	65.1	67.7	73.5
4	75.1 *	64.8	67.3	72.9
6	75.2 *	65.4	69.1	73.5
8	75.3 *	67.1	71.3	73.7
10	75.7 *	69.9	74.9	74.1
12	76.4 *	75.3	87.6	77.1
14	77.7 *	83.3	99.2	85.1
16	80.4 *	90.5	109.4	95
18	85.8 *	97.5	118.1	103.3
20	96.6 *	109.3	124.6	111
22	118.3 *	140.4	129.1	117.1
24	161.5 *	162.4	134.1	121.2
26	204.8 *	177.1	142.1	124.6
28	226.4 *	187.3	154.3	141.1
30	237.2 *	194.1	178	155.4
32	242.6 *	199.4	191.3	170.8
34	245.3 *	204.2	200.1	191.8
36	246.6 *	208.5	209.2	203
38	247.3 *	209.6	218.2	206.4
40	247.7 *	209.6	225.9	210.2
42	247.8 *	209.9	233.9	212.4
44	248	225.1	242.6	212.5
46	266.3	234.2	265	213.1
48	287	252.6	301.5	213.5
50	308.7	287.1	333.5	214.7
52	331	329	359.6	227.9
54	354.2	354.9	379.7	239.4
56	368.5	372.3	400.5	251.5
58	377.8	389.1	423.6	269.9
60	382.9	398	442.4	292.8

* - INDICATES APPROXIMATE TEMPERATURE

R10125-1
ILL. A8

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	91	92
TIME(MIN.)		
2	75 *	75 *
4	75.1 *	75.1 *
6	75.2 *	75.2 *
8	75.3 *	75.4 *
10	75.7 *	75.8 *
12	76.4 *	76.6 *
14	77.8 *	78.2 *
16	80.5 *	81.4 *
18	86.1 *	87.9 *
20	97.2 *	100.8 *
22	119.4 *	126.5 *
24	163.7 *	178 *
26	208.1 *	229.5 *
28	230.2 *	255.3 *
30	241.3 *	268.1 *
32	246.9 *	274.6 *
34	249.6 *	277.8 *
36	251 *	279.4 *
38	251.7 *	280.2 *
40	252.1 *	280.6 *
42	252.2 *	280.8 *
44	252.4	281
46	265.7	307.6
48	302.5	331.7
50	336	353.2
52	360.9	382.2
54	385.6	408.5
56	420.3	431
58	445.6	454.8
60	452.5	485.3

* - INDICATES APPROXIMATE TEMPERATURE

R10125-1
ILL. A7

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	101	102	103	104
TIME(MIN.)				
2	65.8	66.1	67.1	66.1
4	65.9	67.2	68	66.2
6	66.4	70	69.8	67
8	67.8	75.6	73.9	68.3
10	70.8	87.7	83.2	70.3
12	74.9	103.6	96.5	72.5
14	81.6	112.8	105.2	75.3
16	85.9	121.3	111.1	79.2
18	91.1	129.8	112.2	83.1
20	94.5	138.5	120.3	87.5
22	98.4	149	126.9	92
24	101.9	161.7	134.1	96.7
26	105.8	171.8	140.9	102.2
28	110.5	184.1	150.4	108.4
30	116.1	201.9	163.3	115.3
32	120.3	216.6	173	123.2
34	124.6	232.2	183.1	131.8
36	128.6	251.6	196	142.2
38	134.5	275.8	211.9	153.5
40	142.6	289.7	223.8	166.4
42	147.9	307.4	241.5	182.7
44	158.4	338.8	260.1	201.2
46	169	379.2	280.8	223
48	184.6	406.7	302.5	244.2
50	201.3	434	324.7	265.2
52	216.1	467.3	356.1	284.3
54	244.4	503.6	385.9	305.2
56	277.1	529.8	406.4	328.9
58	299.6	554.6	429.8	349.5
60	320.7	577.1	454.8	369.9

R10125-1
ILL. A10

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	97	98	99	100
TIME(MIN.)				
2	67.2	66.3	65.3	65.6
4	66.9	66.3	65.8	65.8
6	67.7	66.6	65.5	65.9
8	68.6	67.8	66.7	66.7
10	69.6	68.5	67.9	68.2
12	73.1	71.7	69.4	70.8
14	80.4	78.8	73.4	75.4
16	92.5	86.3	78.6	81.2
18	108.6	94.8	88	87.6
20	119.8	100.2	100.9	93.3
22	124.9	105.3	109.8	98
24	128.5	109.9	120.7	103.5
26	133.5	118.5	128.4	110.1
28	149.7	131.9	136.1	116.2
30	160.5	139.1	140.7	122.7
32	172	156.3	146.9	140.1
34	185.6	177.9	162.9	141.2
36	197.2	193.6	187.7	148.6
38	203.9	202.2	197.9	174.7
40	206.8	204.9	203.4	195.2
42	209	205.7	207.1	199.2
44	209.5	206.1	208.7.	204
46	210	205.7	215.6	205.2
48	209	204.5	227.9	205
50	208.8	203.9	245.2	205.7
52	208.8	203.7	259.6	206.4
54	208.6	203.2	273.1	206.8
56	208.4	202.2	288.3	206.7
58	207.5	200.5	307.4	214.3
60	206.5	199.3	325.6	237.6

R10125-1
ILL. A9

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	139	140
TIME(MIN.)	68.4	55.1
2	67.9	66.3
4	68.1	58.5
6	68.3	58.6
8	68.3	60.9
10	68.3	59.9
12	68.6	63.3
14	68.8	56.8
16	68.9	55.9
18	69.1	61.3
20	69.6	55.6
22	69.6	74.6
24	70	76.4
26	70.4	78.4
28	71.1	80.8
30	71.7	83.3
32	72.6	85.9
34	73.6	88.7
36	74.4	91.4
38	75.5	94.7
40	76.8	98.2
42	78.1	103.3
44	79.3	107.5
46	80.9	112
48	82.2	
50	83.7	
52	84.7	
54	86.5	
56	87.4	
58	88.6	220.5
60		

R10125-1
ILL. A12

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	105	106	107	108
TIME(MIN.)				
2	66	65.7	65.8	65.5
4	65.8	65.6	66.3	65.5
6	66.2	65.9	67.9	66.5
8	66.9	66.8	69.9	67.4
10	68.4	68.4	73.4	69.1
12	70.4	70.7	77.3	71.5
14	72.6	73.8	81.4	73.7
16	75.7	77.8	86	76.9
18	79.1	81.7	90.3	79.3
20	83.5	86.1	93.8	81.7
22	88.4	91.2	98.2	84.4
24	92.1	95.5	102.9	87.1
26	97.1	100.4	108.1	90.4
28	103.3	105.6	113.3	93.8
30	112.1	110.8	118.2	98.2
32	119.3	117	124.5	103.7
34	125.8	123.6	132.2	108.8
36	132.6	130.6	146.6	114.5
38	138.5	137	164.4	121.1
40	143.6	145.1	176.5	128.1
42	149.7	157.1	180.6	135.4
44	157.3	170.1	189.8	143.1
46	175	182.1	200.7	150
48	189.7	194.8	214.4	156.9
50	200.5	209.3	229.6	166.6
52	218.1	227.5	244.1	190.3
54	241.4	247.1	261.1	206.8
56	259.9	265.6	276.6	215.3
58	277.8	283.6	297.7	219
60	302.4	301.7	314.9	221.4

R10125-1
ILL. A11

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	145	146	147	148
TIME(MIN.)				
2	68.8	67.4	67.6	70.2
4	68.8	67.6	67.6	69.7
6	69.2	68.2	67.8	69.6
8	72.4	69.3	67.9	69.5
10	81.6	71.3	68.5	69.7
12	94.6	75.5	69.6	70.1
14	112.1	82.1	71.2	71.2
16	126.5	89.8	73.1	72.8
18	141.8	97.5	75.7	75
20	152.4	105.2	79.3	78.1
22	164.1	112.3	83.6	82
24	170.9	118.7	89.1	86.3
26	177.7	124.7	94.9	92.3
28	187.4	131.2	101.2	100.8
30	198.8	138.9	107.4	113
32	210.9	147.7	115	124
34	220.3	157	122.7	131.8
36	244.8	166.1	129.9	138.5
38	234.8	172.2	137.1	145.5
40	240	178.3	144.2	150.5
42	246.6	185	151.5	154.1
44	247.7	192.9	158.8	156.6
46	268	201.3	166.4	160.9
48	279.9	211.3	174.5	166.7
50	287.9	220.9	182.2	173
52	296.3	139.1	188.4	179.5
54	305.8	236.5	198.6	186.8
56	321.2	252.5	207.9	194.4
58	334.8	264.7	217.6	204
60	350	280.1	228.2	214.2

R10125-1
ILL. A14

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	141	142	143	144
TIME(MIN.)				
2	76.1	67.3	68.3	67.3
4	98.3	67.4	70.6	67.5
6	119.6	67.7	76.8	68.1
8	130.7	68.6	86.8	69.3
10	137.9	70.1	102.1	71.5
12	142.6	72.6	120.8	74.6
14	148.8	75.5	138.5	78.5
16	152.1	78.9	153.6	82.4
18	155.6	82.1	166	86.5
20	161	84.9	174.6	90.3
22	166.4	87.8	180.7	94.2
24	171.3	90.2	184.9	98
26	176.2	92.9	188.5	101.7
28	181.2	94.9	191.3	104.6
30	186.1	96.9	196.1	108.2
32	190.5	99.6	202.4	111.7
34	196.5	102.3	207.3	115.5
36	203.7	106	215.1	119.5
38	212.5	109.7	227.6	124
40	220.6	113.7	238.7	128.8
42	225.7	118.3	249.1	133.8
44	229.6	123	254.4	139
46	233.7	126.7	270.5	144.2
48	239.2	130.7	280.3	150
50	245.2	135.5	291.2	155.2
52	250.4	140.9	301.4	162.3
54	258.3	146	315.5	167.9
56	267.7	151.5	322	175.5
58	275.1	156.8	336.3	182.5
60	283.3	162.3	347.8	189.9

R10125-1
ILL. A13

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	153	154	155	156
TIME(MIN.)				
2	68	68	68.2	67.5
4	68	68	68.3	67.5
6	68.1	68.1	68.3	67.7
8	68.2	68.3	68.4	68.4
10	68.4	68.8	68.9	69.8
12	68.8	69.6	70.3	71.9
14	69.6	71	72.6	74.6
16	70.9	73	76.1	77.1
18	73.4	75.5	81.3	79.7
20	77.2	79	88.8	82.1
22	82	83.8	98.2	84.5
24	87.2	89.9	107.7	87.3
26	93.2	97.2	116.7	89.5
28	99.7	105.7	125.7	92
30	106.6	115.3	135.6	94.7
32	113.9	124.5	145.7	97.4
34	122.2	131.5	154.6	100.7
36	130.9	136.9	161.5	103.5
38	140.1	141.3	166.4	106.8
40	149	145.9	170.2	110.3
42	155.3	150.6	173.6	114.2
44	159.5	155.4	176.5	117.7
46	163.7	160.8	180.4	121.9
48	168	166.6	185.6	126.3
50	172.6	172.1	192.6	130.2
52	178.5	178.3	201.3	134.3
54	184.8	184.6	211.3	138.5
56	192.5	192.5	222.1	143.3
58	201.2	202.3	233.7	148.2
60	210.1	214.1	245.5	153.4

R10125-1
ILL. A16

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	149	150	151	152
TIME(MIN.)				
2	67.6	68.3	67.9	67.8
4	67.6	68.1	67.8	68.1
6	67.6	68.3	67.9	68.8
8	67.7	68.5	67.9	73
10	67.8	69.2	68	77.7
12	68.1	70	68.4	84
14	68.8	72	69	90.3
16	70	74.3	69.9	114.3
18	71.6	77.7	71.2	132.9
20	73.8	81.8	72.7	142.3
22	76.6	86.5	74.7	157.2
24	80	92	77.3	164.4
26	83.9	98.9	80.4	171.7
28	88.4	107.2	84.3	184.8
30	94	117	88.8	206.1
32	100.6	129.9	94.2	223.7
34	106.5	144.7	100.6	229.2
36	113.6	158.3	108.1	230.7
38	121.4	169.1	116.5	244.1
40	128	175.3	124	254.1
42	132.7	179.3	129.5	262.5
44	137.8	182.1	134.1	288.1
46	143.1	185.2	138.8	299
48	149.3	189.1	143.7	307.6
50	155.5	194.2	148.4	315.6
52	161.8	200.6	153.9	323.9
54	168.3	207.1	158.9	337.4
56	175	214.5	165.3	351.7
58	182.1	222.7	172.3	368.3
60	189.5	232.5	179.7	386.5

R10125-I
ILL. A15

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	157	158	159	160
TIME(MIN.)				
2	67.4	67.8	74.2	
4	67.5	67.8	79.7	
6	68.7	68.3	88.5	
8	71.3	69.3	99.4	
10	75.5	71.9	114.6	
12	79.7	75.3	120.1	156.7
14	85.1	79.4	121.4	162.1
16	92.2	83.2	131.4	165.5
18	99.5	87.5	135.4	167.9
20	108.2	91.6	144.6	170.7
22	115.3	95.9	155.5	175.1
24	122.4	99.8	169.2	178.3
26	132.3	102.5	183.7	181.6
28	143.7	106.3	195.8	184.7
30	155.4	110.3	208.7	186.8
32	164	114.7	219.6	188.6
34	171.1	119.5	228.6	192
36	179.7	123.9	234.6	195.6
38	191	127.2	257.4	198.8
40	197	132.5	283.8	202.4
42	199.8	137.1	304.2	206.9
44	206.3	145.2	325	211.5
46	201.9	147.7	326.5	218.3
48	202	152.9	327.8	228.3
50	202.4	158.5	336.2	236.6
52	202.7	164.9	352.4	240.9
54	201.1	171.9	364.9	245.8
56	186.9	179.8	380.1	250.5
58	190.9	188	394.1	254.7
60	138	196.4	407.9	259.7

R10125-1
ILL. A17

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	169	170	171	172
TIME(MIN.)				
2			67.4	67.4
4			69.1	67.8
6			76.1	69.6
8			79.7	73.1
10			82.4	77.2
12			82.8	82.4
14			86.5	87.3
16			93.3	92.6
18			94.3	98.1
20			97.7	104.2
22			101.3	110.3
24			104.6	115.4
26			108.1	121.3
28			107.7	126.6
30			113.6	132.2
32			117.1	137.8
34			120.7	143.3
36			121	150
38			124.1	157.2
40			130.9	164.6
42			134.9	172.8
44			137.2	180.9
46			143.9	187
48			143.5	196.1
50			148.2	205.7
52			154.9	211.8
54			164.8	217.9
56			157.2	229.1
58			169.1	240
60			169.8	249.3

R10125-1
ILL. A20

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	165	166	167	168
TIME(MIN.)				
2	68.1	68	68.5	100.4
4	68.2	68.3	68.7	136.8
6	68.8	70	71.1	150.7
8	69.4	74.8	72.7	161.3
10	70.8	79.7	75.8	169
12	71.6	83.6	79.9	177.3
14	75.9	88.4	85.5	184.1
16	76.2	94.7	92.9	188.5
18	82.1	103.3	101.3	192.2
20	88.6	111.9	113.2	194.7
22	98.2	120.4	129.1	197.6
24	108.2	129.9	137.9	200.8
26	118.8	141.9	153.6	204.8
28	129.6	156.6	170.3	209.1
30	140.3	172.6	185.6	213.7
32	152.3	192.2	198.7	216.9
34	167.5	212.4	208.5	220.7
36	184.6	229.3	224.9	235.2
38	201.5	245.8	245.1	242.7
40	208.8	254.5	256.6	259.7
42	210.4	265	266.4	268.7
44	214.9	286.6	274.9	278.4
46	211.9	303.7	285.3	288.3
48	212.3	316.9	296.7	297.7
50	212.8	329.4	309.2	307.8
52	223.9	342	321.7	316.6
54	244.4	355.1	334.6	325.2
56	265.7	369.2	348.4	336.1
58	284.6	381.6	362.6	346.8
60	299.9	392.9	377.1	342.6

R10125-1
ILL. A19

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	177	178	179	180
TIME(MIN.)				
2	68		67.8	
4	68		67.9	
6	68.2		67.9	
8	68.9		68	
10	70.4		68.4	
12	73		69	
14	76.4		69.9	
16	80.7		71.1	
18	86.2		72.7	
20	93.1		75.1	
22	101.5		78.1	
24	111.1		81.9	
26	122.3		86.6	
28	133.7		92.3	
30	145.8		99.4	
32	157.3		107.8	
34	169.3		117	
36	179.4		126	
38	188.3		133.7	
40	199.4		140.3	
42	211		147	
44	225		154.6	
46	236.8		163.7	
48	249.5		173	
50	262.6		182.7	
52	273.4		192.7	
54	285.3		203.1	
56	299.7		213.8	
58	316		225.6	
60	334.7		239.5	

R10125-1
ILL. A22

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	173	174	175	176
TIME(MIN.)				
2	67.9	67.5	68.6	68
4	71.2	68.6	70.2	68.1
6	79.5	72.4	75.7	67.7
8	91.9	79.3	84.2	66.8
10	104.6	86.9	91.4	64.5
12	117.1	95	98.7	61.1
14	128.9	103.3	107.7	56.3
16	140	110.8	117.7	86.9
18	149.2	118.6	133.5	95
20	156.2	125.4	157.1	105
22	162.8	132.2	185.9	115.9
24	168.2	137.7	218.1	126.8
26	174.2	144.4	246.9	136.5
28	181.6	151	272.3	146.2
30	188.1	156.8	295.6	155.3
32	195.2	162.3	321.8	165.1
34	202.7	169.3	345.3	173.3
36	211.3	176.8	356.5	182.9
38	219.7	186.1	358.2	192.8
40	229.2	194.7	366.9	205.9
42	237.6	201.7	376.4	217.2
44	247.2	213.7	385.9	231.7
46	255.9	221.4	395.6	244.9
48	264.1	232.9	405.2	256.8
50	274.8	243.3	415.6	271.5
52	281.6	253	427.2	283.5
54	285.9	259.9	438.5	299
56	296.9	272.4	452	313.3
58	305.3	281	466.8	326.9
60	312.3	290.5	482.1	341.4

R10125-1
ILL. A21

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	185	186	187	188
TIME(MIN.)				
2	67.8	67.6	67.7	67.6
4	67.9	68	68	68
6	68.2	70.8	70.2	71.1
8	69.2	76.8	75.7	78.1
10	71.9	83.6	83.5	87
12	77	90.7	92.2	95.6
14	85.5	98.2	101.3	104.3
16	96.4	105.1	110	111.7
18	108	111.4	119	118.2
20	118.9	118.8	126.3	125.4
22	127.5	124.6	134.2	131.9
24	135	130	140.5	137.8
26	140.9	135.1	146.6	143.7
28	146.8	140.8	151.7	150.5
30	153.2	145.4	157.8	157.3
32	159.5	152.2	164.1	164.1
34	166.1	160.1	171.5	171.7
36	173.7	167.8	179.3	179.1
38	179.3	176.4	188	188.5
40	186.6	185.2	198.5	197.5
42	194.5	193.3	208.1	207.2
44	202	201.4	219.2	218
46	211.2	210.6	229.2	228.7
48	220.9	219.9	241.6	239.6
50	231.5	229	252.3	250.3
52	241.8	239.9	263.7	261.8
54	254.2	251.1	275.4	272.9
56	271.7	261.8	291.1	285.4
58	292.2	273	303.2	297.3
60	311.5	286	319.5	308.9

R10125-1
ILL. A24

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	181	182	183	184
TIME(MIN.)				
2		68.1	67.9	67.8
4		69.6	67.8	67.7
6		73.6	67.9	67.9
8		85	68.3	68.2
10		93.9	68.8	68.7
12		98.2	70.1	70
14		104.4	71.7	72
16		118.3	74.2	74.8
18		130.8	77.6	78.5
20		136.2	82.2	83
22		170.6	87.8	88.6
24		190.9	94.8	95.5
26		207.8	103.3	103.7
28		225.9	113.4	113.5
30		245.8	124.6	122.5
32		267.2	135.8	132.2
34		289.7	147	142.9
36		311.4	158	153.7
38		328.2	167.2	162.6
40		345.9	175.8	169.8
42		358.1	184.2	177.3
44		370.6	193.1	185.3
46		383.3	202.8	193.6
48		395.1	213.1	202.2
50		406.9	224.4	211.6
52		419.8	235.5	221.5
54		433.3	247.7	232.8
56		446.9	260.5	244.1
58		460.2	273.3	256.3
60		473.9	286.7	269.3

R10125-1
ILL. A23

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	194	195	196	197
TIME(MIN.)				
2	68.5	68.4	68.9	68.3
4	70.5	68.5	72.5	68.5
6	81	70	77.1	69.8
8	84.9	72.2	84.8	71.7
10	96	75	91.5	75.1
12	107	78	97.7	79.9
14	114.9	81.7	106.5	86.8
16	124.8	86.6	100.2	92.5
18	142.4	94.6	109.2	99.3
20	173.6	100.6	120.5	105.7
22	209.8	108.7	133.1	111
24	232.9	118	146.2	117.7
26	248	130.9	160.9	128.6
28	292.4	145.7	176.6	142.6
30	291.3	162.2	193.2	153
32	308	170.5	213.4	170.5
34	314.4	191.2	246.8	205.1
36	331.1	204.3	270.4	222.9
38	340.9	209.6	290.5	230.6
40	354.5	211.1	307.6	241.6
42	365	214.5	322.2	250.5
44	380.4	227.4	332.5	266.7
46	401.3	250.6	345.5	278.9
48	411.3	270.1	359.1	290.8
50	423.2	284.6	370.9	303
52	437	300.1	376	315.5
54	450.9	317.4	386.4	327.6
56	465.4	341.1	396.4	340
58	482.4	356.8	406.5	352.3
60	496.9	372.5	417.9	365.2

R10125-1
ILL. A26

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.) / TIME(MIN.)	189	191	192	193
2	70.5	67.9	68.5	71.3
4	95.3	68	68.7	93.1
6	124.3	68.5	68.9	124.4
8	147.2	69.3	69.3	141.8
10	165.7	70.4	69.8	156.5
12	177	71.9	70.4	170.8
14	181.9	73.6	71.3	181.5
16	187.9	75.3	71.6	188.2
18	193.2	77.3	72.4	195.3
20	197.2	79.4	73.1	202.9
22	195.2	81.7	73.6	213.7
24	196.5	83.7	74.9	220.8
26	202.2	85.8	75.4	233.7
28	226.1	87.9	76.5	244.2
30	244.7	90.2	77.2	246.4
32	262.2	92.5	78.1	249.3
34	280.8	94.6	79.5	244.4
36	293	96.6	80.2	240.5
38	304.6	98.9	81.8	234.7
40	320.2	101.1	83	249.2
42	338.5	103.9	84.3	262.4
44	355.8	106.3	85.5	272.4
46	368.6	108.8	86.7	282.2
48	381.3	111.5	88.4	291.1
50	400.4	114.4	89.9	300.2
52	422.9	117	92.6	309.3
54	433.2	120.2	92.7	318.1
56	445.4	123.4	96.4	325.9
58	458.6	126.6	95.8	334.3
60	471.4	129.3	98.4	343.1

R10125-1
ILL. A25

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	259	260
TIME(MIN)		
.02	65.6	65.1
2.02	66	66.7
4.02	68.9	68.2
6 02	74.7	73.9
8.02	86.2	83.7
10.02	102.2	96.7
12.02	118.3	114.1
14.02	138.2	136 7
16.02	160.7	162.1
18.02	178.4	174.2
20 02	188.8	185.4
22 02	192	192.8
24.02	195.8	176.6
26.02	199.3	201.6
28 02	203.9	211.6
30.02	210.6	228
32.02	216.7	245.4
34.02	240.1	269.3
36.02	272.6	295.8
38.02	302.1	321.7
40.02	334.4	350.7
42.02	365.8	380.1
44.02	397.3	410.8
46.02	428.7	441.5
48.02	461.1	473.6
49.35	480	492.3
51.32	512.3	524.5
53.32	544.4	556.9
55.33	575.3	587.4
57.33	604	616.9
59.32	631.8	646
61.32	659.9	674.6

R10125-1
ILL. A28

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.) 178

TIME(MIN.)	
2	86.6
4	122.3
6	128.5
8	153.3
10	144.8
12	150
14	179.8
16	191.5
18	180
20	189.6
22	199.1
24	200.4
26	234
28	237.4
30	246.9
32	250.8
34	245.1
36	238.3
38	237.8
40	236.3
42	246
44	254.4
46	262.7
48	270.6
50	278.9
52	287.1
54	294.9
56	302.7
58	310.9
60	318.9

R10125-1
ILL. A27

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	265	266	267	268
TIME(MIN.)				
.02	67	67	67	66.9
2.02	67	66.9	67.1	67
4.02	67.1	67.1	67.1	67
6.02	66.9	67	67	67
8.02	67	67	67	67
10.02	67.1	67.1	67.1	67
12.02	67.1	67.2	67.2	67.1
14.02	67.4	67.5	67.5	67.4
16.02	67.7	67.9	68.2	67.9
18.02	68.5	68.7	69.1	68.7
20.02	69.9	70.1	70.7	70
22.02	71.8	72.1	73.4	71.7
24.02	75.2	75.3	78.3	74.3
26.02	80.2	80.1	83.9	78.6
28.02	86.2	87.3	91.2	85.9
30.02	93.9	99.8	100.6	95.7
32.02	102.8	116.2	112.2	107.6
34.02	114.1	131.7	127.2	125
36.02	147.8	144.6	146.5	150.9
38.02	161.1	156.3	160.7	157.3
40.02	175.2	168.9	172.8	166.9
42.02	186.4	180.1	185.8	183.4
44.02	197.8	191.7	195.8	192.8
46.02	202.5	198.9	199.3	198.1
48.02	206	204.2	205.8	203.7
49.35	207.6	207.1	209.2	205.3
51.32	209.1	212	217.5	208.4
53.32	208.5	215.1	227.8	210.7
55.33	213.7	219.1	237	212.6
57.33	226.1	231.9	247.2	216.1
59.32	246.2	249.4	261.9	223
61.32	267.2	269.1	282	237.9

R10125-1
ILL. A30

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	261	262	263	264
TIME(MIN.)				
.02	65.6	65.9	67	66.8
2.02	66.2	66.7	66.8	66.9
4.02	69	71.2	66.8	67
6.02	75.6	80.6	66.9	66.9
8.02	85.1	103.5	67.1	67
10.02	102.7	127.1	67.4	67
12.02	130.4	146.3	67.8	67.1
14.02	149	165.2	69	67.3
16.02	156.8	175.3	71.3	67.9
18.02	168.7	180.3	74.4	68.8
20.02	176.3	189.3	78.7	69.9
22.02	183	198.5	85.3	72
24.02	187.2	222	93.6	75.7
26.02	192.3	271.8	100	81.8
28.02	233	298.2	110.3	91.8
30.02	280.6	331.7	112.9	106.3
32.02	317	362.6	131.7	128.3
34.02	346.9	388.2	144.4	143.4
36.02	380.6	444	154.8	152.6
38.02	394.9	482	168.6	162.1
40.02	422.4	508.8	185.4	176.8
42.02	474.1	534.9	194.8	188.7
44.02	498.6	563.9	201.8	198.3
46.02	513.6	593.2	205.7	203.7
48.02	526.9	624.5	208	207.5
49.35	539.5	634.9	209.2	208.8
51.32	572.6	658.2	217.2	209.4
53.32	600.3	687.7	238.3	208.8
55.33	629.4	711.9	256.7	211.6
57.33	660	736.1	275.7	218.1
59.32	740.2	764.9	296.4	233.8
61.32	768.9	791.7	316.8	247.7

R10125-1
ILL. A29

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	273	274	275	276
TIME(MIN.)				
.02	67	67.9	68.0	66.6
2.02	67	67.9	68.9	67.6
4.02	67.2	68.2	69	75.6
6.02	67.2	68.2	69.3	91.7
8.02	67.4	68.5	69.5	117.2
10.02	67.6	68.5	69.5	147.9
12.02	68.9	68.6	69.6	175.2
14.02	70.2	68.8	69.7	197
16.02	75.5	69	70	216.6
18.02	77.3	69.4	70.1	233.8
20.02	84.6	69.5	70	250.1
22.02	83.1	69.8	70.2	268.1
24.02	84.1	70.3	70.3	290
26.02	87.9	70.6	70.4	316.7
28.02	97.5	71.1	70.6	346.8
30.02	98.8	71.6	70.7	378.1
32.02	102.2	72.2	70.9	409.8
34.02	100.4	72.8	70.9	439.3
36.02	105.2	73.4	71.1	467.4
38.02	107.2	74.2	71.3	495.9
40.02	107.6	74.7	71.3	524.3
42.02	112.9	75.5	71.5	552.2
44.02	111.8	77	71.7	573.575 *
46.02	131.9	78	72	594.95 *
48.02	141.1	81.2	72.3	637.7
49.35	154.5	84.2	72.5	654.6
51.32	157.5	88.1	73	683.8
53.32	171.5	93.9	73.3	712.4
55.33	183	103.8	73.7	739.2
57.33	181.9	113.2	74.5	766.2
59.32	179.6	119.3	75.6	791.9
61.32	177.8	124.3	77.3	818.8

* - INDICATES APPROXIMATE TEMPERATURE

R10125-1
ILL. A32

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	269	270	271	272
TIME(MIN.)				
.02	66.6	65.9	66.2	66.1
2.02	66.7	65.8	66.1	66.1
4.02	66.7	65.9	66.2	66.1
6.02	66.7	66	66.2	66.5
8.02	66.7	67.6	67	69.3
10.02	66.8	72.4	72	74.2
12.02	67	83.8	111.2	92.8
14.02	67.9	106.6	139.9	118.3
16.02	69.2	125.9	146.9	129
18.02	71.3	137.9	148.7	134.3
20.02	74.1	148	159	143.1
22.02	77.7	159.5	166	151.1
24.02	82.5	168.3	169.6	157.2
26.02	88.7	174.1	170.4	159.7
28.02	97	179.2	169.9	162.9
30.02	107.9	182.5	169.5	163.8
32.02	119.1	185.3	170.6	164.7
34.02	129.8	187.8	173.2	166.3
36.02	138.1	190.3	175.3	167.5
38.02	144	192.5	178.4	170.6
40.02	160.6	193.7	177	170.9
42.02	176.3	195.1	178.4	171.2
44.02	185	197.2	180.3	175.1
46.02	192.6	199.6	175.1	182.1
48.02	199.7	201.5	184	185
49.35	202	202.5	189.8	170.8
51.32	206.5	204.4	195.2	195.7
53.32	210	207.4	203.3	198.5
55.33	209.8	208.7	204.9	202.4
57.33	211.2	207.6	203.8	200.9
59.32	209.6	206.8	200.5	200.6
61.32	212	206.2	201.3	198.9

R10125-1
ILL. A31

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS)	281	282	283	284
TIME(MIN.)				
.02	67	67	67	66.9
2.02	67	67	67	66.9
4.02	66.9	67	67	66.8
6.02	66.9	67.2	67.1	66.9
8.02	67	67.5	67.5	67.3
10.02	67.2	68.4	67.8	68.4
12.02	68.5	69.9	68.8	70.2
14.02	69	71.9	70.3	73.1
16.02	71.4	75.5	72.4	76.9
18.02	75.4	80.8	76	81.2
20.02	80.4	87.5	81	86.2
22.02	86.9	95	89.2	92.5
24.02	96	105.4	96.7	98.3
26.02	107.2	117.4	102.9	107.2
28.02	131.5	134.1	111.7	119
30.02	161.2	161	122.2	144.5
32.02	187	185.9	134.9	173.2
34.02	205.3	206.9	148.9	182.5
36.02	210.1	220.3	165.3	179.8
38.02	211.8	228	197.7	183.6
40.02	214.9	234.1	207.2	186.2
42.02	215.7	241.6	209.3	205.6
44.02	216	250.1	210.4	210
46.02	215.7	258.6	226.2	210.7
48.02	215	268.6	235.3	211
49.35	215.1	274.7	240.6	222
51.32	224.3	285.6	251.5	240
53.32	252.7	298	256.4	248.7
55.33	268.7	311.9	269.3	251.1
57.33	289.9	327.6	285.2	253
59.32	312.8	345.2	300.8	258.9
61.32	335	364.4	319.6	271.9

R10125-I
ILL. A34

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS)	277	278	279	280
TIME(MIN)				
.02	66.2	67	66.9	66.8
2.02	70.3	66.8	66.8	66.9
4.02	85.3	67.1	66.9	67
6.02	109.3	68	66.9	66.9
8.02	138.6	70.5	67	67.3
10.02	175.8	75	67.3	67.9
12.02	210.4	81.1	68	68.4
14.02	226.8	94.6	70.2	70.2
16.02	243.3	122.9	73.8	73.1
18.02	256.8	173.8	78.3	78.1
20.02	270	209.3	82.6	80.7
22.02	285.9	209.5	74.8	90
24.02	308.3	208.4	109.8	100.1
26.02	340	211.4	124.2	106.9
28.02	308.3	212.2	141.6	117.2
30.02	422.6	213.6	162.4	130.9
32.02	462.6	214.8	189	144.7
34.02	500.7	220.7	206	160.1
36.02	535	228	211.4	176.7
38.02	565.8	234.6	225.4	191.6
40.02	596.1	241.5	221.7	213.1
42.02	626.1	251.3	226.4	223.8
44.02	653.8	262.3	233.4	226.7
46.02	680	278.8	241.8	230.2
48.02	706.2	298.3	253.9	239.3
49.35	721.2	312.5	262.4	246.3
51.32	745.4	340.1	279.5	258.1
53.32	768.9	368.6	300.3	273
55.33	792	401.9	320.4	286.1
57.33	814.7	437.9	340.7	302.9
59.32	836.6	476	361.5	319.3
61.32	858.4	519.8	382.5	337.7

R10125-1
ILL. A33

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	292
TIME(MIN.)	
.02	649.3
2.02	915.4
4.02	1325.2
6.02	1419.6
8.02	1586.4
10.02	1633.8
12.02	1632.9
14.02	1668
16.02	1634.2
18.02	1616.3
20.02	1648.7
22.02	1650.2
24.02	1659.5
26.02	1663.8
28.02	1668.2
30.02	1656.6
32.02	1632.7
34.02	1586.2
36.02	1588.3
38.02	1589.2
40.02	1612.4
42.02	1627.2
44.02	1658.4
46.02	1677
48.02	1697.1
49.35	1690.7
51.32	1711.3
53.32	1732.2
55.33	1741.7
57.33	1743.4
59.32	1749.3
61.32	1752.2

R10125-1
ILL. A36

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	285	286	287	288
TIME(MIN.)				
.02	65.5	67.9	65.7	65.1
2.02	65.6	111.8	70.6	69.4
4.02	65.9	147.3	86.6	94.3
6.02	74.6	174	99.3	107.3
8.02	97.9	186.7	118.5	133.2
10.02	140	198.3	140.6	157.8
12.02	204.3	211.3	160	181.2
14.02	206.2	221.8	176.8	201.5
16.02	200.9	232.8	190.5	213.3
18.02	201	239.7	209.8	224.2
20.02	207.7	247.6	219.7	238
22.02	208.8	263.1	228.4	25.14
24.02	209	289.5	236.6	267.3
26.02	207.6	333.7	249.8	285.4
28.02	205.5	400.6	270.2	316
30.02	205.2	466.4	292.6	358.6
32.02	204.8	513.2	323.8	394.2
34.02	204.9	540.2	356.4	433.4
36.02	207.1	551.8	392.8	466.2
38.02	200.6	575.9	420.4	494.1
40.02	204.7	590	453.3	523.7
42.02	207.9	605.8	484.8	550.4
44.02	210.6	637.2	514.9	577.8
46.02	211.8	662.1	546	604.3
48.02	211.9	688.4	574.3	633
49.35	211.9	698.6	597.3	645.7
51.32	211.8	714.4	626.4	671
53.32	211.4	727.9	657.5	695
55.33	210	732.5	687.7	723.3
57.33	208.1	740.8	712.7	747.5
59.32	206.9	759.2	741.5	775.3
61.32	207.3	778.8	771.8	798.1

R10125-1
ILL. A35

3M COMPANY
DECEMBER 21, 1982

CHAN(NOS.)	293	294
TIME(MIN.)		
.02	736.6	868.3
2.02	993.4	1061.2
4.02	1453.8	1441.1
6.02	1393.7	1513.2
8.02	1586.6	1617
10.02	1626.2	1627.6
12.02	1618.2	1639.9
14.02	1631.1	1661.1
16.02	1587.3	1670.8
18.02	1623.8	1658.6
20.02	1634	1656.7
22.02	1660.7	1679.4
24.02	1650.7	1663.3
26.02	1654.9	1676.2
28.02	1648.8	1686.8
30.02	1629.1	1652.2
32.02	1604.5	1619.5
34.02	1566.6	1562.5
36.02	1572.6	1587.2
38.02	1593.4	1606.8
40.02	1618.8	1674.4
42.02	1641.4	1688
44.02	1662.4	1684.7
46.02	1677.8	1680.6
48.02	1697.5	1693
49.35	1697.7	1692.6
51.32	1710.1	1701.3
53.32	1732.9	1720.5
55.33	1741.2	1743.7
57.33	1743.6	1767.4
59.32	1752	1785.8
61.32	1762	1804.2

R10125-1
ILL. A37

APPENDIX B

TEMPERATURES OF THE ASSEMBLY - TEST ASSEMBLY NO. 2

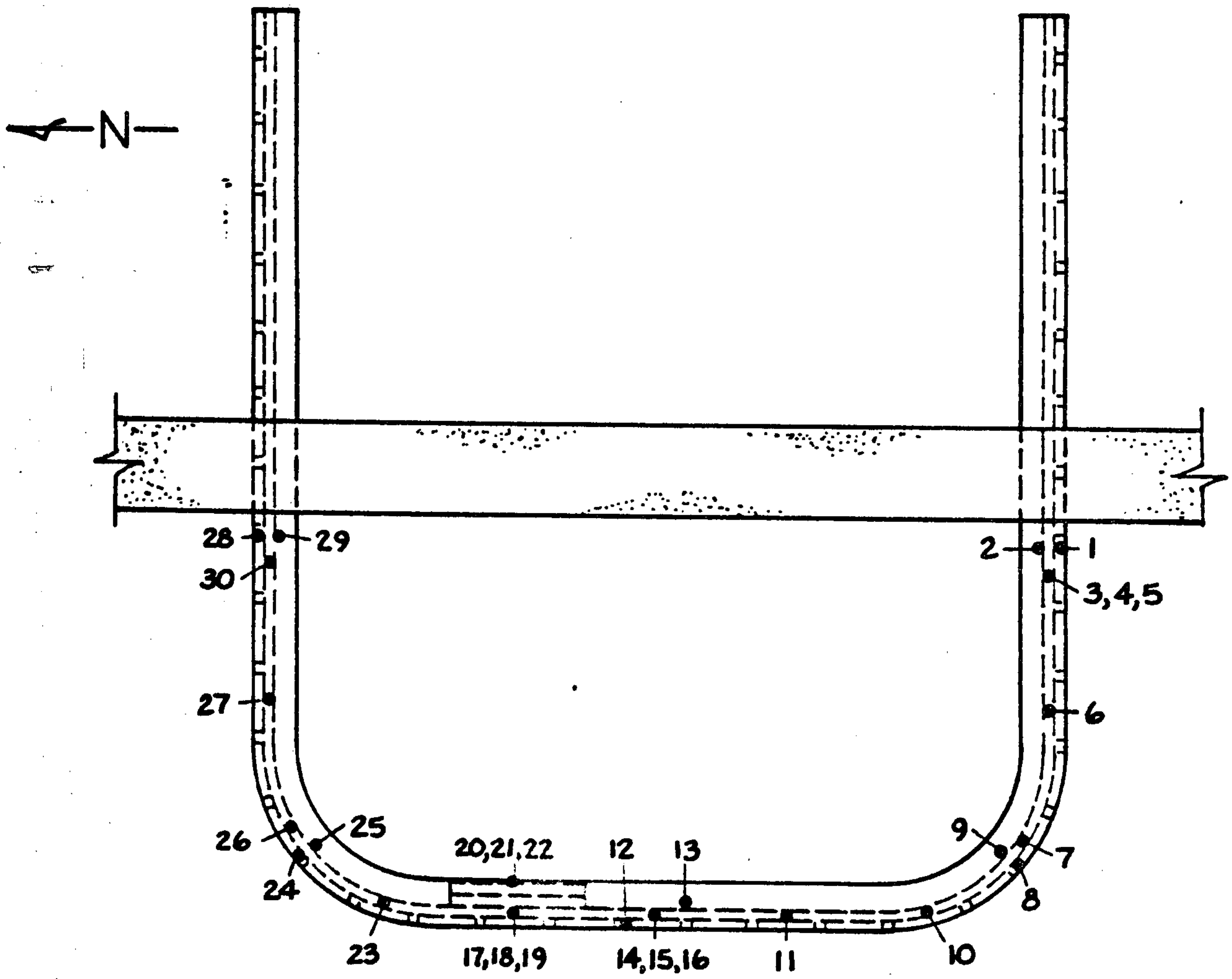
LOCATION OF THERMOCOUPLES:

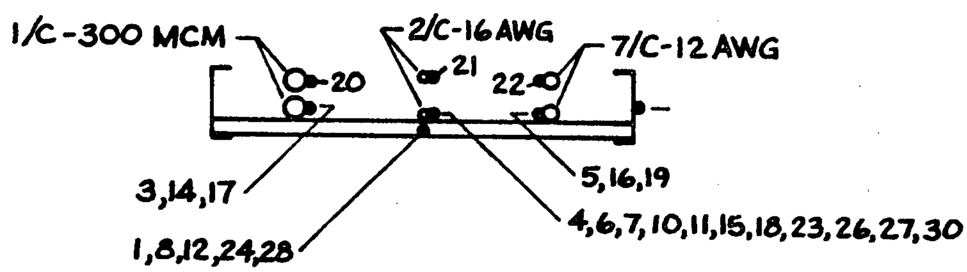
The temperatures on the cables, cable tray, steel conduits, steel junction box and within the electrical circuit protective systems on the exposed side of Test Assembly No. 2 were measured by 129 thermocouples located as shown in ILLS. B1 through B5. The temperatures of the furnace chamber in the "U" of System Nos. 1 and 2 were measured by two thermocouples placed 12 in. from the bottom surface of the floor at the center of each system, as shown in ILL. B1.

TEMPERATURES OF THE ASSEMBLY:

The temperatures on the cables, cable tray, steel conduit, steel junction box and within the electrical circuit protective systems on the exposed side of Test Assembly No. 2 are shown on the tables in ILLS. B6 through B39. The temperatures of the furnace chamber measured in the "U" of System Nos. 1 and 2 are shown on the table in ILL. B40.

CJJ/RMB:jmd

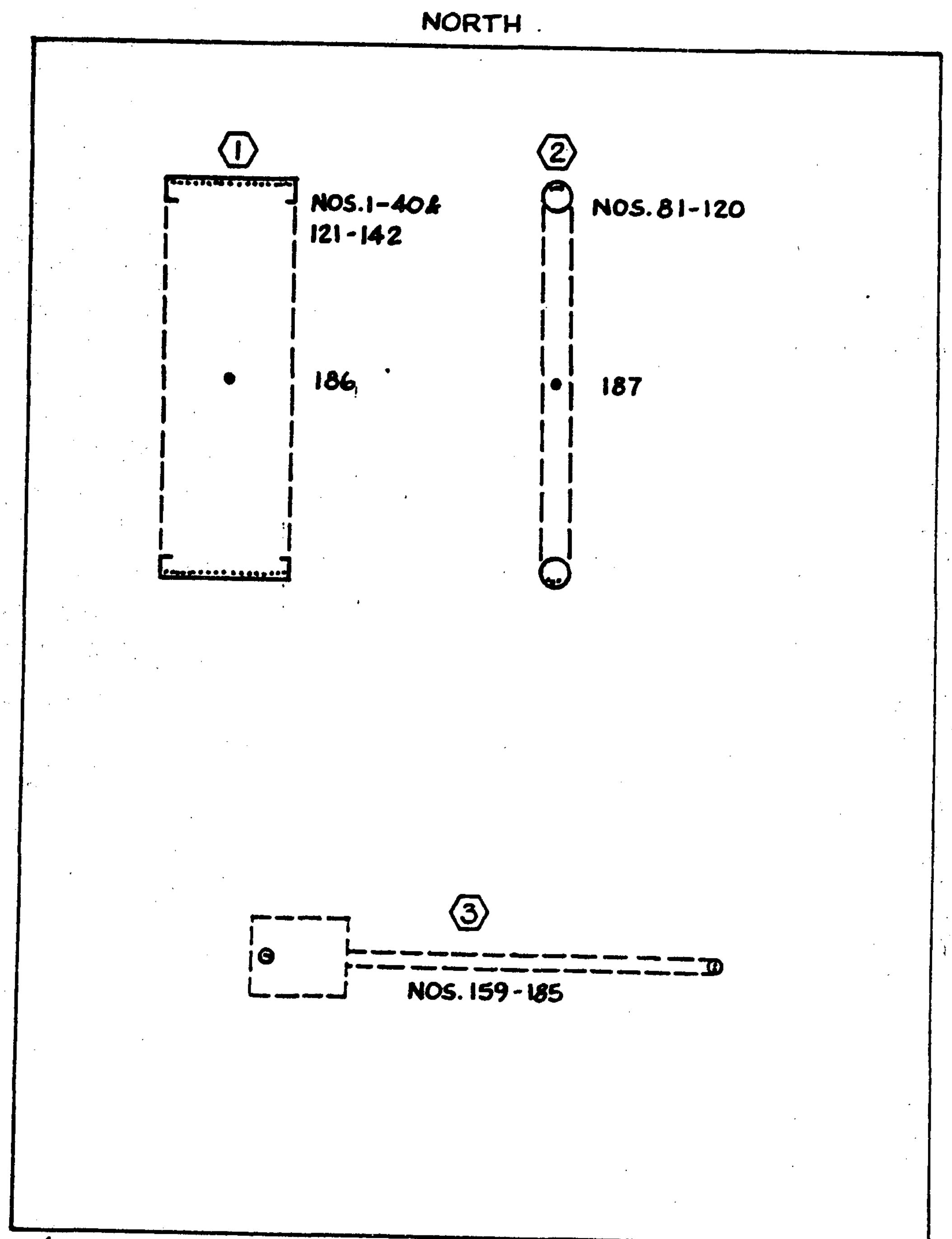




CABLE AND CABLE TRAY THERMOCOUPLES-
SYSTEM NO. 1

R10125-2
ILL. B2

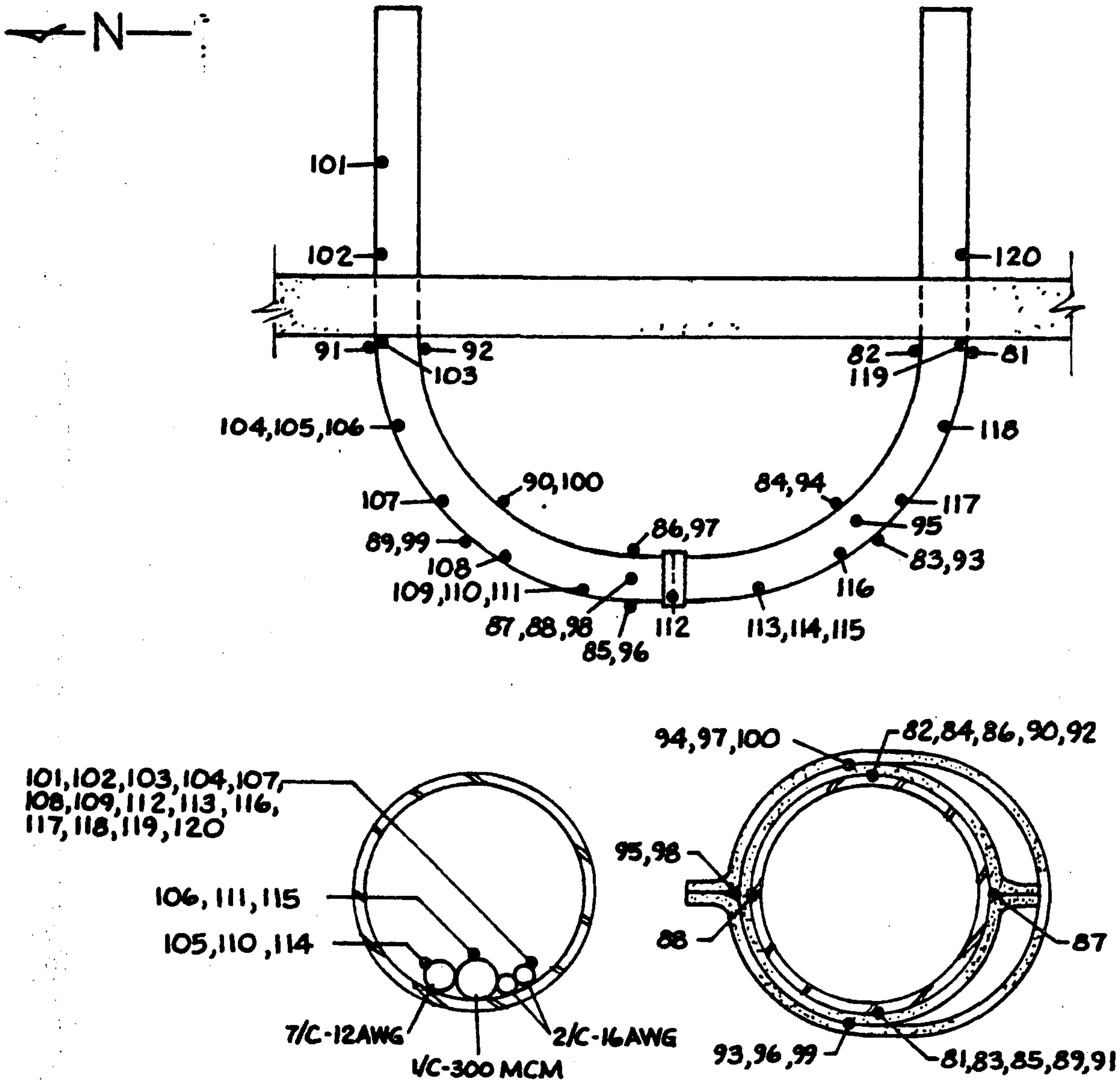
1-NOM. 4"x24" OPEN-LADDER STL. CABLE TRAY W/MINIMUM CABLE FILL.
2-NOM. 5"ø RIGID STL. CONDUIT W/ MINIMUM CABLE FILL.
3-12"x12"x6" STL. JUNCTION BOX W/NOM. 2"ø RIGID STL. CONDUIT W/MINIMUM CABLE FILL.



(T.C. NOS. 186 & 187 LOCATED 12" BELOW FLOOR IN "U" OF SYSTEM)

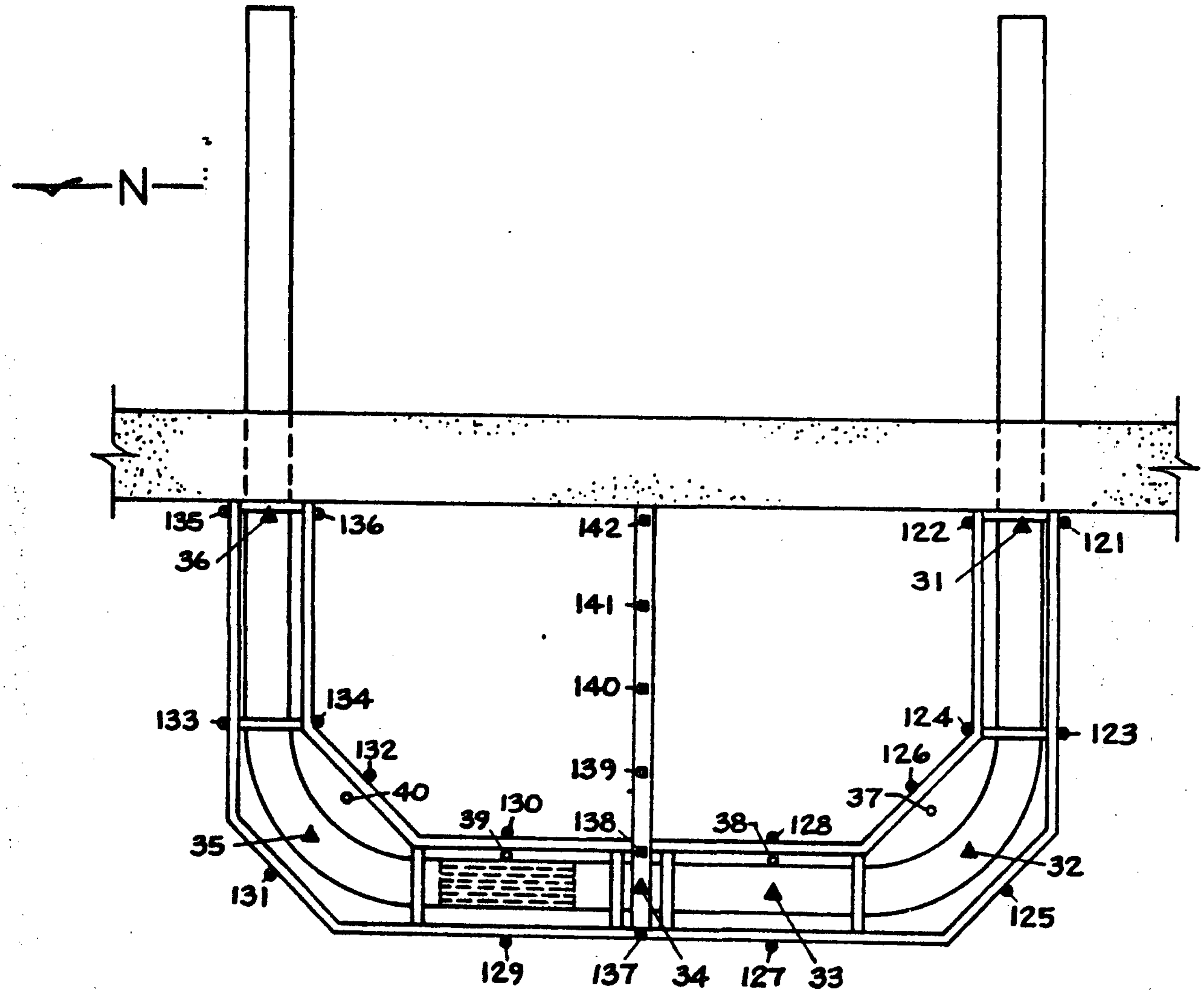
THERMOCOUPLE LOCATIONS

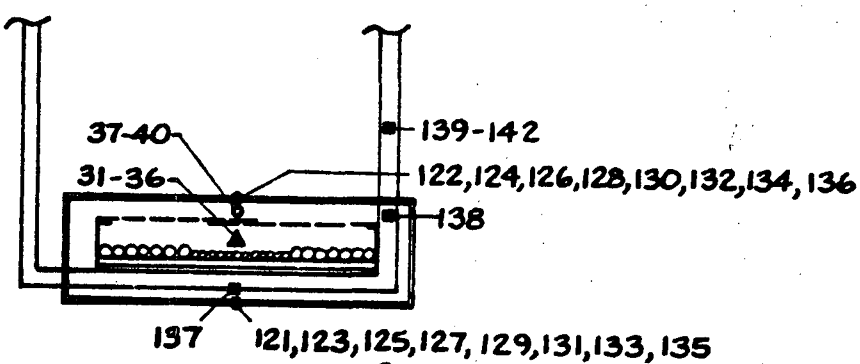
R10125-2
ILL. B1



CONDUIT, CABLE AND PROTECTIVE SYSTEM THERMOCOUPLES-SYSTEM NO. 2

R10125-2
ILL. B4





▲ - IN AIR INSIDE MAT WRAP APPROX. ¾" ABOVE CABLES
○ - IN AIR BETWEEN MAT WRAP & COMPOSITE SHEET
● - BETWEEN COMPOSITE SHEET & UNISTRUT® FRAMING
■ - ON UNISTRUT® TRAPEZE SUPPORT

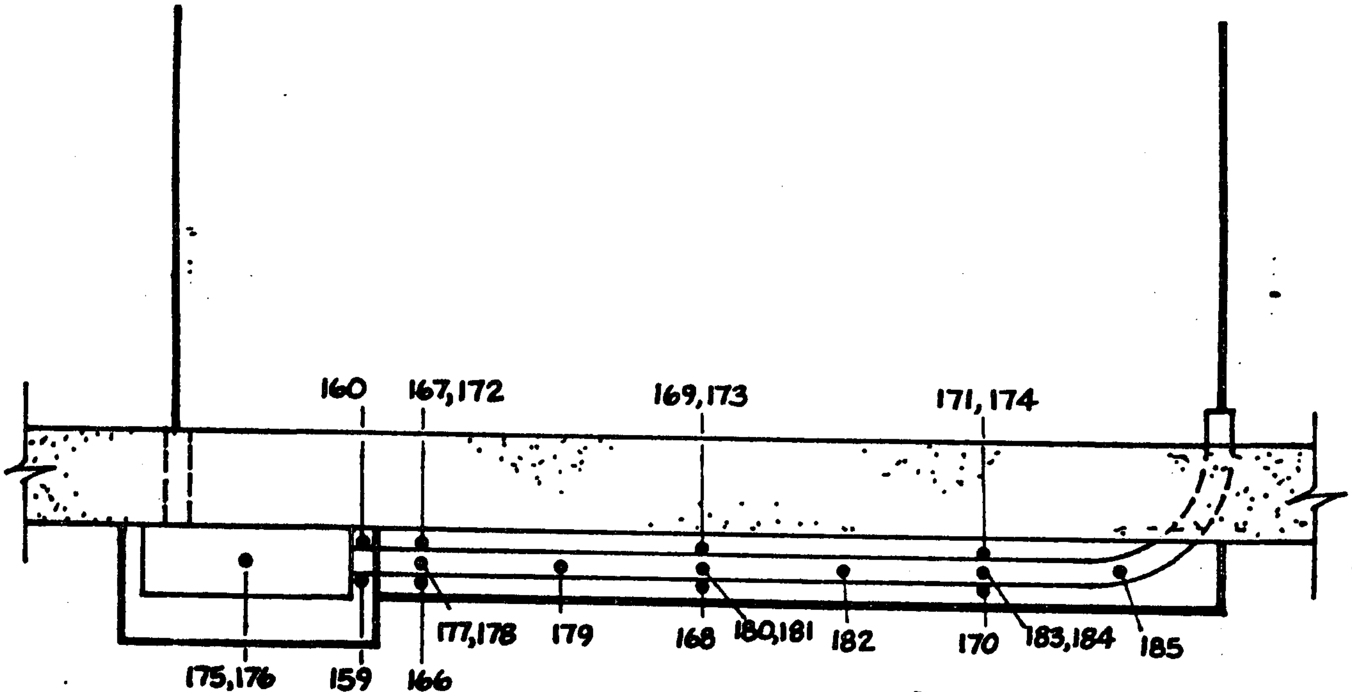
PROTECTIVE SYSTEM THERMOCOUPLES-
SYSTEM NO. 1

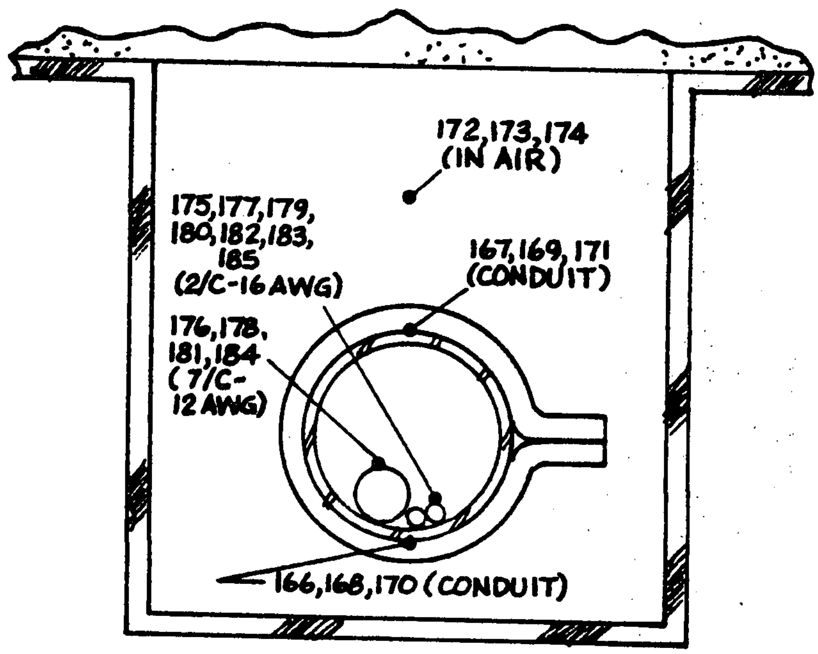
R10125-2
ILL. B3

3M COMPANY
MARCH 3, 1983

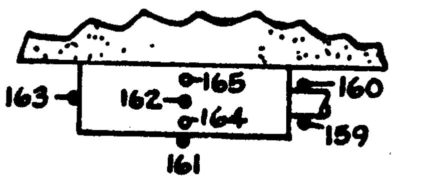
CHAN(NOS.)	1	2	4	5
TIME(MIN.)				
2	69.2	69.7	69.2	69.6
4	69.5	70	69.5	69.9
6	70.4	71.4	70.6	70.9
8	72.3	74.3	72.5	72.1
10	75.4	79.3	75.4	74.3
12	79.3	86.2	79.4	77.1
14	83.8	92.5	83.9	80.1
16	88.6	99	88.9	84
18	93.8	104.8	94	88.1
20	98.9	109.2	99.1	91.9
22	104	114.4	104.2	95.8
24	110	120.8	110.1	100.8
26	116.5	124.7	116	105.2
28	122.9	131.6	121	118.2
30	130.6	142.3	128.4	127.4
32	144.1	154.1	157.2	138.6
34	154.7	162.9	169.3	148.9
36	167.6	172.9	186.7	161.3
38	180.6	185.5	210.2	178.5
40	191	200.1	243	201.2
42	209.2	218.3	267.5	229.5
44	236.3	238.8	282.8	247.2
46	261.2	259.4	303.4	262.6
48	285.2	279	323.7	278.9
50	314.4	298.2	345.6	291.8
52	339.4	317.1	367.3	308
54	355.8	335.5	387.4	325.3
56	373.3	351.6	407	342.3
58	387.9	368.6	423.6	364.4
60	403.2	383.6	441.1	384.7

R10125-2
ILL. B6

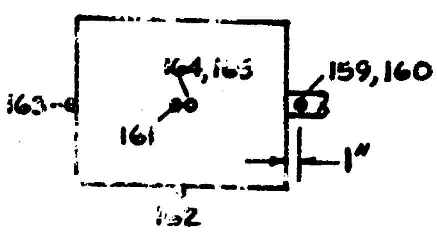




JUNCTION BOX THERMOCOUPLES



SIDE VIEW



BOTTOM VIEW

T.C. NO.	LOCATION
159,160	ON CONDUIT 1" FROM JUNCTION BOX W/IN ENCLOSURE
161	ON BOTTOM CENTER OF JUNCTION BOX
162	ON SIDE OF JUNCTION BOX @ CENTER
163	ON END OF JUNCTION BOX @ CENTER
164	INSIDE JUNCTION BOX, IN AIR, 1" ABOVE BOTTOM OF BOX
165	INSIDE JUNCTION BOX, IN AIR, 1" BELOW TOP OF BOX

CONDUIT CABLE JUNCTION BOX AND AIR THERMOCOUPLES-
SYSTEM NO. 3

R10125-2
ILL. B5

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	10	11	12	13
TIME(MIN.)				
2	69.3	69.1	68.4	68.8
4	69.4	69.5	68.6	68.8
6	69.6	70.9	69.4	69.1
8	70.1	73	70.8	69.9
10	71.1	74.5	72.7	71.3
12	72.2	77.5	75	73.4
14	73.4	79.6	77.3	75.9
16	75.3	81.9	79.7	78.9
18	76.6	83.9	82.1	81.9
20	78.4	86.5	84.1	85.1
22	80.4	90.1	86.3	88.4
24	82.8	93.3	88.7	91.7
26	85.5	97	91.8	95.3
28	88.7	101.1	96.1	99.4
30	92.8	108.1	102.3	104.8
32	107.4	120.1	119.5	118.3
34	119.8	131.1	127.1	136.5
36	132.9	[illegible]	133.4	156.3
38	146.9	[illegible]	140.7	172.7
40	162	[illegible]	154.9	185.7
42	170.1	20[illegible]	169.5	193.2
44	176.5	228	186.9	201.5
46	180.4	252.7	208.1	225.2
48	183.4	276.8	[illegible]	258.2
50	188.7	291.6		290.6
52	188.9	309.8		322.6
54	189.9	328.7	[illegible]	351.9
56	209.2	348.9	[illegible]	380.5
58	261.5	370	343.7	407.3
60	277.9	394.9	363.9	431.8

R10125-2
ILL4 B8

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	6	7	8	9
TIME(MIN.)				
2	69.4	69.3	69.3	69.4
4	69.5	69.5	69.4	69.6
6	69.9	69.9	70	70.3
8	70.9	70.7	71	71.6
10	72.3	72.2	72.4	73.6
12	74.6	74	74.3	76.4
14	77.2	76.3	76.6	79.7
16	80.3	78.9	79.2	83.3
18	83.5	81.7	82	87.4
20	86.9	85	85.1	91.7
22	90.6	88.5	88.6	96.7
24	95.2	92.3	92.8	102.2
26	100.8	98.8	97.8	107.7
28	107.8	104.6	103.6	113.5
30	117.3	110	110.4	120.9
32	140.1	129.6	128.6	135.1
34	151.6	141.1	139.1	146.7
36	162	152.7	150.6	158.1
38	172.4	163.8	160.8	170
40	183.2	175.3	169.9	183.2
42	203.5	189	178.5	199.3
44	231.4	206.2	187.6	226.1
46	268.2	229.8	202.7	250.3
48	296.1	258.1	227	275.2
50	322.2	276.4	254.5	299.9
52	351.3	294.9	280.5	328.9
54	381.5	316.4	305.5	359
56	412.9	343.2	330.3	390.4
58	443	370.2	354.6	420.8
60	468.4	403.6	380	448.5

R10125-2
ILL. B7

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	18	19	20	21
TIME(MIN.)				
2	68	68.1	67.9	67.9
4	68.3	68.3	68	67.9
6	69	69.2	68.7	68.2
8	70.8	70.5	69.5	68.7
10	72.6	72.2	70.6	69.8
12	74.9	73.6	71.7	71.2
14	77.3	75.1	73.1	72.7
16	80.1	76.9	75.4	74.8
18	82.4	78.5	77.7	77.7
20	83.3	80.2	79.3	79.7
22	85.8	82.1	80.8	82.2
24	89.4	85	82.7	84.7
26	91.7	86.6	86.1	87.7
28	95.9	90.5	92.5	92.2
30	103.6	96.4	102.6	100.9
32	109.8	110.2	117.6	111.4
34	110.6	116.5	130	126.1
36	127.4	125.6	142.1	143.1
38	134.9	134	155.1	156.8
40	132.7	132.6	170	171.8
42	136	146.4	185.6	187.6
44	147.2	155.3	193.5	199.1
46	155.9	165	233.5	208
48	179.3	174.6	247.9	215.1
50	198.3	185.4	264.1	228.5
52	209.5	196.4	276.2	240
54	218	211.5	286.6	251.4
56	228.6	218.6	295.1	261.3
58	241.3	234.4	304.7	273.1
60	256	247.5	315.4	285.7

R10125-2
ILL. B10

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	14	15	16	17
TIME(MIN.)				
2	68.7	68.7	68.4	68.5
4	68.8	68.9	68.6	68.8
6	69.2	69.9	69.1	69.3
8	70	71.5	70	70
10	71.3	73.7	71.2	71.3
12	72.9	76.1	72.7	72.2
14	76.6	78.7	74.4	73.6
16	77.8	81.4	76.4	75.1
18	81.3	84.7	79	75.9
20	80.3	87.5	81.7	77.9
22	84	90.6	84	80.1
24	86.3	94.3	86.7	80.1
26	89.8	98.4	89	82.6
28	92.2	101.4	93.4	85.9
30	98.7	108	97.7	90.2
32	118.2	128.7	125.3	98.8
34	123.8	141.1	143.7	106.6
36	132.3	157.1	162.6	117.7
38	147.3	170.1	183.3	124.6
40	168	187.4	198.5	132.3
42	168.8	213.3	222.4	143.7
44	179.5	240.8	244	152
46	186.3	273	265.5	160.5
48	188.5	306.3	289.9	172.7
50	199.8	338	310.6	185.9
52	208 2	367	326.1	194.6
54	259.1	394 3	342.3	199
56	292.9	418.2	366.4	201
58	313.8	439.2	389.1	201.9
60	332.4	463.6	413.9	203.7

R10125-2
ILL. B9

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	26	27	28	29
TIME(MIN.)				
2	68.5	68.8	68.3	68.4
4	68.7	69	68.4	70.7
6	68.9	69.8	69.3	75.9
8	69.5	71.3	71.8	83.7
10	70.6	73.7	76.2	92.4
12	72.7	77.4	82.2	102.1
14	75.8	82.6	90.1	111.6
16	80	89.5	100.4	121.3
18	84.3	99.1	116.7	136
20	89.3	113.2	132.4	144.9
22	95.7	125.3	140.1	150.6
24	104.2	133.7	143.4	153.9
26	115.7	138.6	142.8	157.3
28	126.3	136.5	138.4	163.7
30	134.1	137.2	136.8	174.4
32	146.1	150.2	151.2	206.8
34	153.6	157.7	159	233.8
36	161.8	169.1	168.4	242.2
38	167.8	180.7	177.1	253.5
40	175.3	194.4	187.9	268.4
42	180.1	213.1	202.6	281.6
44	184.2	237.5	225.2	295.8
46	192.6	262.3	251.7	312.5
48	207.3	282.9	272.6	328.6
50	223.6	305.1	290.9	343.7
52	253.5	327.1	313.4	359.1
54	274.3	350.3	334.5	374.2
56	293.5	374.4	352.7	387.3
58	314.4	399.7	371.4	398.1
60	336.5	427.6	389.4	408.4

R10125-2
ILL. B12

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	22	23	24	25
TIME(MIN.)				
2	67.7	68.4	68.6	68.6
4	67.9	68.4	68.8	68.7
6	68.6	68.6	69.2	69
8	69.6	69	70	69.8
10	71.2	69.9	71.5	71.4
12	73	71.1	73.4	73.6
14	74.8	72.8	76.1	76.5
16	78.3	75.1	79.2	80.3
18	81.8	77.8	82.8	84.8
20	83.7	80.8	86.9	90.2
22	85.3	83.6	92.1	97.1
24	87	87.2	98.9	106.1
26	89.4	92.5	107.3	117.4
28	95.4	99.6	118.1	127.3
30	110.7	108.5	128.3	134
32	134.6	124.3	143.8	146.5
34	147.6	131.3	152.9	157.6
36	159.5	141 [illegible]	161.3	168.6
38	168.7	151.3	168.8	178.7
40	180 7	155.3	174.3	184.9
42	194.4	168.4	180.2	189.8
44	207.6	177.3	184.8	193.9
46	256.3	183.9	190.1	198.1
48	294.9	188.8	198.1	210.9
50	317.6	192.8	212.4	229.5
52	334.3	194 5	234.2	257.6
54	348.1	196.7	263.8	291.1
56	361.1	197.9	291.5	322.8
58	372 9	193 9	316.6	351.9
60	384 5	214 5	339.3	378.8

R10125-2
ILL. B11

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	34	35	36	37
TIME(MIN.)				
2	68.5	68.8	68.9	76.1
4	68.5	68.9	69.1	97.1
6	68.9	69.2	71.2	119.2
8	69.7	69.9	76.1	142
10	70.9	71.4	82.5	159.9
12	72.1	73.4	90.6	174.3
14	73.6	76.8	101	185
16	75.7	81.1	113.9	192.5
18	78.4	85.9	134.1	197.9
20	80.6	92.5	146.2	203.4
22	82.9	100.5	149.6	207.2
24	85.6	110	152.4	220.2
26	88.3	120.7	149.3	237.3
28	90.8	129	142.9	265.9
30	94.3	135.5	148.3	310.3
32	114.9	146.7	176	383.9
34	119.3	154.3	185.8	436.2
36	131.2	162.5	207.4	490.3
38	149.6	169.8	228.6	538.6
40	182.7	177.3	255.5	591.4
42	210.4	181.9	270.8	646.3
44	238	186.9	306.4	696.5
46	269.4	194.6	316.2	746.5
48	303.7	20[illegible]	311.9	773.4
50	336.5	22[illegible]	318.6	803.4
52	361.8	240.4	342.5	832.5
54	390.8	258.6	[illegible].3	860.5
56	413.8	272.7	[illegible]	887.2
58	448.5	297.3	394.[illegible]	913.6
60	480.8	326	414.5	938.2

R10125-2
ILL. B14

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	30	31	32	33
TIME(MIN.)				
2	68.9	69.2	69.6	69.2
4	69.2	69.6	69.6	69.4
6	70.6	71.2	69.8	70.1
8	73.4	74.8	70.4	71.1
10	77.8	80	71.4	72.6
12	83.4	86	73.2	74.3
14	91.6	92.3	75.4	76.1
16	101.9	98.1	78.3	78.1
18	120.5	103.9	81.7	80.1
20	134.2	109.1	85.3	82.2
22	140.8	114.7	89.4	84.6
24	145.2	120.9	97.9	87.2
26	144.8	125.7	114.9	90.2
28	141.9	132.1	113.8	93.9
30	141	139.9	112	98.7
32	159.1	163.9	138	112.2
34	169	179.3	146.4	121
36	179.4	198.2	157	133
38	194	220.9	168.1	148.9
40	213.9	246.3	186.4	167.4
42	240.2	271.9	198.8	186.2
44	265.6	295.4	209.9	204.3
46	285.3	313.5	222.6	225.2
48	305.2	331.9	243.3	248.1
50	324.7	351.1	257.7	268.4
52	347	368	275.8	295.2
54	368.2	383.8	303.2	324.7
56	387.4	401.8	329	355.4
58	405.7	399.9	360	383.9
60	425	434.5	400.9	409.3

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	81
TIME(MIN.)	
2	70.9
4	80.3
6	120.4
8	105.2
10	111.7
12	117.3
14	137.8
16	161.1
18	170.4
20	176.6
22	189.2
24	207.3
26	214.4
28	213.4
30	221.4
32	239.5
34	214
36	286.8
38	300.4
40	315
42	328.1
44	340.1
46	351.9
48	364.3
50	376.8
52	389.4
54	401.7
56	413.8
58	425.7
60	437.7

R10125-2
ILL., B16

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	38	39	40
TIME(MIN.)			
2	76.6	81.6	77.8
4	92.7	112	96.7
6	109.7	159.3	119.1
8	126.1	192.4	140.3
10	139.4	212	160
12	152.7	223.1	174.9
14	165.5	197.9	185.2
16	173.8	215.8	193.6
18	182.6	196.1	199.3
20	188	185.5	206.9
22	196.8	192.7	215.2
24	210	229.7	226.6
26	261.4	299.5	246.2
28	361.8	420.7	275.7
30	447.7	528	320
32	451.8	419.5	403.2
34	543.9	531.2	464.9
36	589	598.3	519.7
38	623.9	646	564.9
40	675.2	694.5	617.5
42	714.2	734.5	664.4
44	756.7	767.9	703.7
46	788.3	798	740.9
48	817	826.4	769.8
50	848.4	854.9	797.1
52	872.1	883.3	824.7
54	896.9	909.3	850.7
56	923.1	934.3	878.3
58	946.9	958 7	902.9
60	968.5	981.3	927.3

R10125-2
ILL. B15

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	86	87	88	89
TIME(MIN.)				
2	81.6	74	71.8	72.2
4	93.1	82.7	77.2	74.5
6	104.1	89	82.2	79.7
8	122.1	106.6	93.1	86.1
10	140	120.6	98.8	92.8
12	163.4	135.6	110	104.4
14	184.9	150.2	123.8	116
16	209.5	154.2	141.8	128.4
18	235.2	170.4	161.9	148.4
20	258.2	185.2	180.4	168.4
22	273	200.4	196	186.2
24	309.9	215.5	209.5	207.9
26	341.9	308.7	240.2	211.6
28	362	324.5	262.9	219.7
30	379.2	338.3	283.9	248.5
32	394.6	364.7	302.1	280.7
34	409.8	383	319.7	312.4
36	423.2	399.3	333.6	337.9
38	436.7	413.8	351.2	358.4
40	452.4	428	371.2	377.4
42	467.5	444.9	388	396.2
44	481.6	459.9	404.5	412.6
46	495.3	476.7	420	428.5
48	509.1	486.8	436.8	447.7
50	522.8	494.2	453.3	466.5
52	536.9	508.9	471.7	485.8
54	550.9	523.9	493.2	505.4
56	565.4	538.9	513.7	524.4
58	580.6	552.2	535.6	543.8
60	595	566.8	554.2	563.1

R10125-2
ILL. B18

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	82	83	84	85
TIME(MIN.)				
2	70	70.3	70	70.7
4	72.2	73.1	74.8	73
6	79.5	78.5	86.7	85.9
8	93.7	82.5	92	94.6
10	105.1	89.9	97.4	94.7
12	115.4	98	104.3	111.4
14	127.1	106	112.5	129.2
16	141.7	114.7	125.2	155.9
18	148.7	123	142.4	164
20	162	137.7	162.3	180.7
22	177.6	158.9	185.8	195.8
24	194.6	186 7	209.2	213.2
26	212	192	209.6	216.8
28	211.8	205.1	209.3	280.3
30	215.9	220	249.2	308.1
32	252.9	255.6	272.9	331.2
34	273.3	272.3	293.2	352.5
36	285.4	289.3	313 7	374.4
38	295.6	306.8	333.8	396.5
40	306 8	325 9	354.2	418.4
42	319.9	346.4	374.6	441.1
44	334	367.2	394.3	462.6
46	347.6	387.9	413.4	483.7
48	360	408.5	432.7	503.8
50	371.5	428.8	452.2	523.4
52	383 2	449.5	471.9	543.8
54	394.8	469.9	491.2	565.9
56	406.5	489.9	510	587.8
58	418.1	510	529	606.9
60	429.3	530	547.7	624.3

R10125-2
ILL. B17

3M COMPANY
MARCH 3, 1983

CHAN(NOS.)	94	95	96	97
TIME(MIN.)				
2	84.6	101.9	131.5	198.2
4	118.8	162.6	220.7	234.3
6	195	200.9	373.2	341
8	204	197.5	477.5	432.6
10	203.9	196.1	571.1	502.7
12	204.8	197.5	651.7	563.7
14	209.2	197.9	719.9	590.7
16	233.8	196	788.6	627.3
18	278.7	196.3	831.6	667.6
20	334.4	286.8	847.3	701.7
22	383.8	329.5	870	737.2
24	420.5	354.7	907.4	780.6
26	463.9	368.9	942.9	817.5
28	493.3	405.4	987.5	844.9
30	521	454.5	1032.4	865.3
32	548.4	502.4	1063.6	885.6
34	576.4	547.1	1089.2	898.8
36	603	585.9	1119.6	912.4
38	627.3	618.2	1147.1	933
40	651.6	646.9	1172.3	965.4
42	676.6	675.6	1192.5	986.8
44	704.9	704.5	1210.2	1002.6
46	734	734.2	1225.6	1019.3
48	767.4	765.5	1232.9	1041.8
50	813.8	802.1	1240.6	1077.7
52	885.7	853.4	1266.8	1147
54	990.6	924.5	1294.4	1237.2
56	1109.4	1016.3	1312.5	1292.9
58	1199.1	1105.6	1317.2	1307.7
60	1246.4	1171.2	1316.8	1308.4

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