TESTS FOR FIRE PROTECTION
FOR COMPLETE FIRE ENGULFMENT OF CABLE TRAYS
AND CONDUITS CONTAINING GROUPED ELECTRICAL CONDUCTORS

TEST REPORT ON KOAWOOL

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SYNOPSIS

A need has been expressed by various electrical utilities and architectural engineering firms for an insulation system to protect cables in the event of large exposure fires in nuclear power plants. Kaowool® blanket insulation with its very low thermal conductivity, was evaluated as an insulation material for the protection of cables in cable trays and conduits in complete fire engulfment.

Tests were performed on both unprotected and protected cable trays and conduits. The protective trays were wrapped with either 1" or 2" of Kaowool blanket insulation. The protected conduits were wrapped with either 2" of Kaowool blanket or 1½" of Kaotemp pipe insulation. Both IEEE-383 qualified and non-qualified cables were tested in the trays. Only IEEE-383 non-qualified cables were tested in the conduits. Solid bottom steel galvanized cable trays, aluminum open ladder cable trays, steel conduit and aluminum conduit were used in the test. The capability of each cable to carry current was monitored during the test using a circuit breaker - lighted display board. The cable trays and conduits were heated in a natural gas fired furnace according to the heating rate designated in ASTM E-119.

Without protection, the first cable to fail in the cable tray was an IEEE-383 non-qualified cable. It failed at eight (8) minutes into the test. The first qualified cable failed at ten (10) minutes into the test. The unqualified cable in the unprotected conduit failed at thirteen (13) minutes into the test. With 2" of Kaowool blanket protection wrapped around the cable tray and conduits, the cables were able to withstand fifty (50) to sixty (60) minutes of fire exposure before the first cable failed. The Kaowool blanket provided approximately

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equal protection for both IEEE-383 qualified and non-qualified cable. However, it was discovered during these tests that in order for the blanket to provide maximum protection, the butt joints between adjacent blankets had to be sealed tight. One inch of Kaowool blanket wrap around the cable trays (with an additional 4" wide, 1" thick strip around the butt joints) provided approximately forty (40) minutes of protection in a complete fire engulfment. One and one-half inches of Kaotemp pipe insulation around the conduit provided approximately forty-five (45) minutes of fire protection.

Within the limits of this investigation, the results indicated the following conclusions:

CONCLUSIONS

1. Cables in an unprotected solid bottom cable tray failed in approximately eight (8) minutes in a complete engulfment fire.
2. Wrapping solid bottom or open ladder cable trays and conduit with 2" of Kaowool blanket (with all butt joints tight) provides at least fifty (50) minutes of protection in complete engulfment fires.
3. Wrapping solid bottom cable trays with 1" of Kaowool blanket (4" overlap over butt joints) provides approximately forty (40) minutes of protection in complete engulfment fires.
4. Wrapping conduit with 1½" of Kaotemp pipe insulation (tight butt joints) provides approximately 45 minutes of protection in complete engulfment fires.
5. Loose or open butt joints in insulation may lead to early cable failure in engulfment fires.

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6. The Kaowool blanket wrap provides protection for both IEEE-383 qualified and non-qualified cables.

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INTRODUCTION

With the recent fire at the Browns Ferry Nuclear Power Plant, there has been a great deal of interest in protecting electrical cables in case of a fire. In some areas of older and more recently built nuclear power plants, cables of redundant electrical systems, which are necessary for the safe shutdown of the reactor, are in close proximity. If a fire should occur in one of these areas, both electrical systems could be destroyed before the fire is extinguished and control of the reactor may be lost. Therefore, fire protection for redundant cable systems, which are essential for the safe shutdown of the reactor, is needed when they are in close proximity. Using the primary means of extinguishing fires such as sprinkler systems, fire brigades, etc., it is anticipated that a typical fire can be extinguished within thirty (30) minutes. This test was devised to determine the amount of Kaowool® insulation required to provide thirty (30) minutes of protection for cables in a complete fire engulfment.

MATERIALS & EQUIPMENT

The materials used in these tests are shown in Tables I and II. The fire tests were performed in a catenary type furnace, 36" deep and 36" wide. The furnace is shown in Figure 1. The furnace contained two natural gas burners capable of delivering 1.25 million BTU per hour per burner. The furnace was controlled by a Type B thermocouple connected to a CAT controller.* The heating rate in the furnace was programmed** in accordance with the heating

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* Leeds and Northrup CAT Series 60 Controller

** Leeds and Northrup Trendtrak Programmer

MATERIALS & EQUIPMENT - Continued

rate specified in ASTM E-119 and recorded* throughout the test. Eight Type K thermocouples connected to a multipoint recorder** were used to monitor the temperatures in the cable tray and conduit.

In order to monitor the capability of each cable to carry current during the test, a circuit breaker and light display board was constructed. An electrical schematic diagram of the circuit breaker and light board for Test No. 1 is shown in Figure 2. A diagram of the display board used in Test Nos. 2 through 4 is shown in Figure 3. Photographs of the display board are shown in Figures 4 and 5. Two light bulbs were used to monitor each circuit in case one bulb should burn out during the test. The circuit breaker - light display board was capable of monitoring 20 circuits in the cable tray and conduit. The cables were connected to the display board in such a way that if a cable should short against another cable or against the cable tray or conduit, the circuit breaker would open and the lights for that circuit would go out. In addition, if a cable itself should open, the circuit for that cable would be broken and again the lights for that circuit would go out.

EXPERIMENTAL PROCEDURE

Five fire protection tests were performed. The cable tray and conduit loadings for each test are shown in Table III. The cables were laid in the tray and conduit and looped at one end so that all cable terminations were at the other end. This was done so that the cables could be easily connected to a terminal strip which was connected to the circuit breaker - light display

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* Leeds and Northrup Speedomax W Recorder

** Barber Coleman - Model No. 2061-25030

EXPERIMENTAL PROCEDURE - Continued

board. This is shown in the photograph in Figure 6. The cables were placed in the tray in an orderly fashion so that the approximate cable location corresponding to each circuit on the light board would be known. A schematic diagram of a typical layout of the cables with respect to the circuit numbers is shown in Figure 7.

In Fire Protection Test No. 1 a solid bottom, steel, galvanized tray and steel conduit were used. After loading the tray, thermocouples were attached to the cables in various locations to monitor the temperature rise of the cables during the fire test. A schematic diagram of the thermocouple location for Test No. 1 is shown in Figure 8. Thermocouple 8 was attached to the cable in the conduit. A photograph of the thermocouples in the cable tray for Test No. 1 is shown in Figure 9. In this first test no insulation was used to protect the cables in the cable tray or conduit. The cable tray and conduit were installed in the furnace so that their centers were in the center of the furnace. The cable tray was raised approximately two inches so that the flames from the burners would be along the side and bottom of the cable tray. The conduit was suspended above the cable tray. A photograph of the cable tray and conduit after installation is shown in Figure 10. The ends of the furnace and conduit were filled with Kaowool blanket. In order to seal around each cable in the tray, insulating firebrick dust was poured around the cables. Photographs of the sealed furnace and conduit are shown in Figures 11 and 12. The thermocouple for controlling the heating rate in the furnace was inserted through the Kaowool in the back of the furnace. (See Figure 12). In this test as well as all subsequent tests the furnace was fired according to the

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EXPERIMENTAL PROCEDURE - Continued

heating rate designated in ASTM E-119.

Fire Protection Test No. 2 was similar to Test No. 1. The same types of steel cable tray and conduit were used in this test as were used in Test No. 1. The cable loading was the same except the cable B1-9 was changed from 440 volts/3 phase to 110 volts/3 phase (See Figure 3). The thermocouple layout was also modified as shown in Figure 13. Thermocouple 5 was moved over to the side of the cable tray to monitor its temperature. The major difference between this test and Test No. 1 was that both the cable tray and conduit were wrapped with Kaowool insulating blanket. For the cable tray 1" of Kaowool blanket was placed on top of the cables. Two - 1" thick blankets were then wrapped around the cable tray with 3" overlap joints where the blankets met. A schematic diagram of the insulated cable tray is shown in Figure 14. The interior blanket wrap was held on with filament tape, and the exterior blanket was held on with steel brackets. Along the length of the cable tray, where one blanket ended and another began, the blankets were butted together. The location of the butt joints and brackets with respect to position in the furnace is shown in Figure 15. The butt joints for the inner blanket and outer blanket were separated by approximately 18" and the brackets were spaced approximately 24". The insulation on the cable tray extended 12" beyond the end of the furnace and the cable tray itself extended 21" beyond the end of the insulation. Thermocouple 7 (See Figure 13) was placed outside the cable tray on top of the blanket insulation.

The conduit was also wrapped with two 1" thick Kaowool blankets. A schematic diagram of the insulated conduit is shown in Figure 16. The interior

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EXPERIMENTAL PROCEDURE - Continued

blanket was held on using filament tape. The outer blanket was held on using banding material. Two banding materials were tested, one was common carbon steel, the other was stainless steel. The bands were placed 2" on either side of the butt joints of the exterior blanket. The butt joint of the interior blanket was 8" from the butt joint of the exterior blanket. The inner blanket extended 12" outside the furnace and the outer wrap extended 2" outside the furnace. The conduit extended 21" beyond the end of the interior blanket wrap. A photograph of the insulated conduit for Test No. 2 is shown in Figure 17. A photograph of the insulated cable tray after insertion into the furnace is shown in Figure 18. The same method of sealing the ends of the cable tray and conduit and sealing around the entrance to the furnace was used in this test as was used in Test No. 1. A photograph of the insulated cable tray and conduit before testing is shown in Figure 19.

Test No. 3A was the same as Test No. 2 except an aluminum, open ladder cable tray and conduit were used instead of the steel cable tray and conduit. Test No. 3B was the same as Test No. 3A except the galvanized steel brackets, used to hold the outer blanket insulation on the cable tray, were relocated. The brackets were placed 3" on each side of the butt joint on the outer blanket wrap. A photograph showing the location of the brackets for Test No. 3B is shown in Figure 20.

Test No. 4 was similar to Test No. 2 except 1" of Kaowool blanket wrap was used on the steel cable tray rather than 2". One inch of Kaowool blanket was laid on top of the cables in the cable tray. Then 1" of blanket was

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EXPERIMENTAL PROCEDURE - Continued

wrapped around the cable tray with a 3" overlap. Along the length of the cable tray where two blanket ends met, a 4" wide strip of Kaowool blanket was wrapped around the butt joint. The steel bracket was placed over the 4" wide strip. This wrapping technique is shown in the photograph in Figure 21. Filament tape was used temporarily to hold the blanket insulation in place while the brackets were clamped on. The location of the butt joint, bracket and blanket strip in the furnace is shown in Figure 22. The butt joint was located in the center of the furnace. The insulation extended 12" outside the furnace and the cable tray extended 21" beyond the end of the insulation. The thermocouple arrangement in the cable tray was also modified slightly as shown in Figure 23. The conduit was protected with 1½" of Kaotemp pipe insulation. The butt joint between the two pieces of the pipe insulation was located in the center of the furnace. A schematic diagram of the insulated conduit in the furnace is shown in Figure 24. Two-10" wide strips of Kaowool blanket were placed on either end of the Kaotemp pipe insulation so that the insulation would extend 12" outside the furnace. The Kaotemp pipe insulation was held on with stainless steel wire and the Kaowool blanket was held on with filament tape. A photograph of the insulated conduit for Test No. 4 is shown in Figure 25.

RESULTS AND DISCUSSION

The sequence of cable failures which occurred during Test No. 1 is shown in Table IV. The first cable to fail was an IEEE-383 non-qualified cable in the tray. It failed at eight (8) minutes into the test. The second cable failed at ten (10) minutes into the test. It was an IEEE-383 qualified cable located on

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RESULTS AND DISCUSSION - Continued

the bottom of the tray near the side. The third cable to fail was the power cable carrying 440 volts. When this cable failed, there was a power surge through the circuit breaker panel and light board. The power to all cables and the light board was turned off for approximately one minute until the 440 volt power was turned off. When the power was turned back on, several cables had apparently failed. The cables which failed during this power outage are marked with an asterisk in the table. The test was terminated after thirty (30) minutes.

The temperature rise as indicated by the thermocouples in the cable tray and conduit is shown in Figure 26. The temperature increase in various areas of the cable tray was quite erratic. This was probably caused by the thermocouples being near burning cables which would produce large temperature fluctuations. In addition, there were some oscillations in the furnace controller during the early stages of firing. The thermocouples may also have come in contact with 110 volts during the test, which could produce very erratic behavior. In general, Thermocouples 5 through 7, on top of the cable tray increased in temperature fairly rapidly. Thermocouples 1 through 4 increased in temperature more slowly since they were protected by the cables on top. Thermocouple 8 in the conduit increased in temperature slowly at first but, after seven (7) minutes into the test, began to increase very rapidly. Following the test the burned cables in the cable trays were removed and inspected. A photograph of the cables after the test is shown in Figure 27.

The sequence of cable failures in Test No. 2 is shown in Table V. In this test the steel solid bottom cable tray and steel conduit were wrapped with 2" of Kaowool. The first cable failure occurred at fifty-one (51) minutes into

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RESULTS AND DISCUSSION - Continued

the test. The cable was the IEEE-383-qualified cable located in the bottom of the cable tray next to the side. The cable in the conduit, which was a non-qualified cable, failed at one (1) hour and five (5) minutes into the test. The first non-qualified cable in the tray to fail was #15 which failed at one (1) hour and ten (10) minutes into the test. The test was terminated after one (1) hour and seventeen (17) minutes.

The temperature rise in the cable tray and conduit during Test No. 2 is shown in Figure 28. Thermocouples 2 and 4 did not function during this test. Thermocouple 7 malfunctioned during the early part of the test but it was repaired and performed properly after 27 minutes into the test. The results indicate that the insulation works very effectively in retarding the heat flow into the cable tray and conduit. The control thermocouple and Thermocouple 7 (located outside the insulation) indicate that the furnace temperature followed fairly closely the ASTM E-119 curve. The appearance of the cables in the cable tray after the test is shown in Figure 29. Unfortunately this tray was removed from the furnace and opened soon after the test was over. Since there was considerable heat storage in the tray, some of the insulation caught fire when the Kaowool was removed. Therefore the cables in this tray were actually exposed to fire for a longer period of time than one (1) hour and seventeen (17) minutes. The steel brackets around the cable tray and the regular carbon steel and stainless steel banding material around the conduit insulation performed satisfactorily during the test.

Test No. 3A was similar to Test No. 2 except an aluminum open ladder cable

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RESULTS AND DISCUSSION - Continued

tray and an aluminum conduit were used instead of the steel solid bottom tray and conduit. The tray was very weak and flexed considerably during installation into the furnace. It was anticipated that the results would be similar to Test No. 2; however, as shown in Table VI the cables failed very quickly. The first cable failure occurred after eleven (11) minutes into the test. Most of the cables were IEEE-383 qualified. None of the non-qualified cables failed. The test was terminated at thirty (30) minutes into the test. The cable in the conduit did not fail during the test.

The temperature rise in the cable tray was very rapid as indicated by Thermocouples 3 through 6 in the graph shown in Figure 30. However Thermocouples 1 and 2 in the back of the cable tray and Thermocouple 8 in the conduit rose very slowly. The cable tray was pulled out of the furnace and the Kaowool blanket removed to determine the cause of the premature failure. When the tray was removed from the furnace it was noted that the butt joints on the outer layer of Kaowool had opened. This is shown photographically in Figure 31. When the outer layer of Kaowool was removed as shown in Figure 32, it appeared that the inner butt joint had also opened. The inner blanket was discolored with a dark residue probably from the products of combustion of the cables. When the inner insulation was removed (See Figure 33), it was obvious that the cable tray at the butt joint had burned through. These results indicate that probably during installation the butt joints between the Kaowool blankets were opened. During the test the flame from the furnace burners moved through the butt joint on the outer blankets along the sides and bottom of the blanket and then through the inner butt joint and into the cable tray. The direct flames

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RESULTS AND DISCUSSION - Continued

on the bottom and sides of the cable tray caused the premature failure of these cables. Figure 34 shows that the cables in the cable tray were badly burned after only thirty (30) minutes of exposure.

Test No. 3B was essentially a repeat of Test No. 3A except the brackets holding the blanket installation were placed within 3 inches on each side of the outer butt joints. This was done to keep the butt joints sealed tight. The results, shown in Table VII are greatly improved over the results in Test No. 3A. The first cable failure occurred at one (1) hour and one (1) minute into the test. This cable was the IEEE-383 qualified cable located in the bottom of the cable tray near the side. The first non-qualified cable failed at one (1) hour and two (2) minutes into the test. The test was terminated after one (1) hour and thirteen (13) minutes. The conduit did not fail before the test was terminated.

The temperature rise in the cable tray is shown in Figure 35. Again the Kaowool blanket retarded the heat transfer into the tray. This resulted in a slow temperature rise in the tray. Thermocouple 5 which was placed against the side of the tray indicated the highest temperature of all of the thermocouples inside the tray. Following the test the cable tray was removed from the furnace and the Kaowool blanket unwrapped. Figure 36 shows the innerwrap of Kaowool blanket at the butt joint. The joint was still tight and there was essentially no residue from the burning of the cables. The condition of the cables in the cable tray after the test is shown in Figure 37. Since the blanket prevented oxygen from reaching the cables they charred rather than burned. The IEEE-383 qualified cables were charred white, the non-qualified cables were charred black.

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RESULTS AND DISCUSSION - Continued

Since the initial purpose of this test was to provide thirty (30) minutes of protection, further testing was done using only 1" of Kaowool blanket wrapped around the cable tray and 1½" of Kaotemp pipe insulation on the conduit. The sequence of cable failures for this test is shown in Table VIII. The first cable failure occurred at forty (40) minutes into the test. Again this cable was the IEEE-383 qualified cable located in the bottom of the tray near the side. The first non-qualified cable in the tray failed at fifty-two (52) minutes into the test. The cable in the conduit failed at forty-eight (48) minutes into the test. The test was terminated after one (1) hour.

The temperature rise in the tray and conduit is shown in Figure 38. The highest temperature in the tray was indicated by Thermocouple 5 which was located on the side of the tray. The thermocouple in the conduit was indicating somewhat higher temperajures than the thermocouples attached to the cables in the tray. The appearance of the cables in the cable tray after Test No. 4 is shown in Figure 39.

CONCLUSIONS

Within the limits of this investigation, the results indicate the following conclusions:

1. Cables in an unprotected steel, solid bottom cable tray fail in approximately eight (8) minutes in a complete engulfment fire.
2. Wrapping solid bottom or open ladder cable trays and conduit with 2" of Kaowool blanket (with all butt joints tight) provides approximately fifty (50) minutes of protection in complete engulfment fires.

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CONCLUSIONS - Continued

3. Wrapping solid bottom cable trays with 1" of Kaowool blanket (4" overlap over butt joints) provides approximately forth (40) minutes of protection in complete engulfment fires.

4. Wrapping conduit with 1½" Kaotemp pipe insulation (tight butt joints) provides approximately forty five (45) minutes of protection in complete engulfment fires.

5. Loose or open butt butt joints in insulation may lead to early cable failure in engulfment fires.

6. The Kaowool blanket wrap provides protection for both IEEE-383 qualified and non-qualified cable.

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TABLE I

LIST OF CABLE MATERIALS FOR FIRE PROTECTION TESTING FOR COMPLETE FIRE ENGULFMENT OF CABLE TRAYS AND CONDUITS, CONTAINING GROUPED ELECTRICAL CONDUCTORS

Cable Code #	Cable Size: Number of Conductors	Cable Size: Wire Size	Type of Insulation	Supplier
B-19	1	# 9	IEEE-383 Qualified	Okonite Co., Ramsey, N. J.
C-19	7	#14	" " "	" " " "
C-22	19	#12	" " "	" " " "
C-23	2	#12	" " "	" " " "
C-24	4	#12	" " "	" " " "
C-25	7	#12	" " "	" " " "
C-26	9	#12	" " "	" " " "
C-27	12	#12	" " "	" " " "
C-33	4	# 6	" " "	" " " "
M7-9	7	# 9	IEEE-383 Non-Qualified	" " " "

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TABLE II

LIST OF NON-CABLE MATERIALS FOR FIRE PROTECTION TESTING FOR COMPLETE FIRE ENGULFMENT OF CABLE TRAYS AND CONDUITS CONTAINING GROUPED ELECTRICAL CONDUCTORS

Material	Description	
Cable Tray	Aluminum, Open Ladder, 144" L x 18" W x 4" D	P-W Industrials, Philadelphia, Pa.
Cable Tray	Steel Solid Bottom, 144" x 18" x 4"	P-W Industrials, Philadelphia, Pa.
Conduit	Steel, 4" Diameter, 10' Long	P-W Industrials, Philadelphia, Pa.
Conduit	Aluminum, 4" Diameter, 10' Long	P-W Industrials, Philadelphia, Pa.
Kaowool Blanket	1" Thick, 8 lb/ft.^{3}, Needled	Babcock & Wilcox Co., Augusta, Ga.
Kaotemp Pipe Insulation	1½" Thick, 4" Pipe Size	Babcock & Wilcox Co., Augusta, Ga.
Insulating Firebrick Dust	-------------	Babcock & Wilcox Co., Augusta, Ga.

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TABLE III

CABLE TRAY AND CONDUIT LOADINGS FOR FIRE PROTECTION TESTS NO. 1 THROUGH 4

Circuit Number	Test #1 Cable Code #	Test #1 Number of Lengths	Test #2 Cable Code #	Test #2 Number of Lengths	Test #3A Cable Code #	Test #3A Number of Lengths	Test #3B Cable Code #	Test #3B Number of Lengths	Test #4 Cable Code #	Test #4 Number of Lengths
1	C-19	2	C-19	2	C-19	[illegible]	C-19	2	[illegible]	1
2	C-22	2	C-22	2	C-23	[illegible]	C-23	4	[illegible]	2
3	C-23	4	C-23	4	C-24	[illegible]	C-24	2	[illegible]	2
4	C-24	2	C-24	2	C-24	[illegible]	C-24	2	[illegible]	2
5	C-24	2	C-24	2	C-24	[illegible]	C-24	2	[illegible]	2
6	C-24	2	C-24	2	C-25	[illegible]	C-25	2	[illegible]	2
7	C-25	2	C-25	2	C-25	[illegible]	C-25	2	[illegible]	2
8	C-25	2	C-25	2	C-26	[illegible]	C-26	2	[illegible]	2
9	C-26	2	C-26	2	C-27	[illegible]	C-27	2	[illegible]	2
10	C-27	2	C-27	2	C-33	[illegible]	C-33	2	[illegible]	2
11	C-33	2	C-33	2	C-33	[illegible]	C-33	2	[illegible]	2
12	C-33	2	C-33	2	C-33	[illegible]	C-33	2	[illegible]	2
13	C-33	2	C-33	2	C-33	[illegible]	C-33	2	[illegible]	2
14	C-33	2	C-33	2	M7-9	[illegible]	M7-9	2	[illegible]	2
15	M7-9	2	M7-9	2	M7-9	[illegible]	M7-9	2	[illegible]	2
16	M7-9	2	M7-9	2	M7-9	[illegible]	M7-9	4	[illegible]	2
17 (Conduit)	M7-9	2	M7-9	2	M7-9	[illegible]	M7-9	2	M7-9	2
18	B1-9 (Phase 1)	2	B1-9 (Phase 1)	2	B1-9 (Phase 1)	[illegible]	B1-9 (Phase 1)	2	B1-9 (Phase 1)	2
19	B1-9 (Phase 2)	2	B1-9 (Phase 2)	2	B1-9 (Phase 2)	[illegible]	B1-9 (Phase 2)	2	B1-9 (Phase 2)	2
20	B1-9 (Phase 3)	2	B1-9 (Phase 3)	2	B1-9 (Phase 3)	[illegible]	B1-9 (Phase 3)	2	B1-9 (Phase 3)	2
% Tray Fill	33%		33%		33%		35%		34%	

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TABLE IV

CABLE FAILURE SEQUENCE IN TEST NO. 1 - UNPROTECTED STEEL, SOLID BOTTOM CABLE TRAY AND STEEL CONDUIT

	Time (Hr/Min)	Failed Circuit Number	Cable Location	Cable Insulation
	0:00	Test Start	---	---
	0:08	15	Tray	IEEE-383 Non-Qualified
	0:10	1	Tray	Qualified
	0:12	18, 19, 20 (440 V)	Tray	Qualified
	0:13*	3	Tray	Qualified
	0:13*	4	Tray	Qualified
	0:13*	5	Tray	Qualified
	0:13*	6	Tray	Qualified
	0:13*	7	Tray	Qualified
	0:13*	8	Tray	Qualified
	0:13*	16	Tray	Non-Qualified
	0:13*	17	Conduit	Non-Qualified
	0:15	9	Tray	Qualified
	0:20	13	Tray	Qualified
	0:21	2	Tray	Qualified
	0:22	10	Tray	Qualified
	0:28	14	Tray	Qualified
FAIL	0:30	Test Terminated	----	----
PASS				

* Failed during 440V failure and shutdown

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TABLE V

CABLE FAILURE SEQUENCE IN TEST NO. 2 - STEEL SOLID BOTTOM CABLE TRAY AND STEEL CONDUIT WRAPPED WITH 2" KAOWOOL BLANKET (~~LOOSE~~ Tight BUTT JOINTS)

	Time (Hr/Min)	Failed Circuit Number	Cable Location	Cable Insulation
	0:00	Test Start	---	---
FAIL	0:30	---	---	---
PASS	0:51	1	Tray	IEEE-383 Qualified
	0:56	20	Tray	Qualified
	0:57	11	Tray	Qualified
	0:59	3	Tray	Qualified
	0:59	19	Tray	Qualified
	1:01	18	Tray	Qualified
	1:05	17	Conduit	Non-Qualified
	1:07	5	Tray	Qualified
	1:10	4	Tray	Qualified
	1:10	2	Tray	Qualified
	1:10	8	Tray	Qualified
	1:10	6	Tray	Qualified
	1:10	15	Tray	Non-Qualified
	1:10	7	Tray	Qualified
	1:15	12	Tray	Qualified
	1:17	Test Terminated	----	----

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TABLE VI

CABLE FAILURE SEQUENCE IN TEST NO. 3A - ALUMINUM OPEN LADDER CABLE TRAY AND ALUMINUM CONDUIT WRAPPED WITH 2" KAOWOOL BLANKET (~~LOOSE~~ BUTT JOINTS)

LOOSE

	Time (Hr/Min)	Failed Circuit Number	Cable Location	Cable Insulation
	0:00	Test Start	----	IEEE-383 Qualified
	0:11	2	Tray	Qualified
	0:12	5	Tray	Qualified
	0:12	7	Tray	Qualified
	0:13	8	Tray	Qualified
	0:14	6	Tray	Qualified
	0:14	9	Tray	Qualified
	0:15	3	Tray	Qualified
	0:15	11	Tray	Qualified
	0:18	1	Tray	Qualified
	0:18	4	Tray	Qualified
	0:22	10	Tray	Qualified
	0:26	14	Tray	Qualified
FAIL	0:30	Test Terminated	----	----
PASS				

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TABLE VII

CABLE FAILURE SEQUENCE IN TEST NO. 3B - ALUMINUM OPEN LADDER CABLE TRAY AND ALUMINUM CONDUIT WRAPPED WITH 2" KAOWOOL BLANKET (TIGHT BUTT JOINTS)

	Time (Hr/Min)	Failed Circuit Number	Cable Location	Cable Insulation
FAIL	0:00	Test Start	---	---
PASS	1:01	1	Tray	IEEE-383 Qualified
	1:02	16	Tray	Non-Qualified
	1:05	19	Tray	Qualified
	1:06	2	Tray	Qualified
	1:08	20	Tray	Qualified
	1:09	5	Tray	Qualified
	1:09	3	Tray	Qualified
	1:10	4	Tray	Qualified
	1:11	18	Tray	Qualified
	1:13	Test Terminated	----	----

CEC/ps

TABLE VIII

CABLE FAILURE SEQUENCE IN TEST NO. 4 - STEEL SOLID BOTTOM TRAY WRAPPED WITH 1" KAOWOOL BLANKET (4" OVERLAP STRIP OVER BUTT JOINT) AND STEEL CONDUIT WITH 1½" KAOTEMP PIPE INSULATION

	Time (Hr/Min)	Failure Circuit Number	Cable Location	Cable Insulation
FAIL	0:00	Test Start	---	---
PASS	0:40	1	Tray	IEEE-383 Qualified
	0:46	20	Tray	Qualified
	0:46	19	Tray	Qualified
	0:48	17	Conduit	Non-Qualified
	0:50	9	Tray	Qualified
	0:52	15	Tray	Non-Qualified
	0:53	16	Tray	Non-Qualified
	0:53	2	Tray	Qualified
	0:54	18	Tray	Qualified
	0:58	6	Tray	Qualified
	0:58	4	Tray	Qualified
	0:59	3	Tray	Qualified
	0:59	14	Tray	Non-Qualified
	1:00	Test Terminated	----	----

CEC/ps

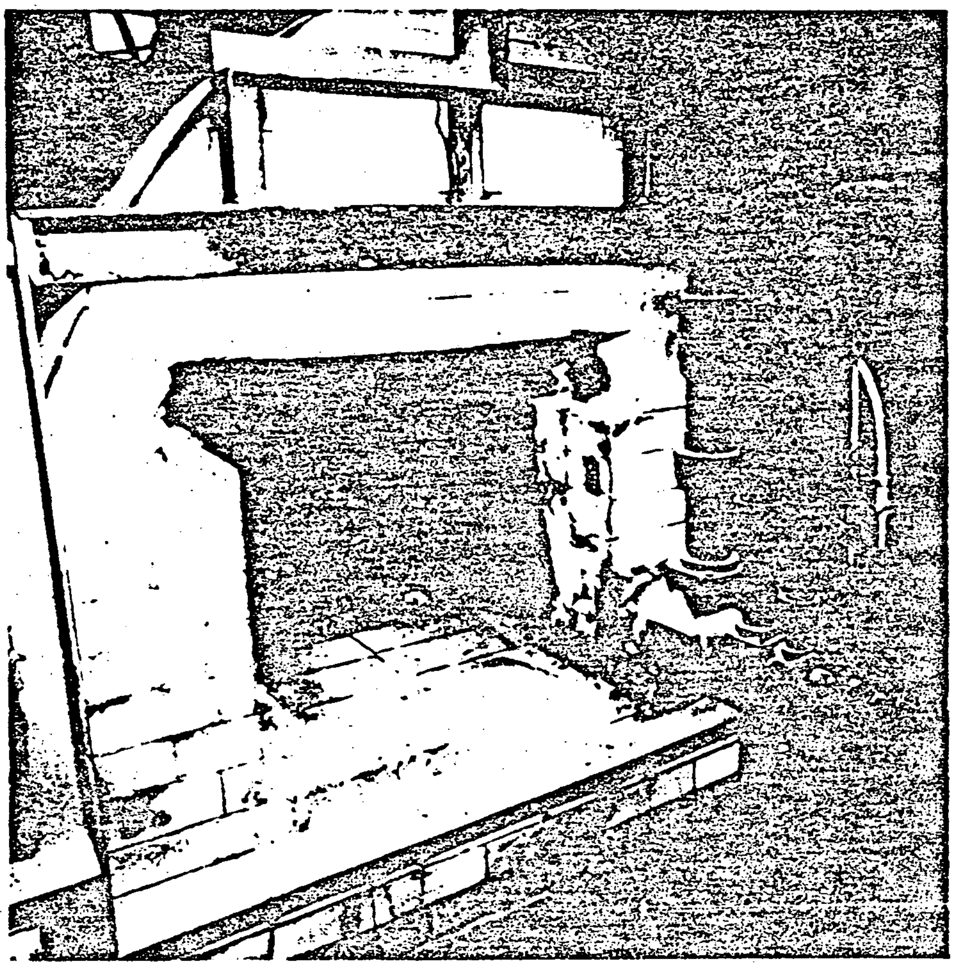
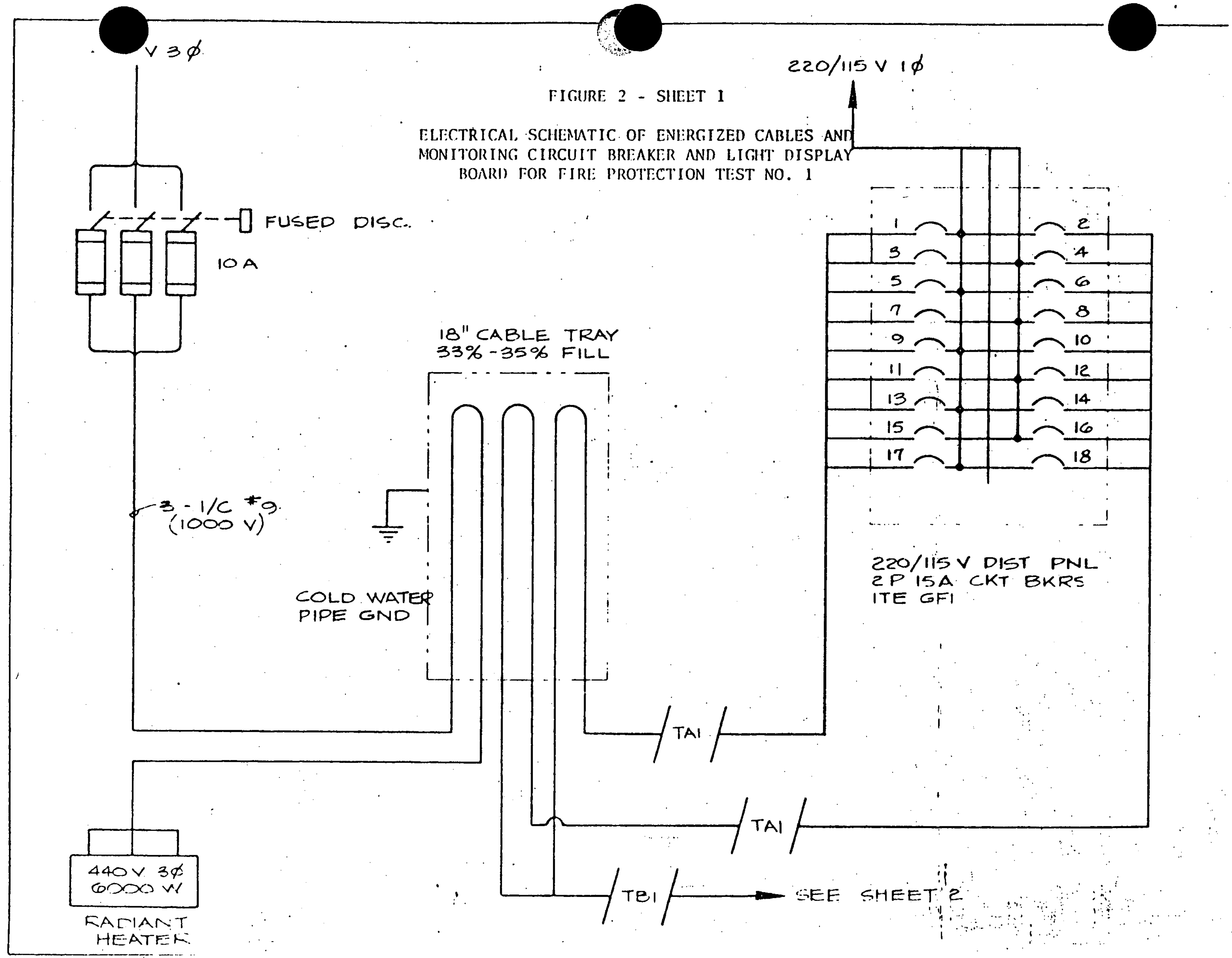


FIGURE 1

CATENARY FURNACE USED IN FIRE TESTS FOR FIRE PROTECTION OF CABLES IN CABLE TRAYS AND CONDUITS

FIGURE 2 - SHEET 1

ELECTRICAL SCHEMATIC OF ENERGIZED CABLES AND MONITORING CIRCUIT BREAKER AND LIGHT DISPLAY BOARD FOR FIRE PROTECTION TEST NO. 1



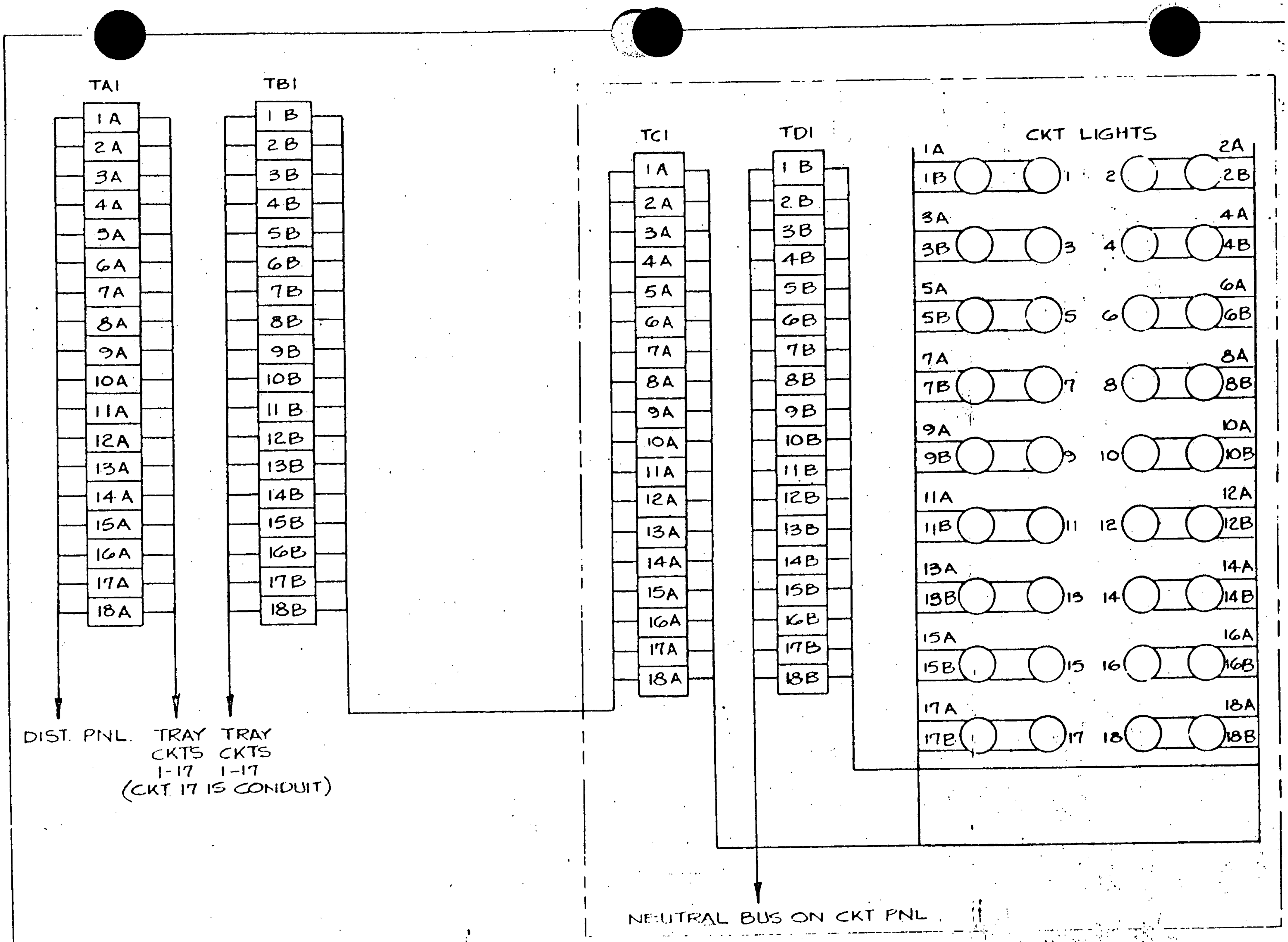
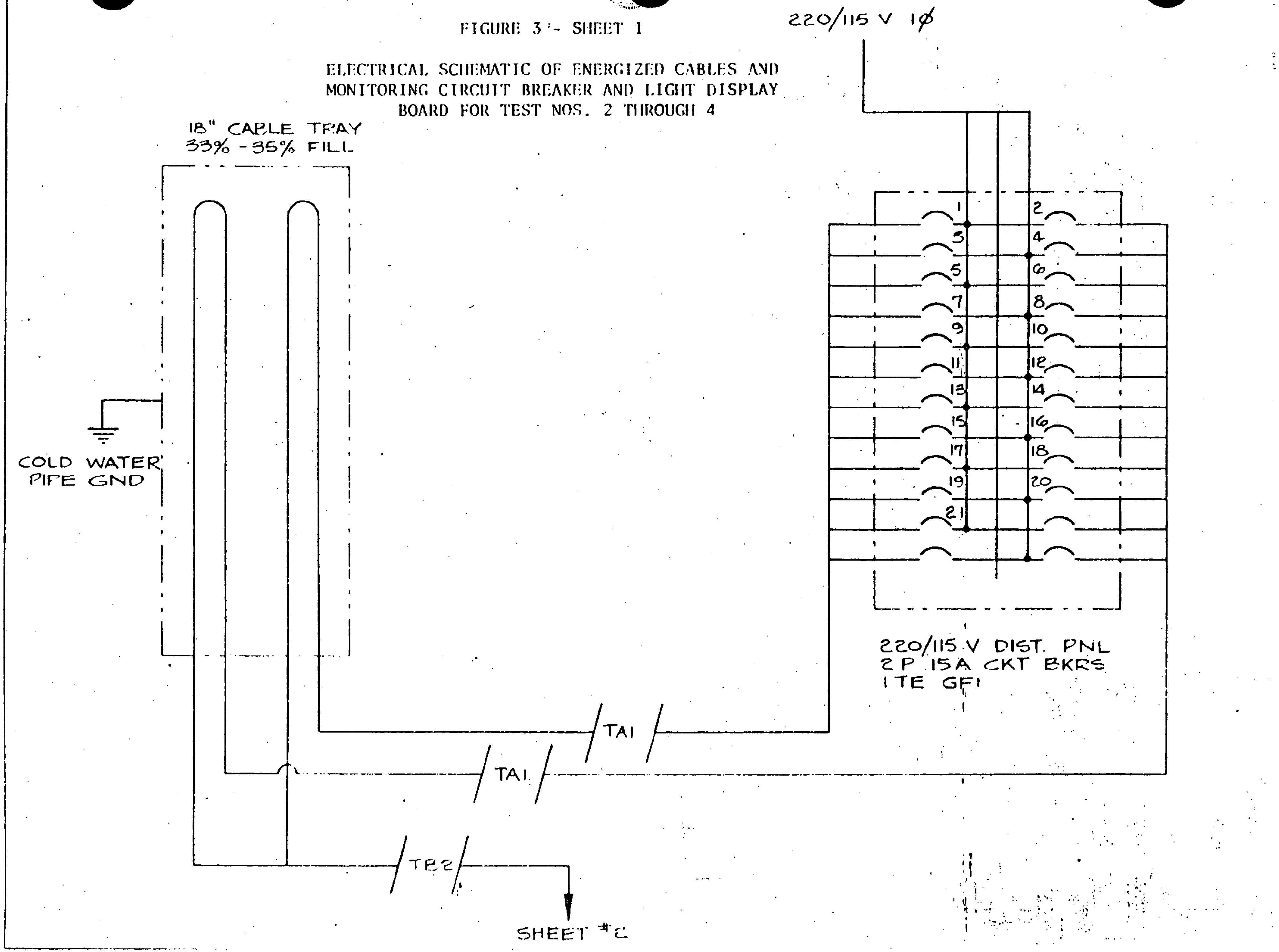


FIGURE 2 - SHEET 2

FIGURE 3 - SHEET 1

ELECTRICAL SCHEMATIC OF ENERGIZED CABLES AND MONITORING CIRCUIT BREAKER AND LIGHT DISPLAY BOARD FOR TEST NOS. 2 THROUGH 4



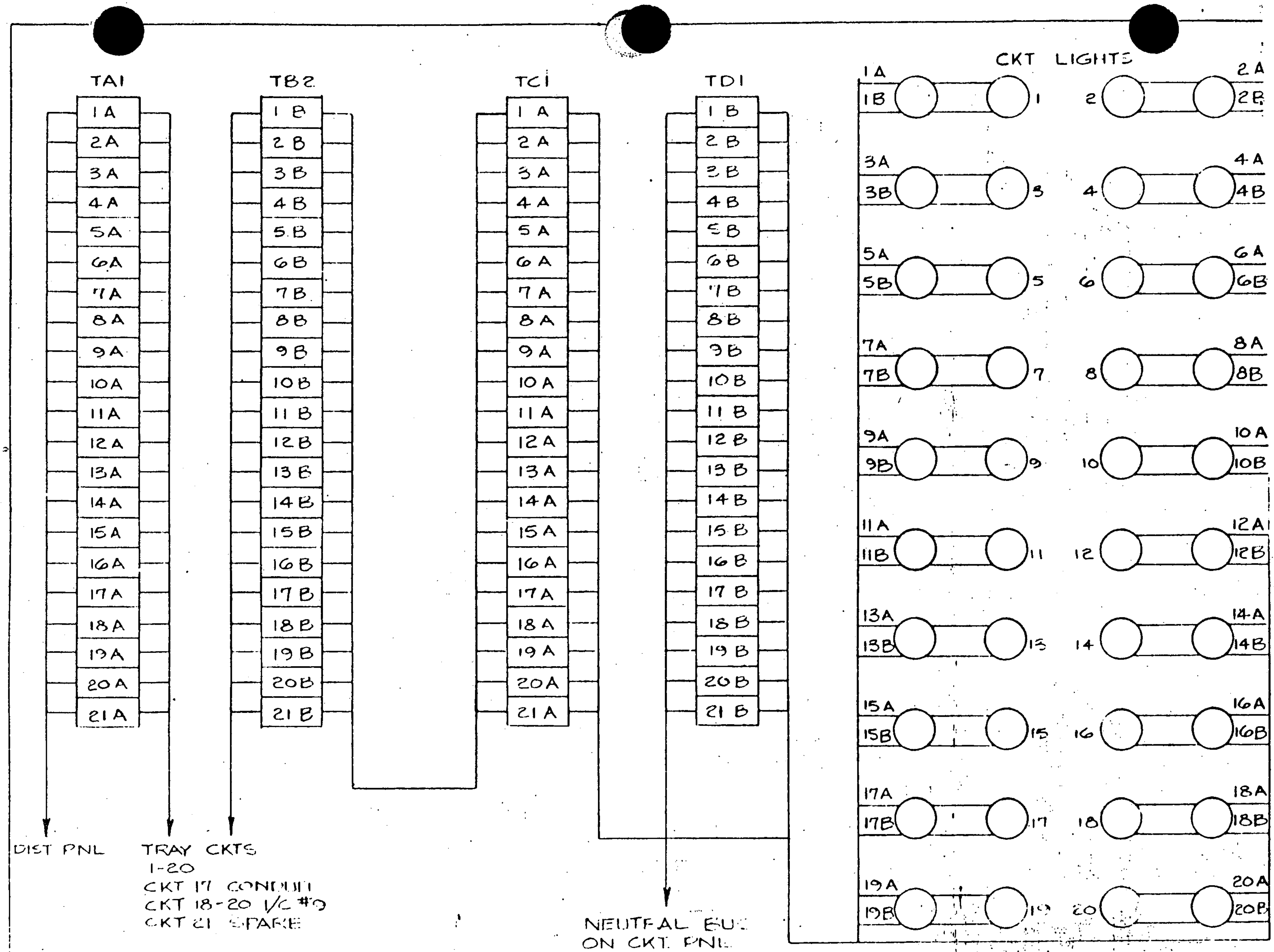


FIGURE 3 - SHEET 2

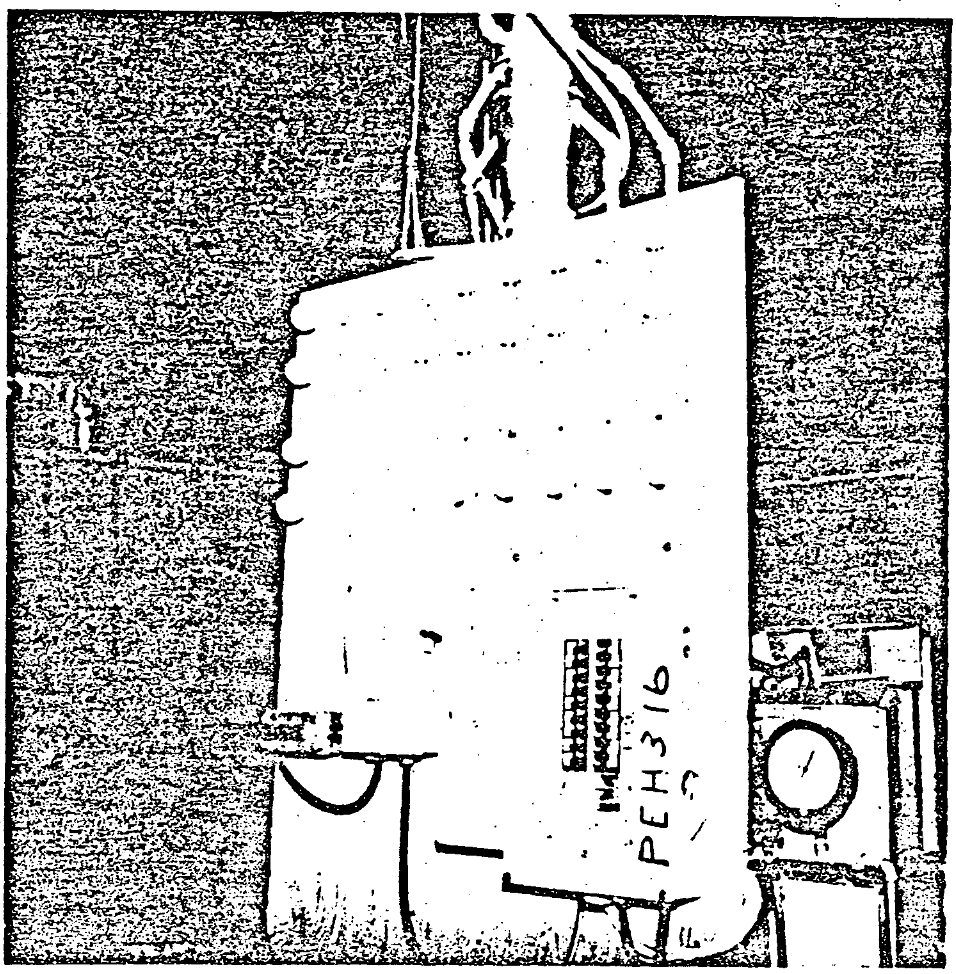


FIGURE 4

CIRCUIT BREAKER AND LIGHT BOARD FOR MONITORING CABLE CIRCUITS IN FIRE PROTECTION TEST NO. 1

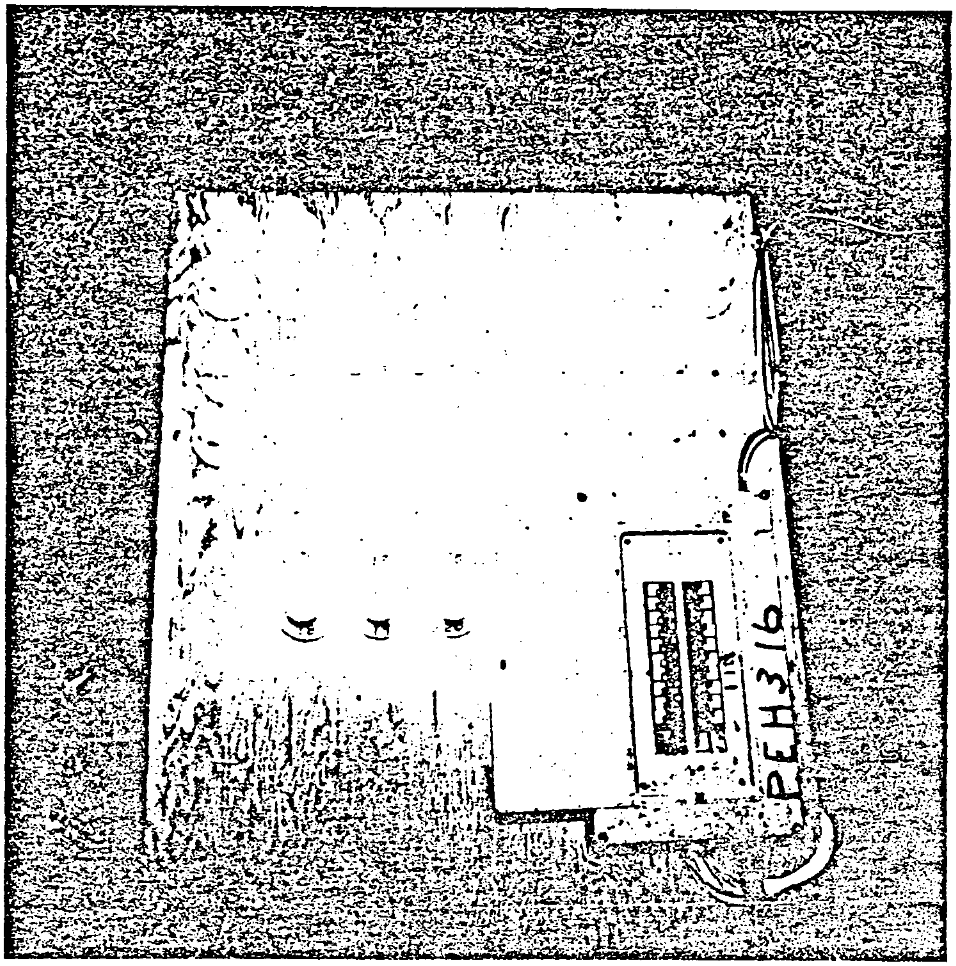


FIGURE 5

CIRCUIT BREAKER AND LIGHT BOARD FOR MONITORING CABLE CIRCUITS IN FIRE PROTECTION TESTS NOS. 2 THROUGH 4

FIGURE 6

CABLE TRAY FILL FOR FIRE PROTECTION TEST NO. 1 SHOWING LOOPING OF CABLES AT FAR END AND CONNECTIONS TO TERMINAL STRIP AT NEAR END

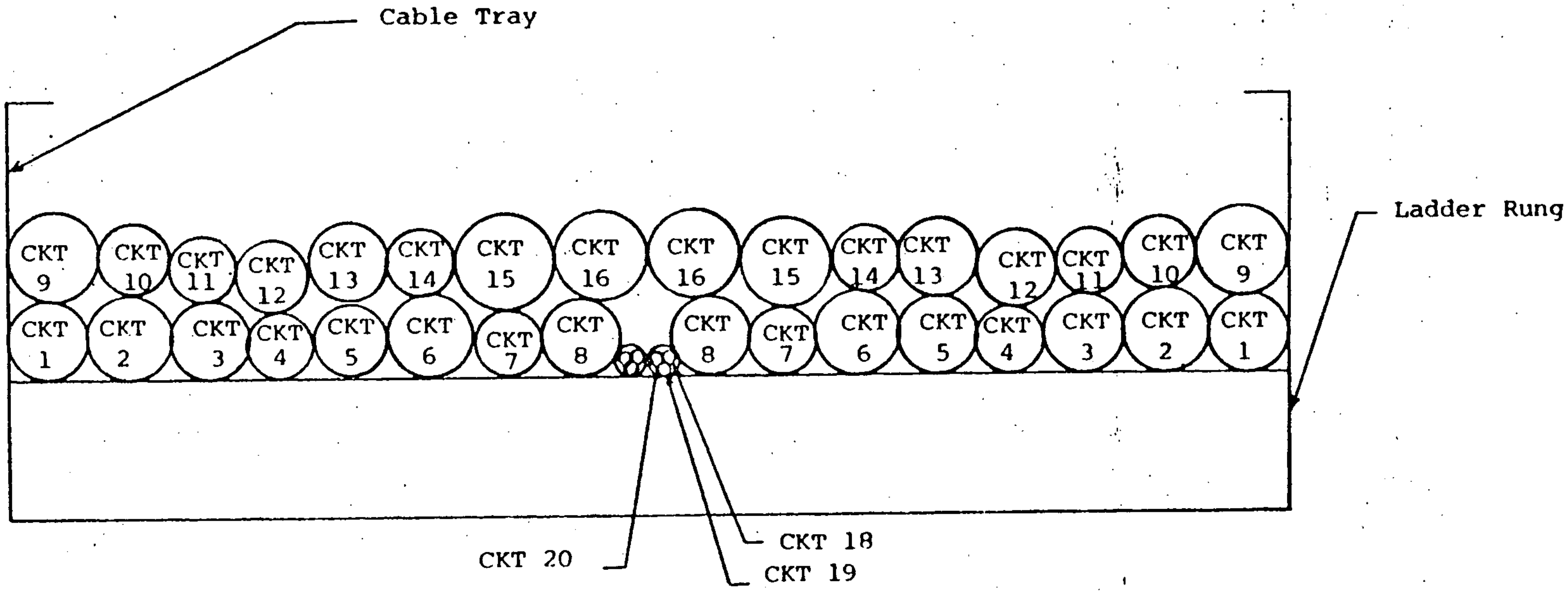


FIGURE 7

SCHEMATIC DIAGRAM OF APPROXIMATE CABLE LOCATIONS IN CABLE TRAY WITH RESPECT TO CIRCUITS ON LIGHT BOARD (*NOTE:* CIRCUIT 17 IS IN CONDUIT)

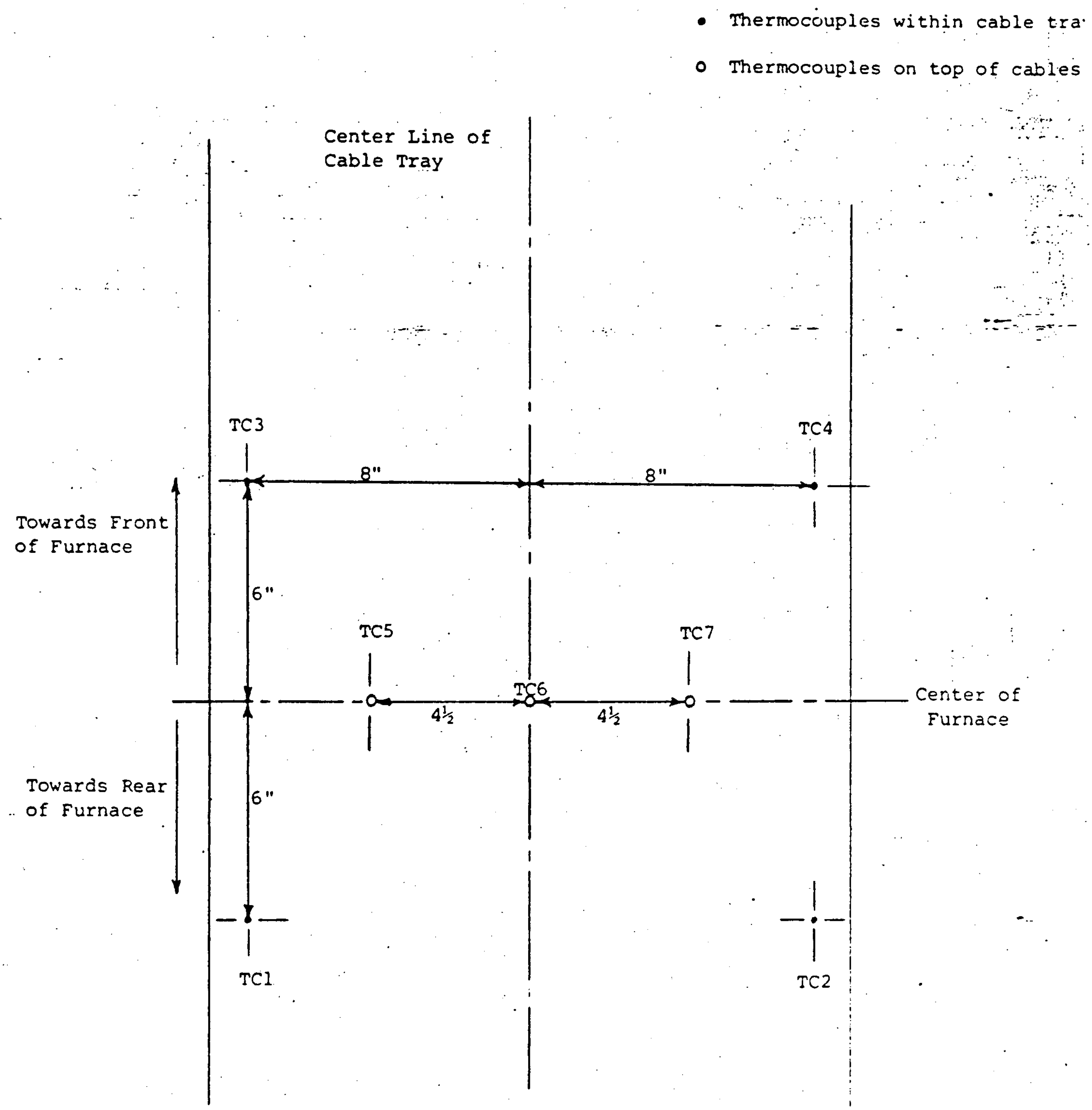


FIGURE 8

SCHEMATIC DIAGRAM OF THERMOCOUPLE LOCATION FOR FIRE PROTECTION TEST NO. 1 (TC 8 ATTACHED TO THE CABLE IN THE CONDUIT)

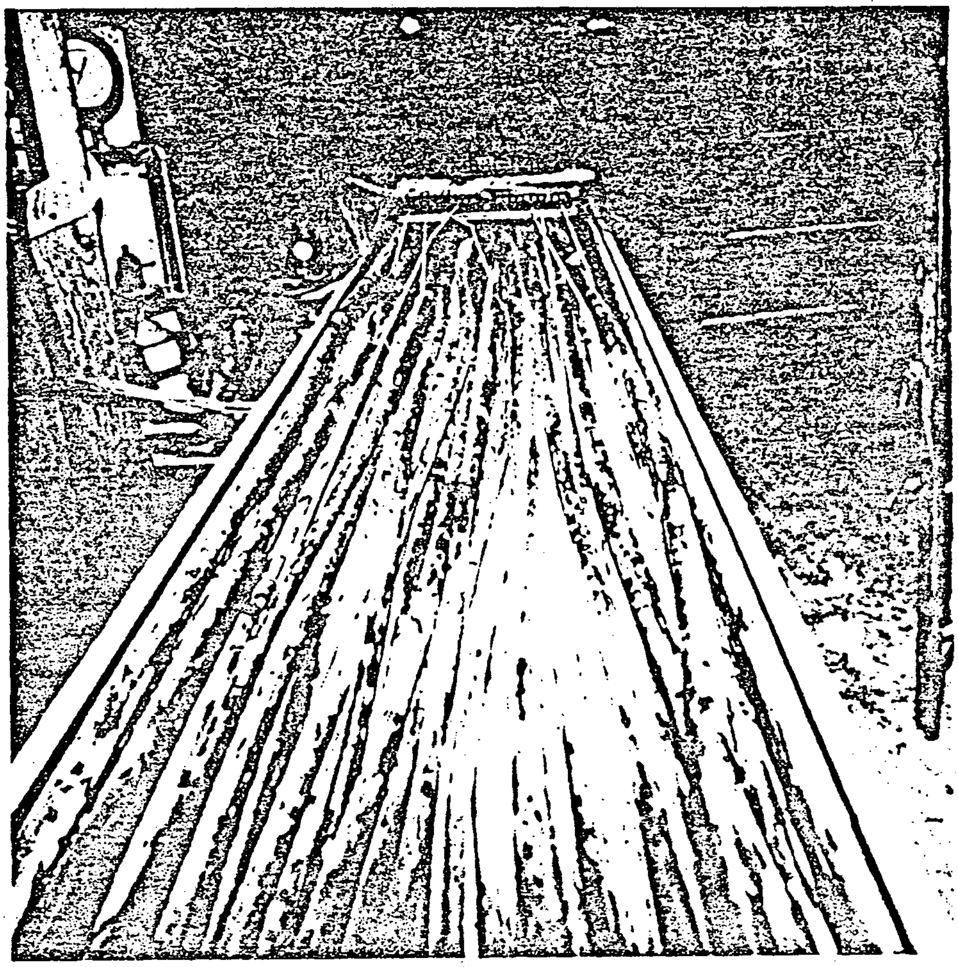


FIGURE 9

THERMOCOUPLES ATTACHED TO CABLES IN CABLE TRAY IN FIRE PROTECTION TEST NO. 1

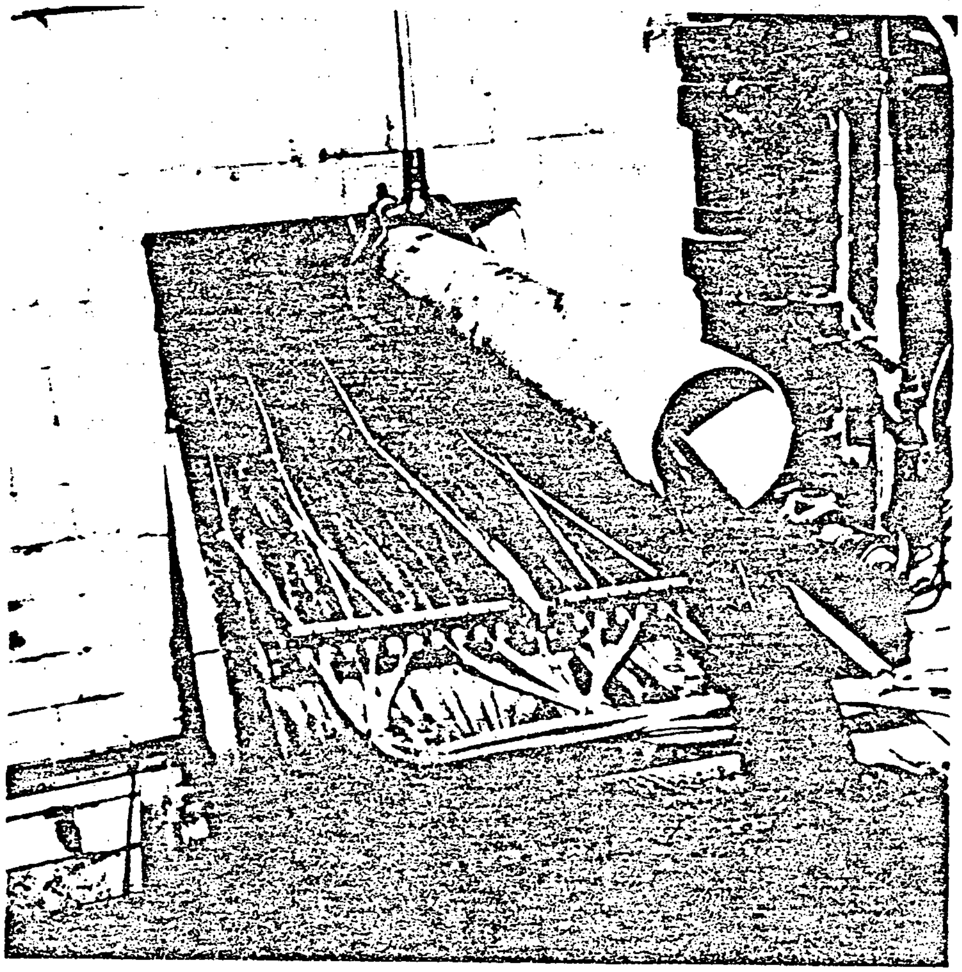


FIGURE 10

LOADED CABLE TRAY AND CONDUIT AFTER INSERTION INTO FURNACE FOR FIRE PROTECTION TEST NO. 1

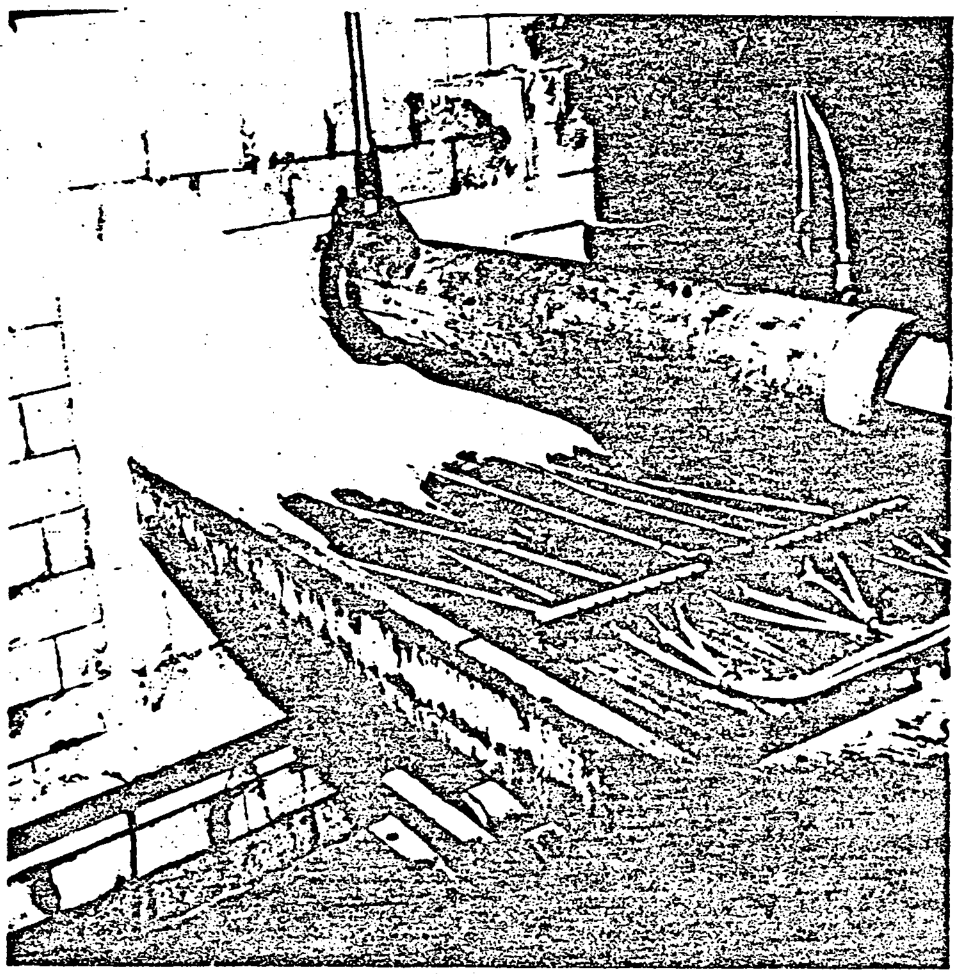


FIGURE 11

SEALING AROUND CABLE TRAY AND CONDUIT
FRONT OF FURNACE - FIRE PROTECTION TEST NO. 1

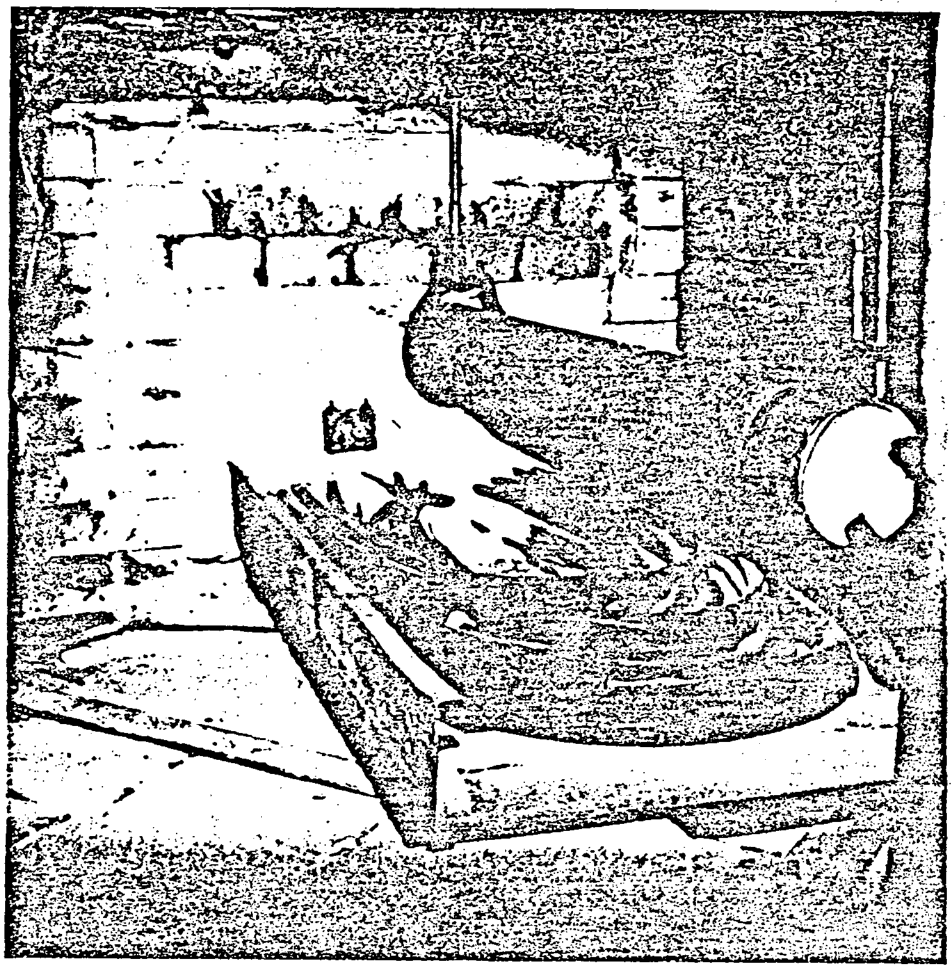


FIGURE 12

SEALING AROUND CABLE TRAY AND CONDUIT - BACK OF FURNACE - FIRE PROTECTION TEST NO. 1 (*NOTE:* INSERTION OF CONTROL THERMOCOUPLE THROUGH KAOWOOL)

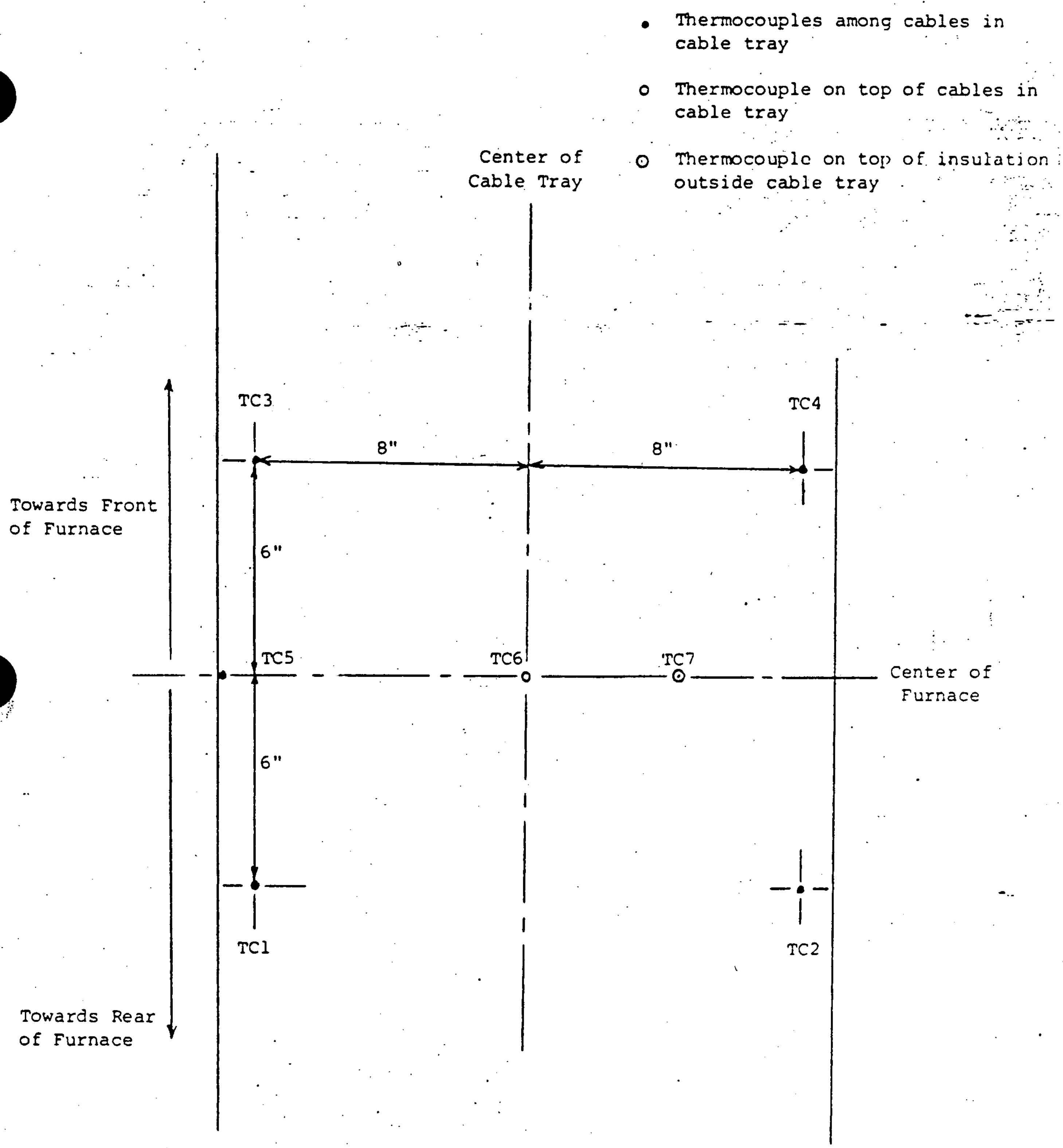


FIGURE 13

SCHEMATIC DIAGRAM OF THERMOCOUPLE LOCATION FOR FIRE PROTECTION TEST NOS. 2 THROUGH 3B (TC 8 ATTACHED TO THE CABLE IN THE CONDUIT)

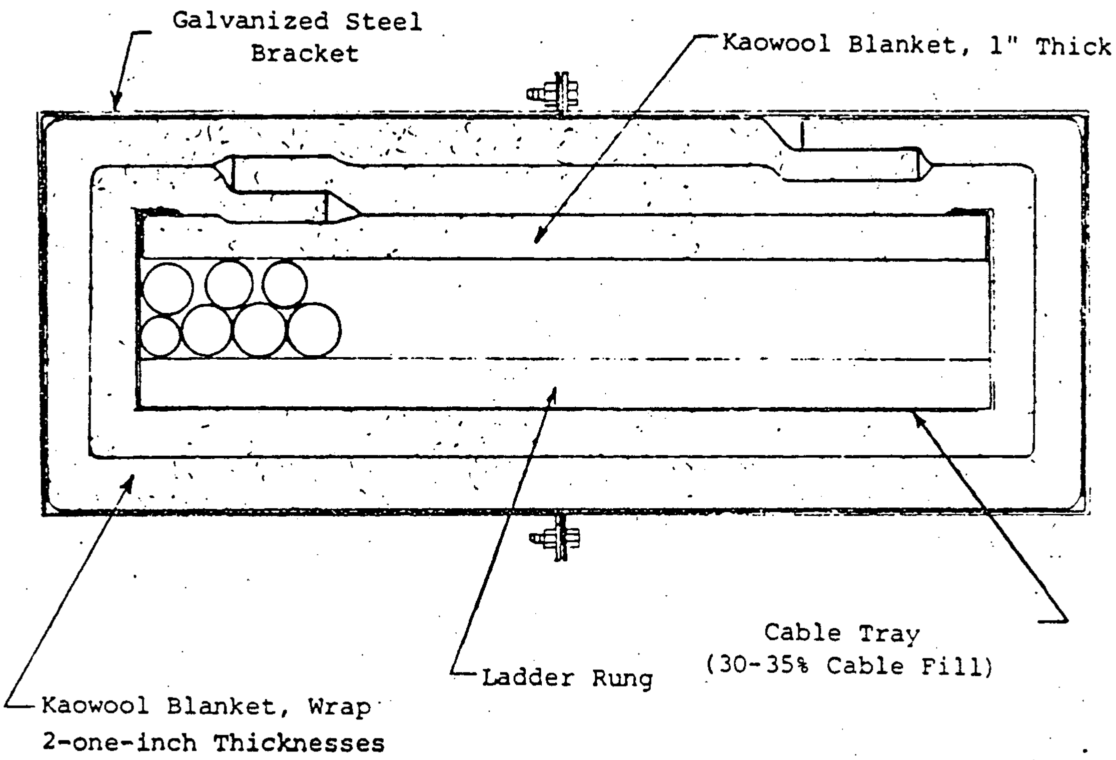


FIGURE 14

SCHEMATIC DIAGRAM OF INSULATED CABLE TRAY FOR FIRE PROTECTION TEST NOS. 2, 3A and 3B

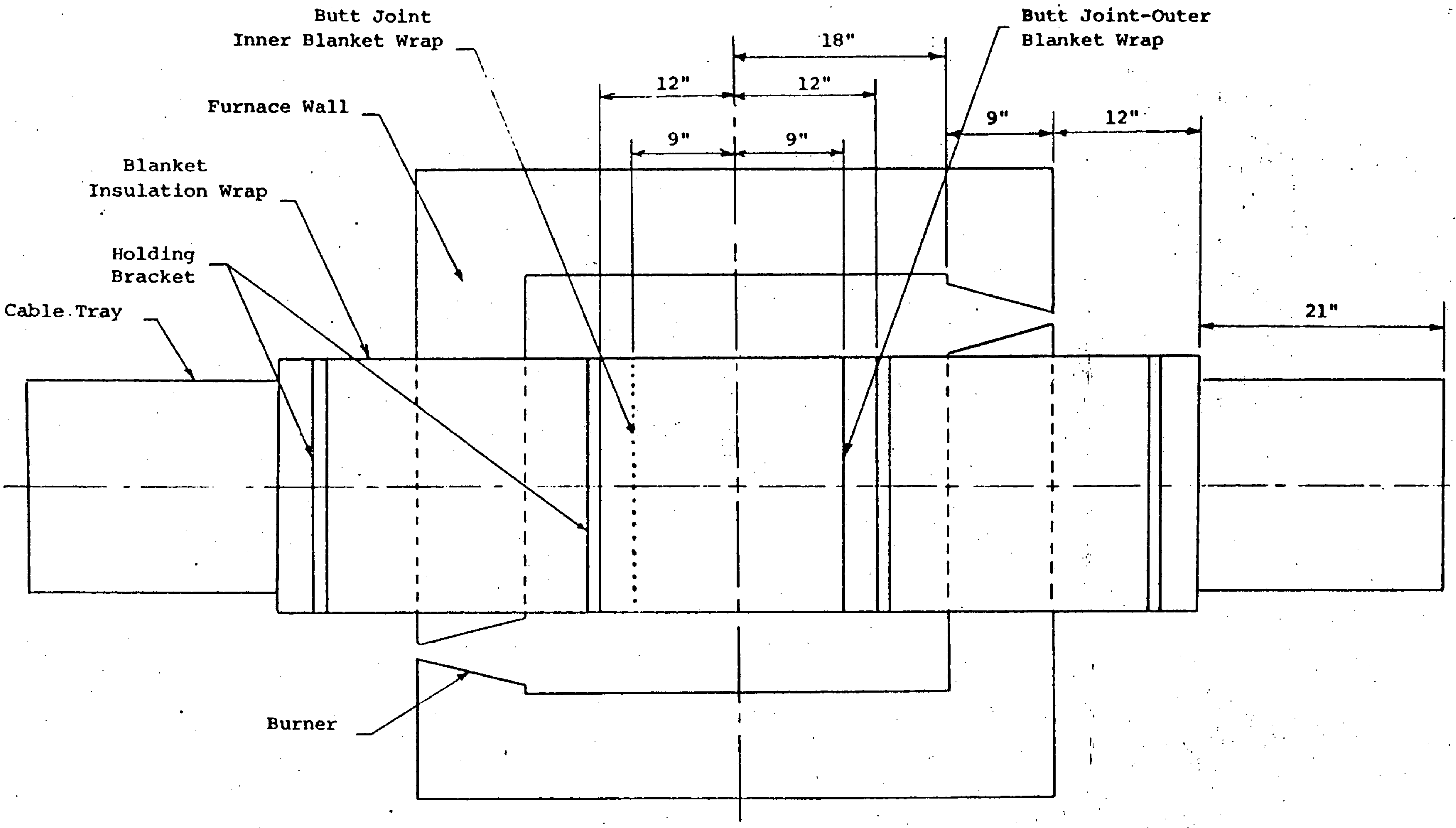


FIGURE 15

SCHEMATIC DIAGRAM OF INSULATED CABLE TRAY IN FURNACE FOR TEST NOS. 2 and 3A (NOTE: LOCATION OF BLANKET BUTT JOINTS AND HOLDING BRACKETS WITHIN FURNACE)

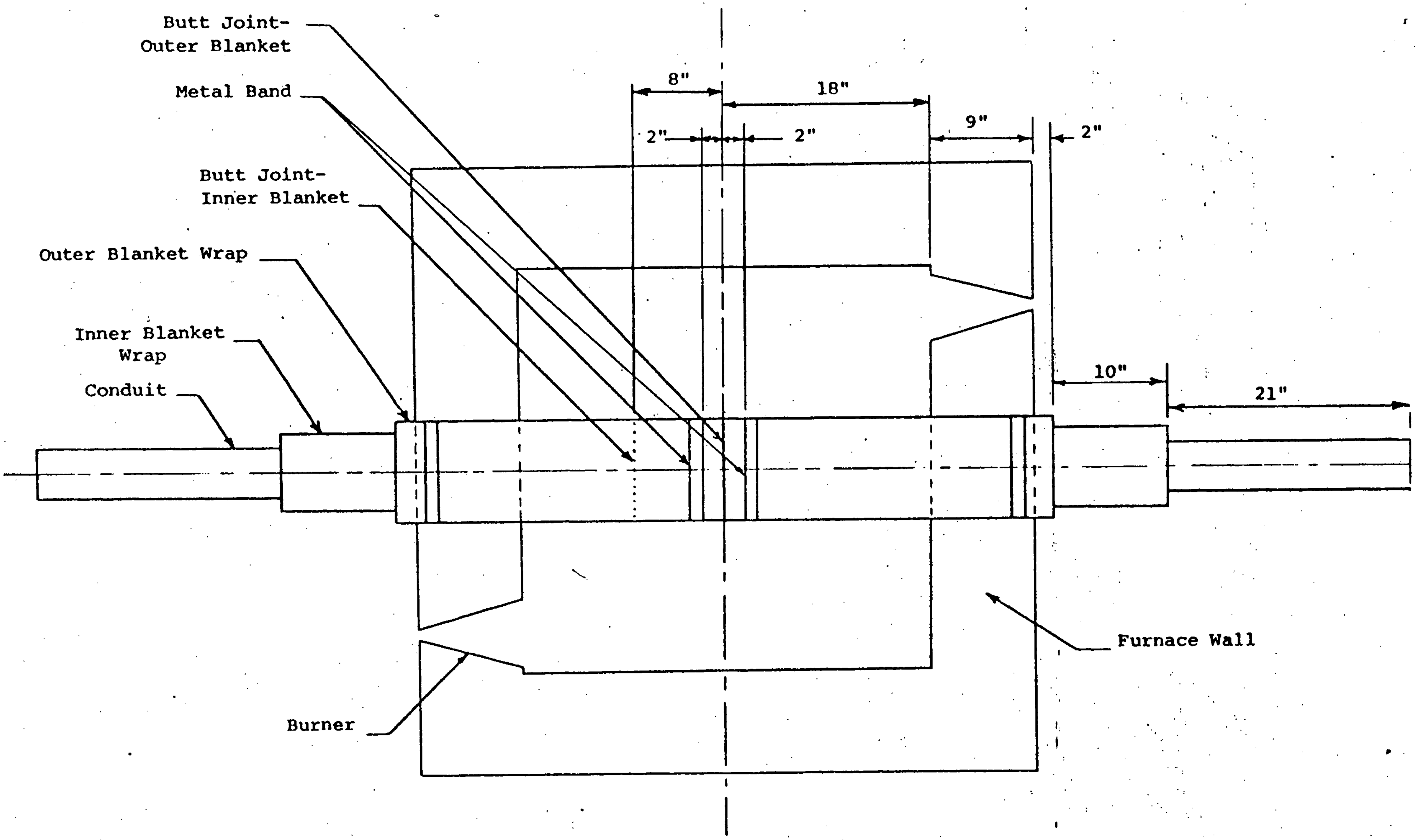


FIGURE 16

SCHEMATIC DIAGRAM OF INSULATED CONDUIT IN FURNACE FOR TEST NOS. 2, 3A and 3B (*NOTE:* LOCATION OF BLANKET BUTT JOINTS AND METAL BANDS WITHIN FURNACE)

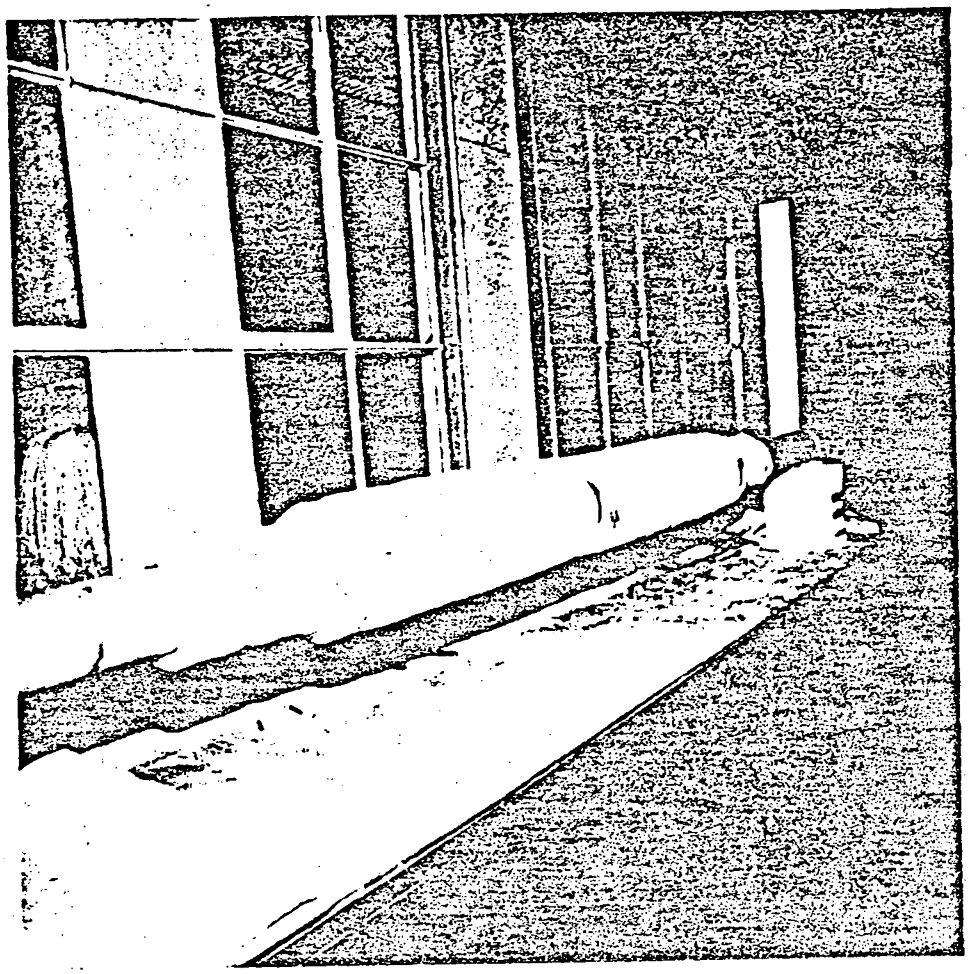


FIGURE 17

INSULATED CONDUIT FOR FIRE PROTECTION TEST NO. 2 BEFORE INSERTION INTO FURNACE

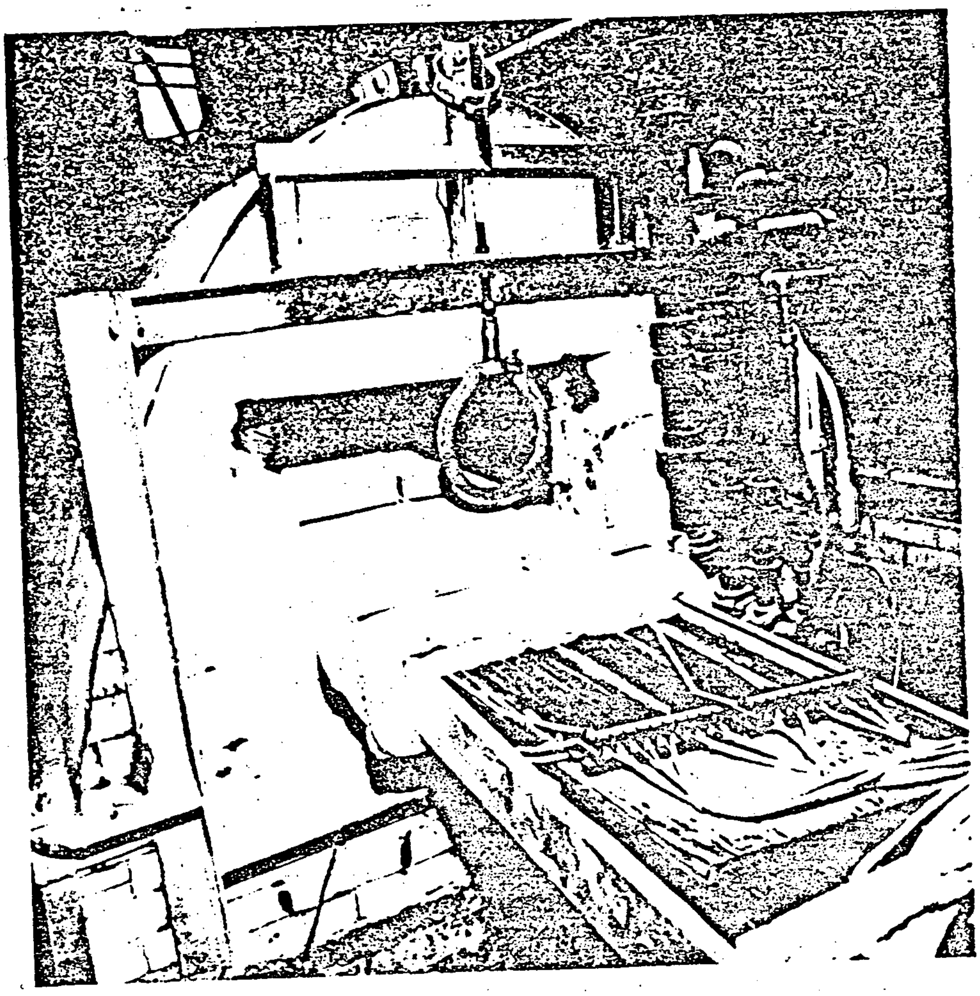


FIGURE 18

INSERTION OF INSULATED CABLE TRAY
INTO FURNACE FOR FIRE PROTECTION TEST NO. 2

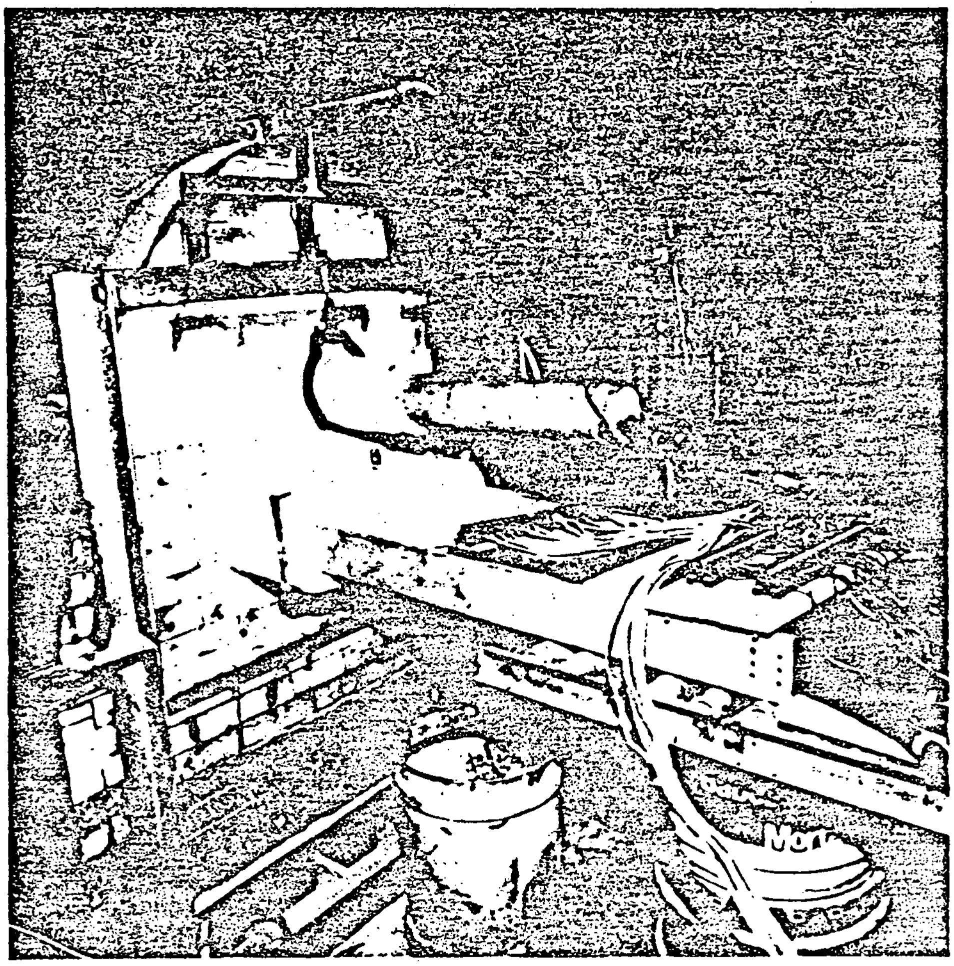


FIGURE 19

INSULATED CABLE TRAY AND CONDUIT INSTALLATION IN FURNACE FOR FIRE PROTECTION TEST NO. 2 (BEFORE TEST)

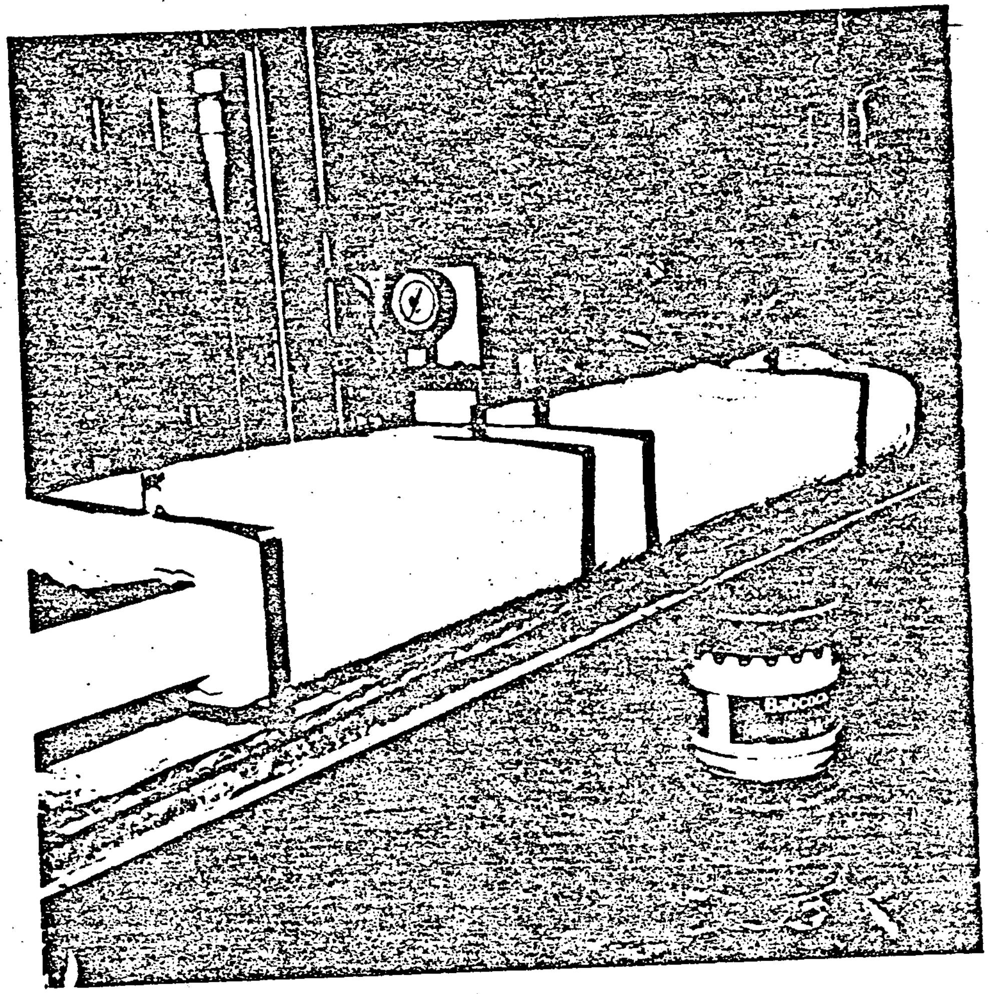


FIGURE 20

INSULATED CABLE TRAY FOR TEST NO. 3B
NOTE: RELOCATION OF HOLDING BRACKETS-
SPACED 3" ON EACH SIDE OF BUTT JOINTS

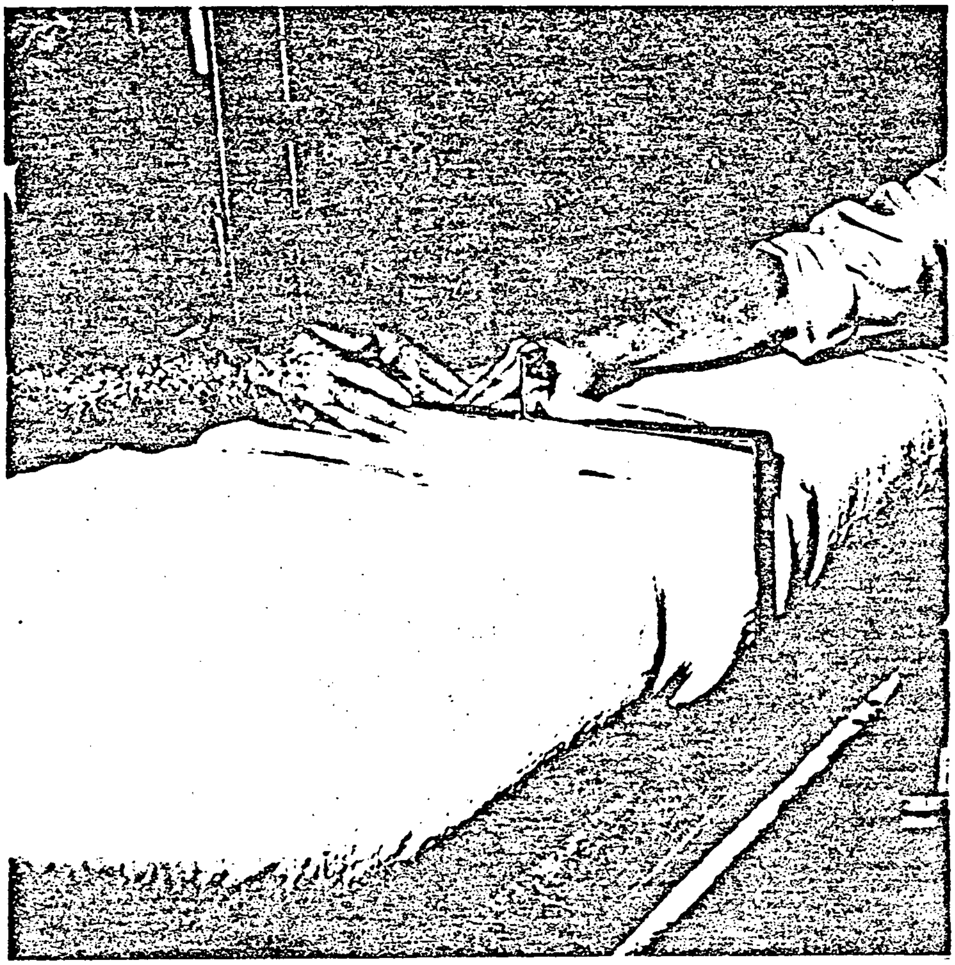


FIGURE 21

FOUR INCH WIDE KAOWOOL BLANKET STRIP [illegible]
OVER BUTT JOINT IN TEST NO. 1

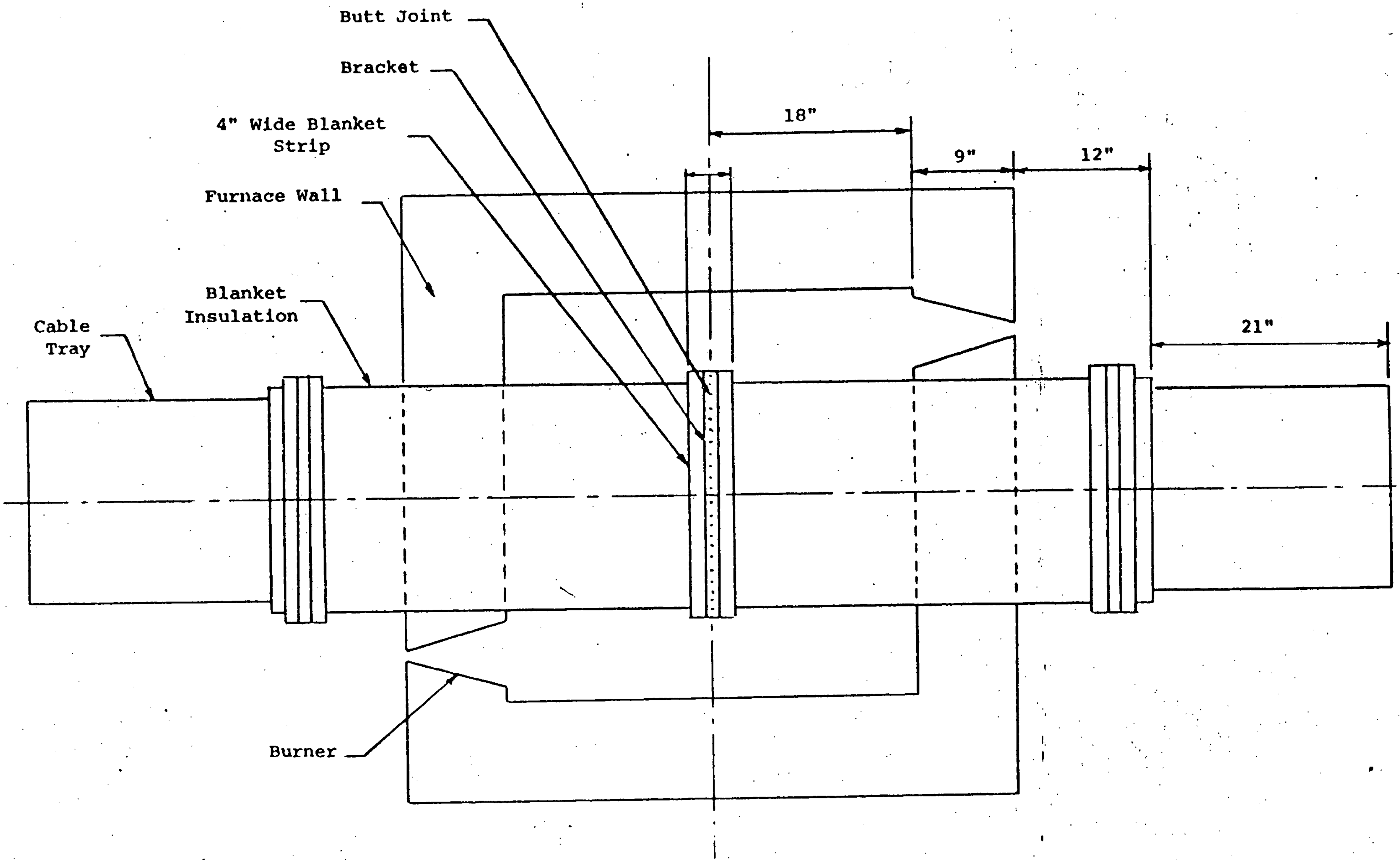


FIGURE 22

SCHEMATIC DIAGRAM OF INSULATED CABLE TRAY IN FURNACE FOR TEST NO. 1 ([illegible] LOCATION BRACKETS AND STRIP OVER BUTT JOINT)

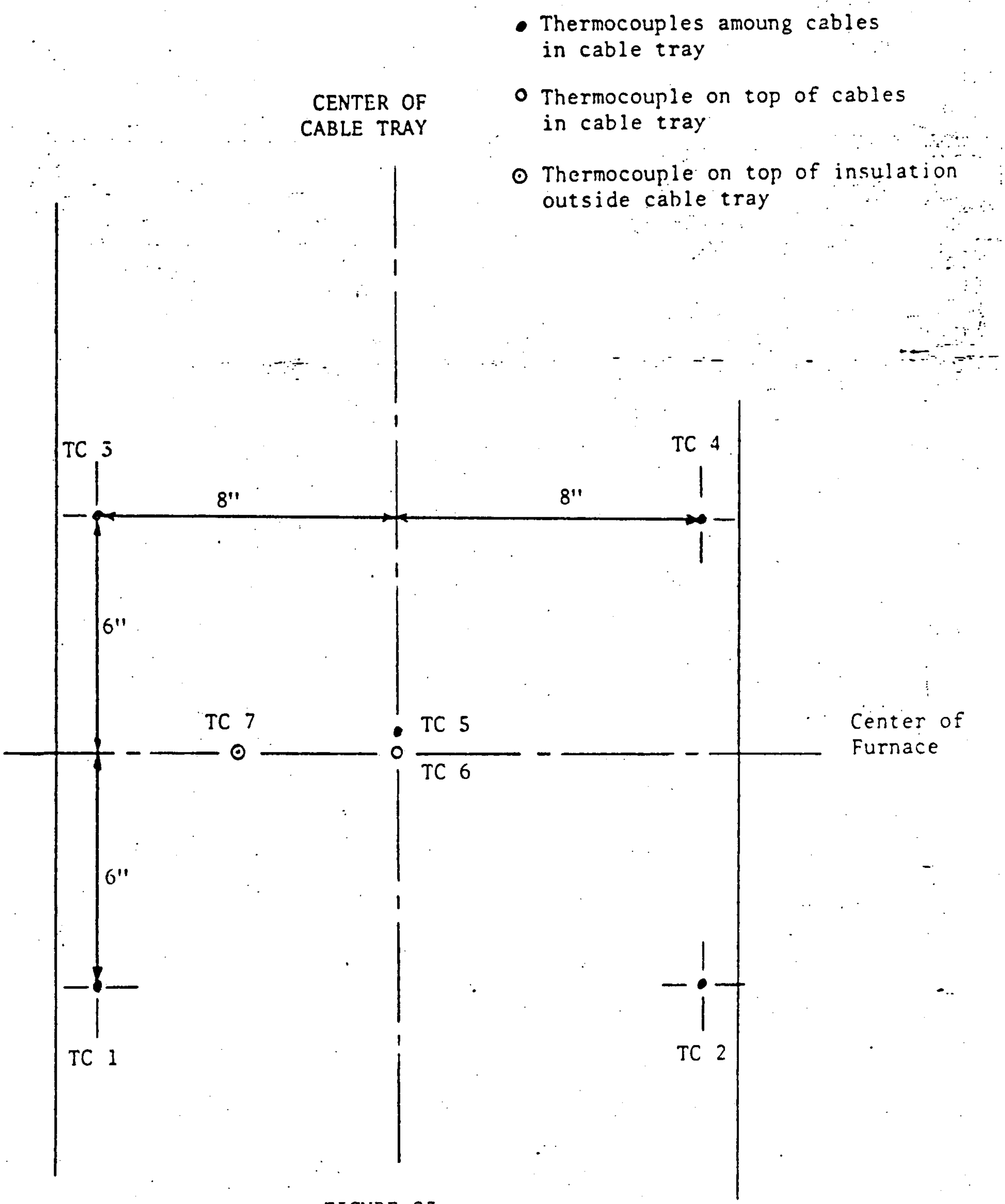


FIGURE 23

SCHEMATIC DIAGRAM OF THERMOCOUPLE LOCATION FOR FIRE PROTECTION TEST NO. 4 (TC 8 ATTACHED TO THE CABLE IN THE CONDUIT)

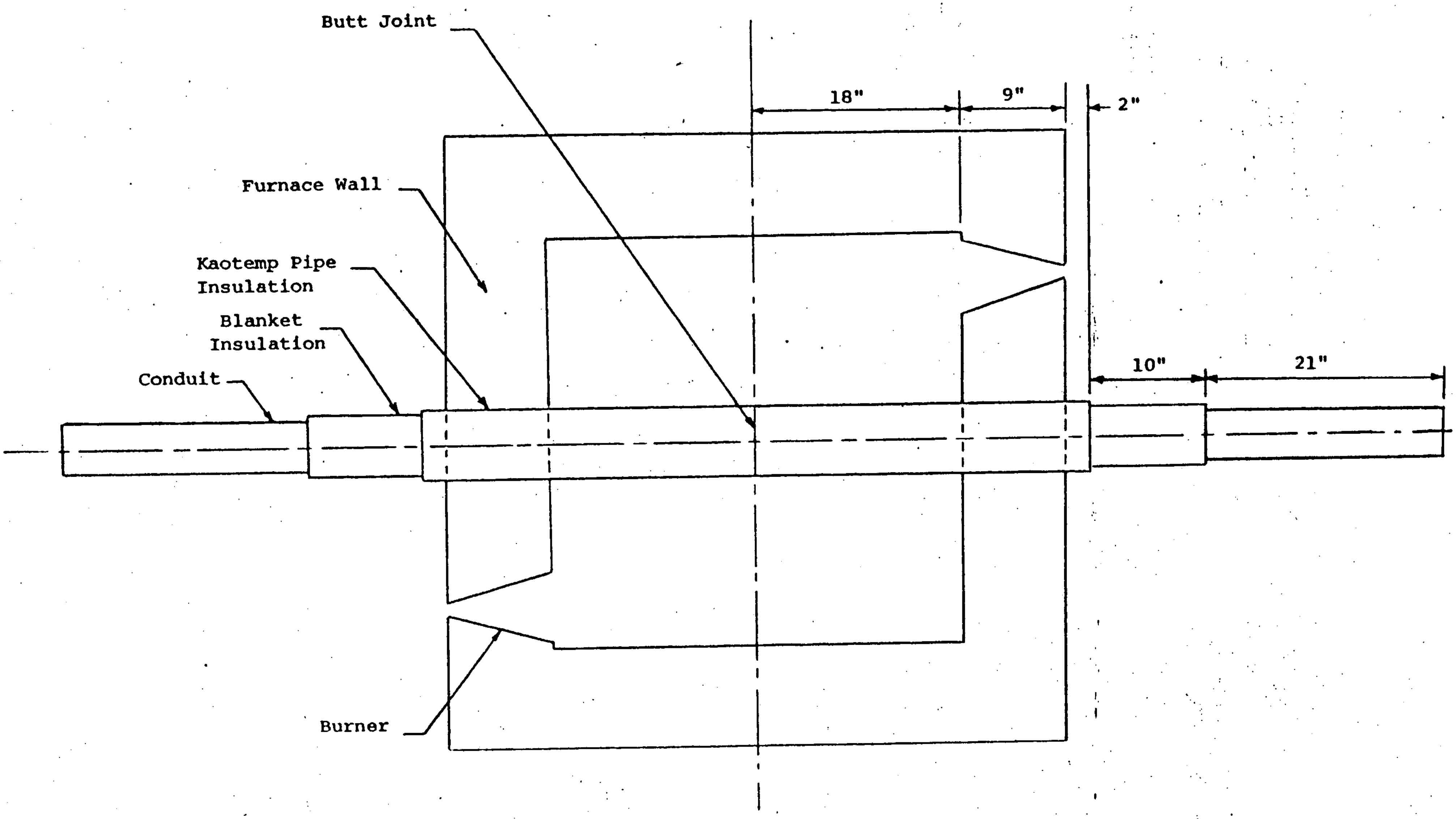


FIGURE 24

SCHEMATIC DIAGRAM OF INSULATED CONDUIT IN FURNACE FOR TEST NO. 4

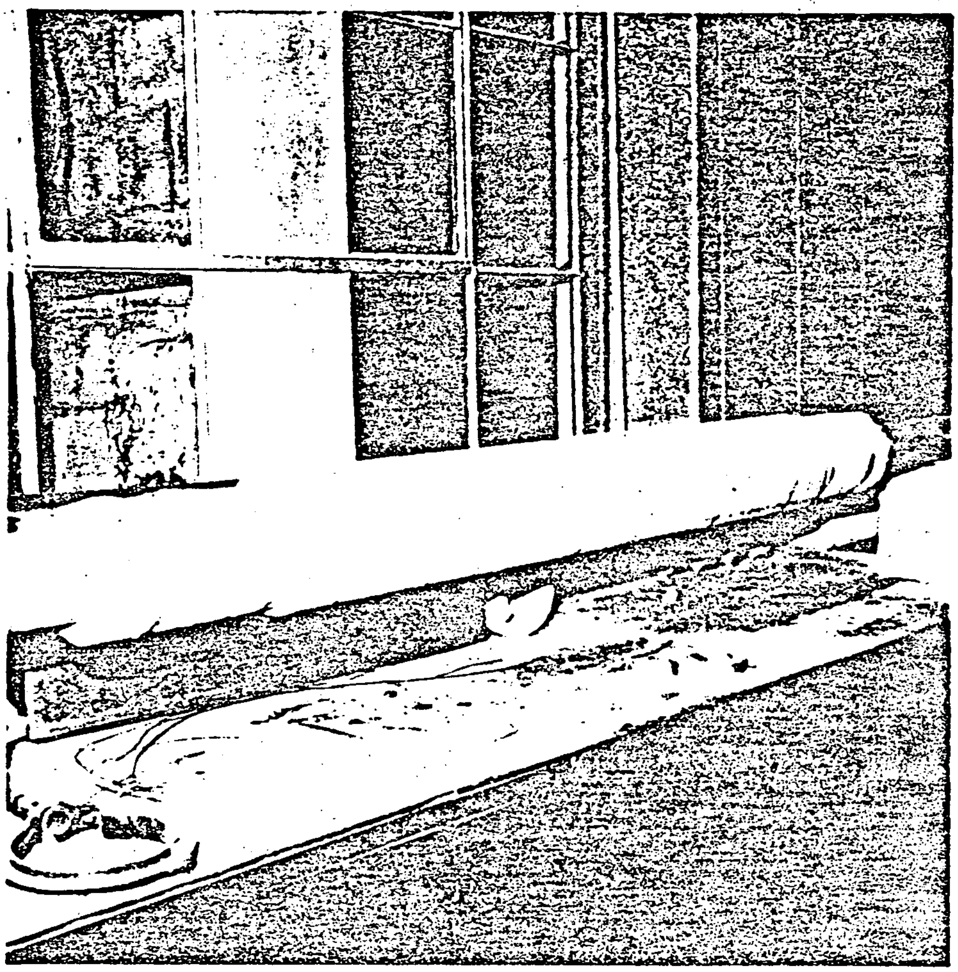
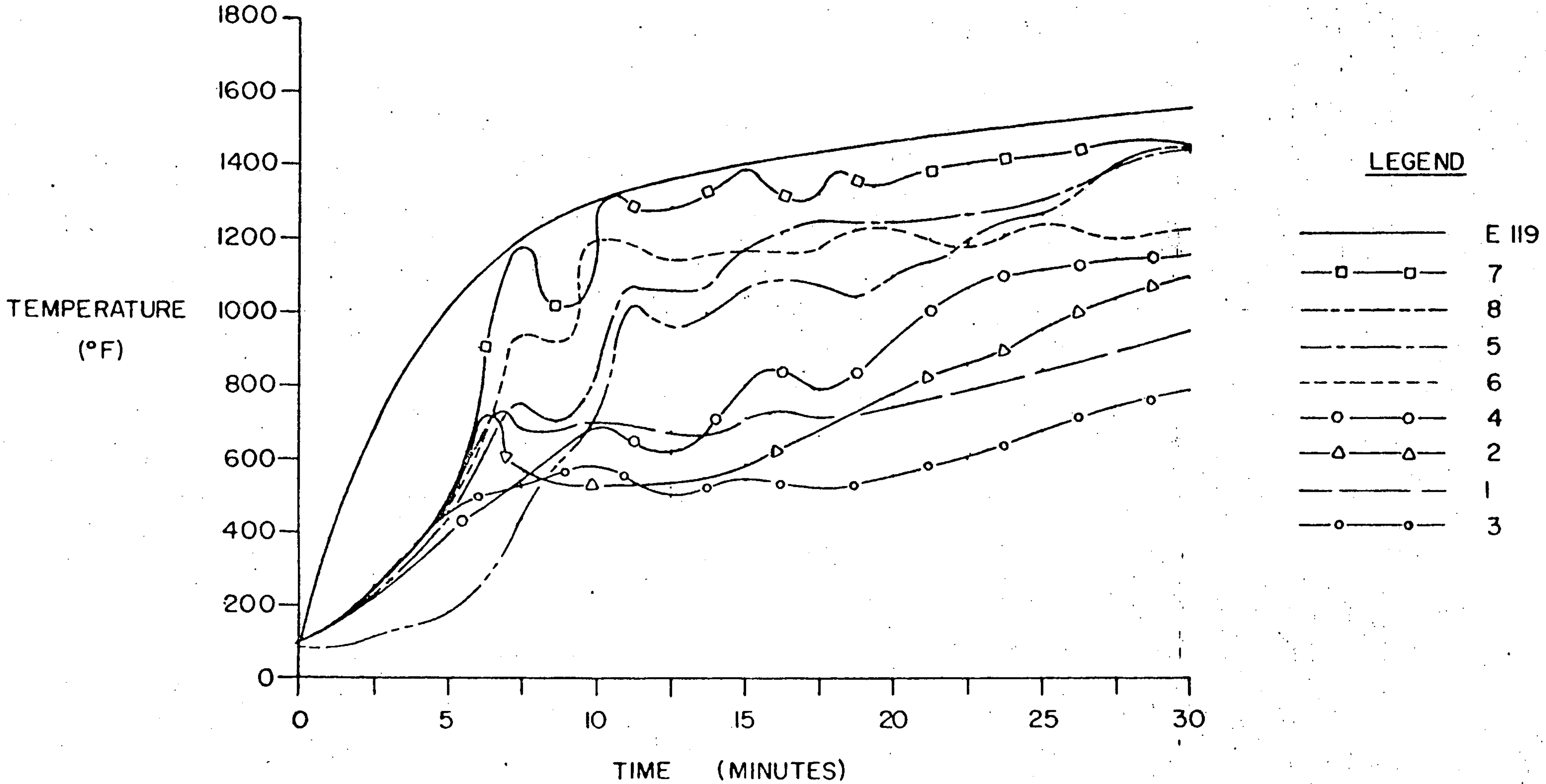


FIGURE 25

INSULATED CONDUIT USING KAOTEMP PIPE
INSULATION FOR FIRE PROTECTION
TEST NO. 4

FIGURE 26

TEMPERATURE INCREASE IN VARIOUS LOCATIONS IN CABLE TRAY AND CONDUIT (SEE FIGURE 8) DURING TEST NO. 1-UNPROTECTED STEEL, SOLID BOTTOM CABLE TRAY AND STEEL CONDUIT



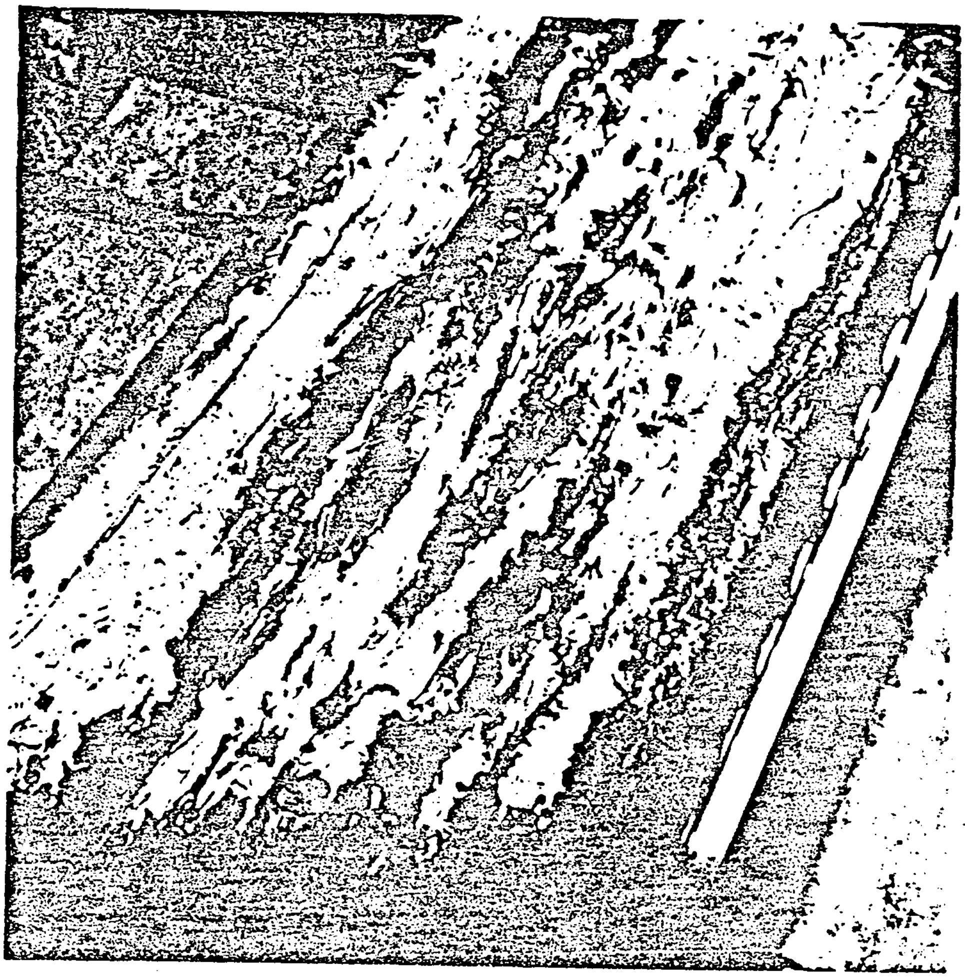
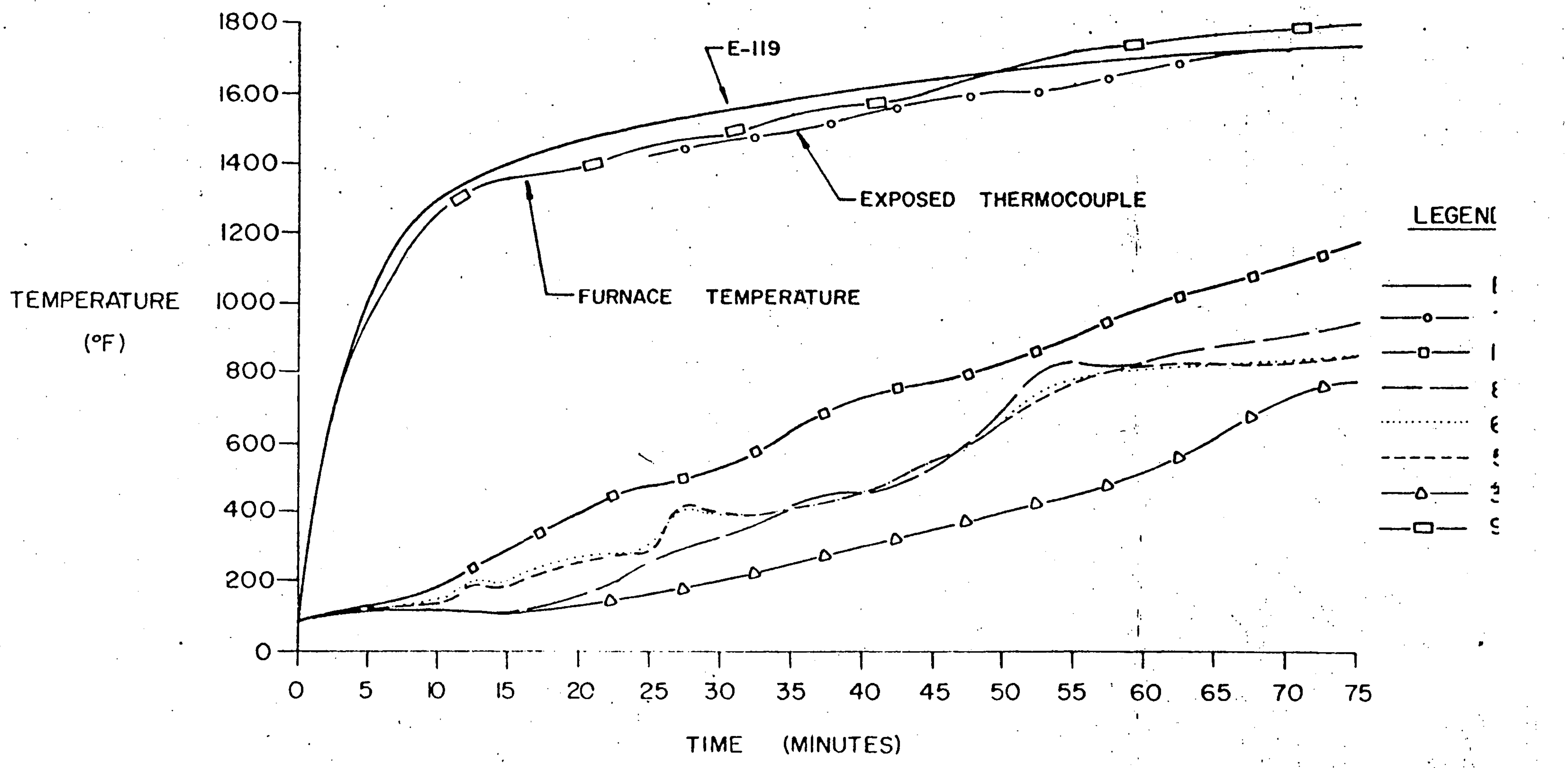


FIGURE 27

APPEARANCE OF CABLES IN CABLE TRAY
AFTER TEST NO. 1 - UNPROTECTED AFTER
EXPOSURE TO FIRE FOR 30 MINUTES

FIGU

TEMPERATURE INCREASE IN VARIOUS LOCATIONS IN CABLE TRAY AND CONDUIT (SEE FIGURE 13) DURING TEST NO. 2-STEEL SOLID BOTTOM CABLE TRAY AND STEEL CONDUIT WRAPPED WITH 2" KAOWOOL BLANKET (LOOSE BUTT JOINTS)



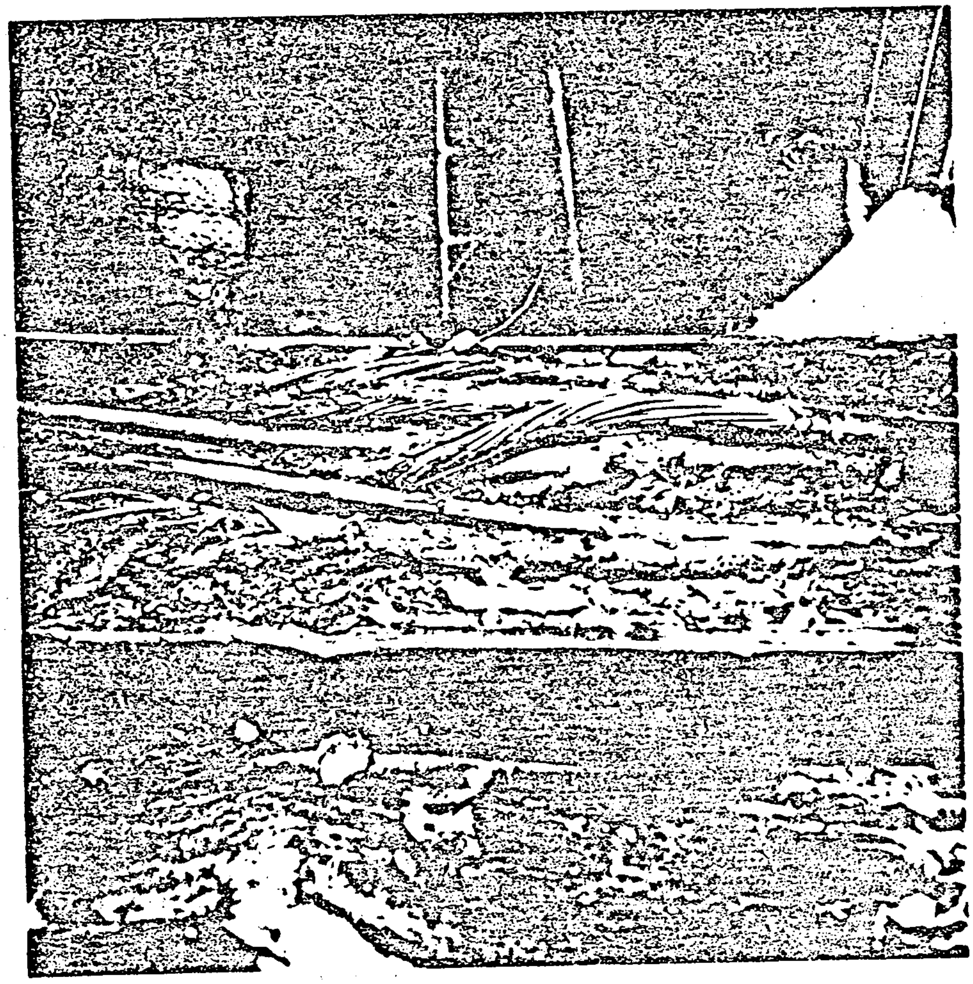


FIGURE 29

APPEARANCE OF CABLES IN CABLE TRAY AFTER TEST NO. 2 - WRAPPED WITH 2" OF KAOWOOL INSULATION AFTER EXPOSURE TO FIRE FOR ONE HOUR AND 17 MINUTES

FIGURE

TEMPERATURE INCREASE IN VARIOUS LOCATIONS IN CABLE TRAY AND CONDUIT (SEE FIGURE 13) DURING TEST NO. 3A-ALUMINUM OPEN LADDER CABLE TRAY AND ALUMINUM CONDUIT WRAPPED WITH 2" KAOWOOL BLANKET (LOOSE BUTT JOINTS)

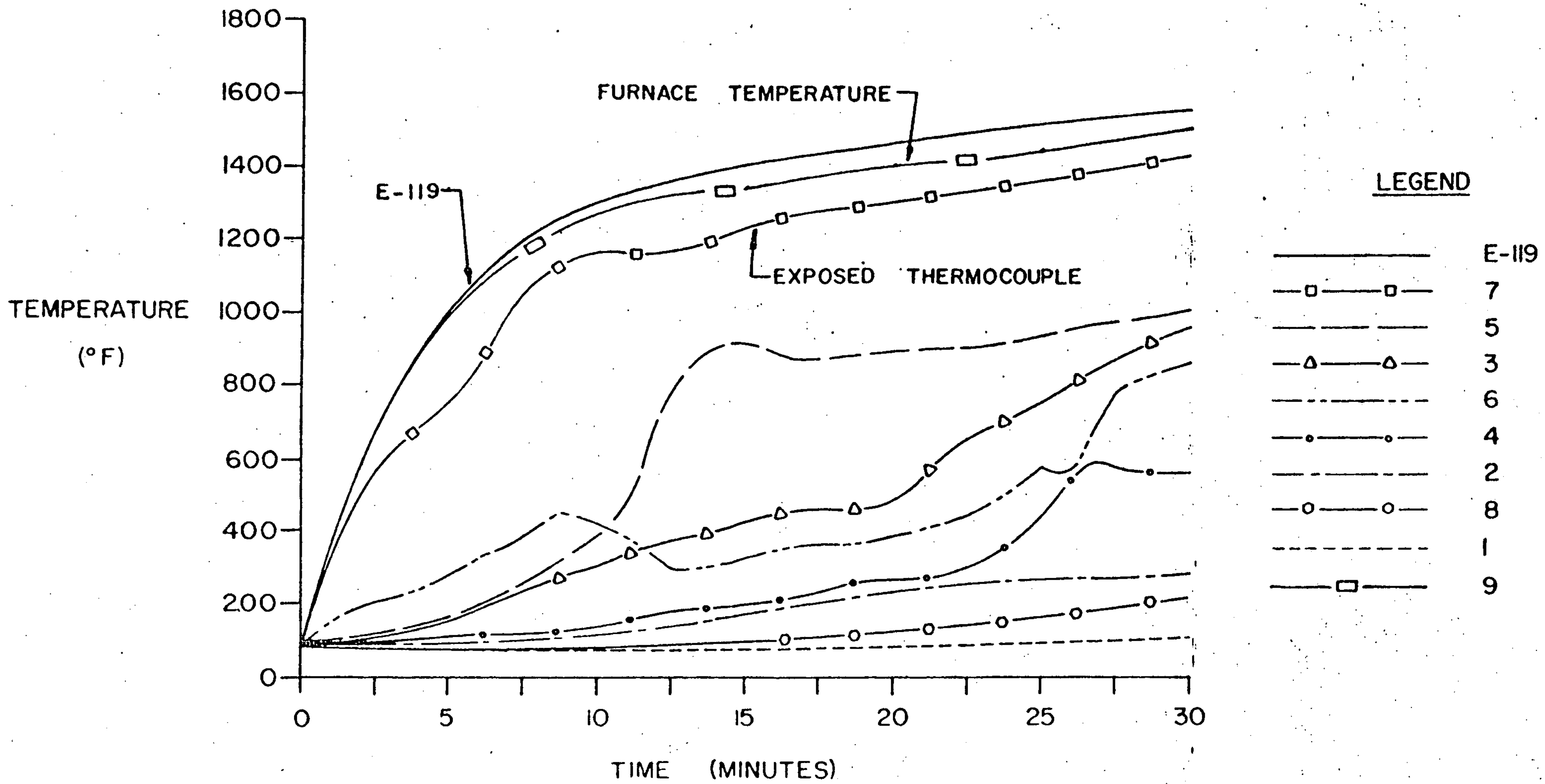


FIGURE 31

OPEN BUTT JOINT IN OUTER KAOWOOL BLANKET WRAP AFTER FIRE TEST NO. 3A

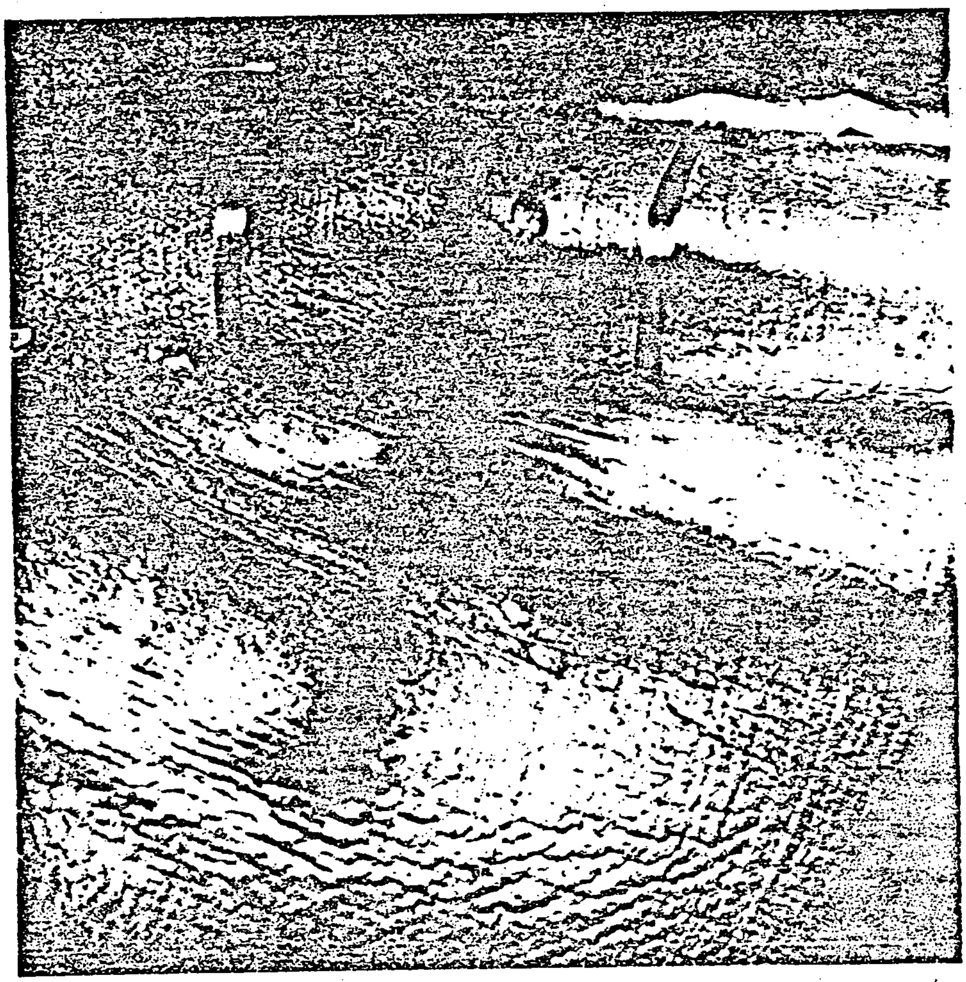


FIGURE 32

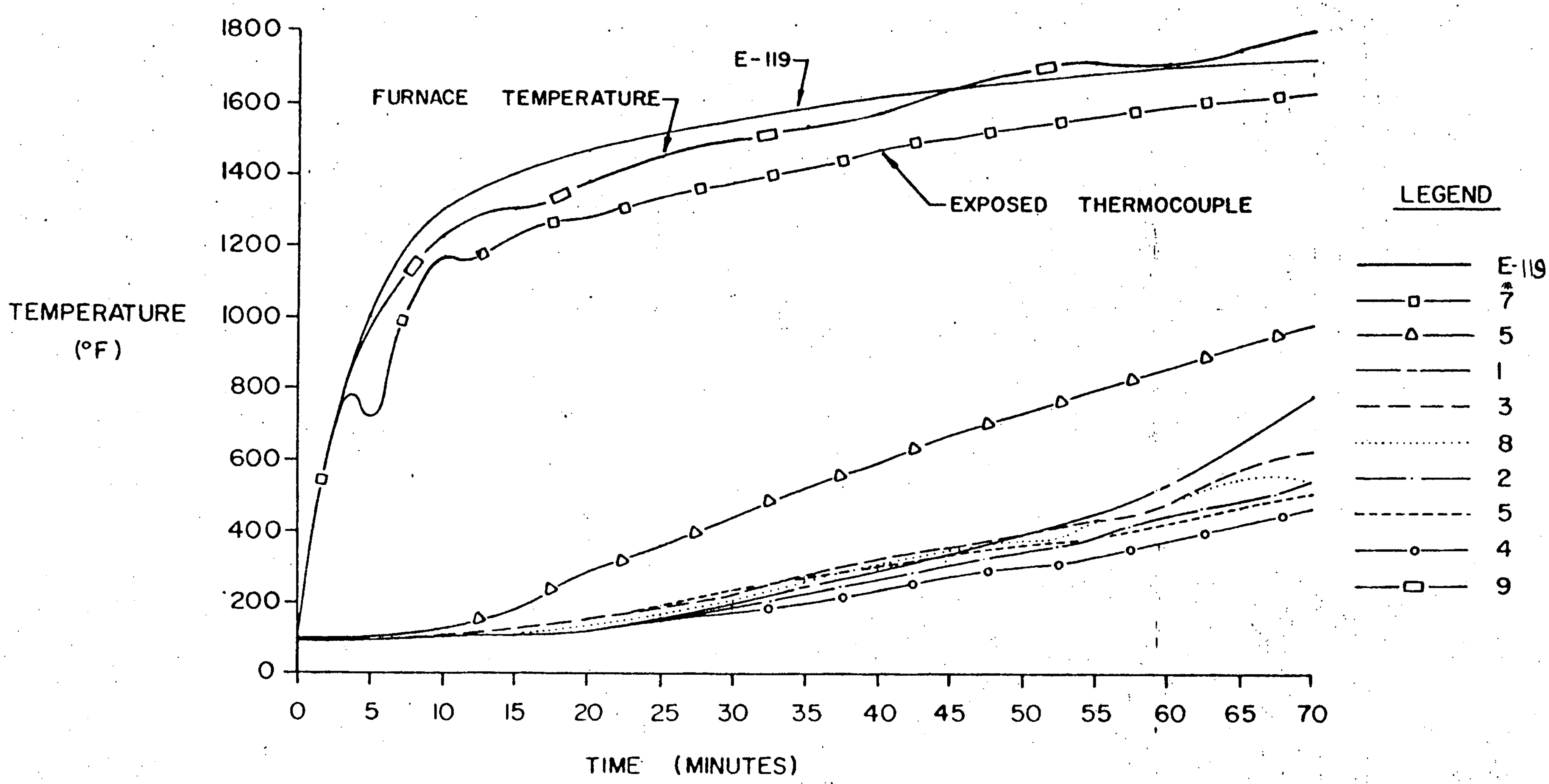
OPEN BUTT JOINT IN INNER KAOWOOL BLANKET WRAP AFTER FIRE TEST NO. 3A

FIGURE 33

APPEARANCE OF CABLE TRAY IN AREA
OF OPEN BUTT JOINT AFTER FIRE TEST NO. 3A

FIGU

TEMPERATURE INCREASE IN VARIOUS LOCATIONS IN CABLE TRAY AND CONDUIT (SEE FIGURE 13) DURING TEST NO. 3B-ALUMINUM OPEN LADDER CABLE TRAY AND ALUMINUM CONDUIT WRAPPED WITH 2" KAOWOOL BLANKET (TIGHT BUTT JOINTS)



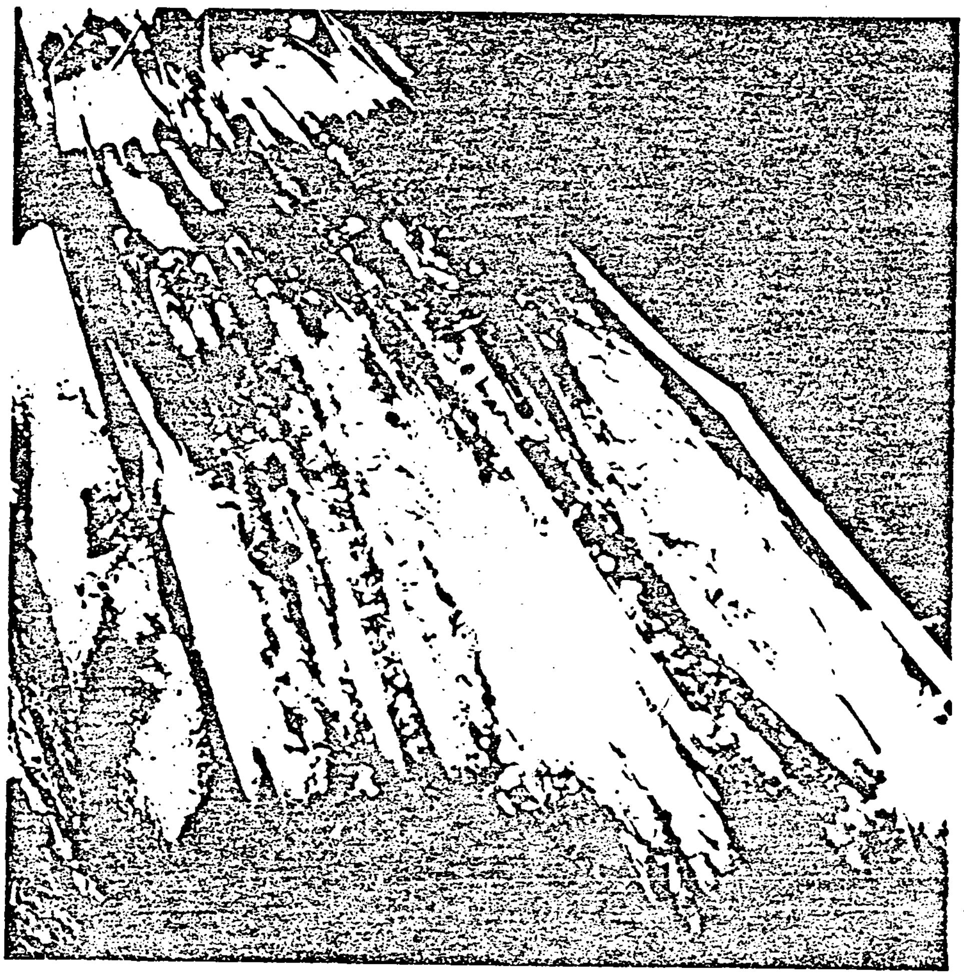


FIGURE 54

APPEARANCE OF CABLES IN CABLE TRAY AFTER TEST NO. 5A - WRAPPED WITH 2" OF KAOWOOL INSULATION-LOOSE BUTT JOINTS

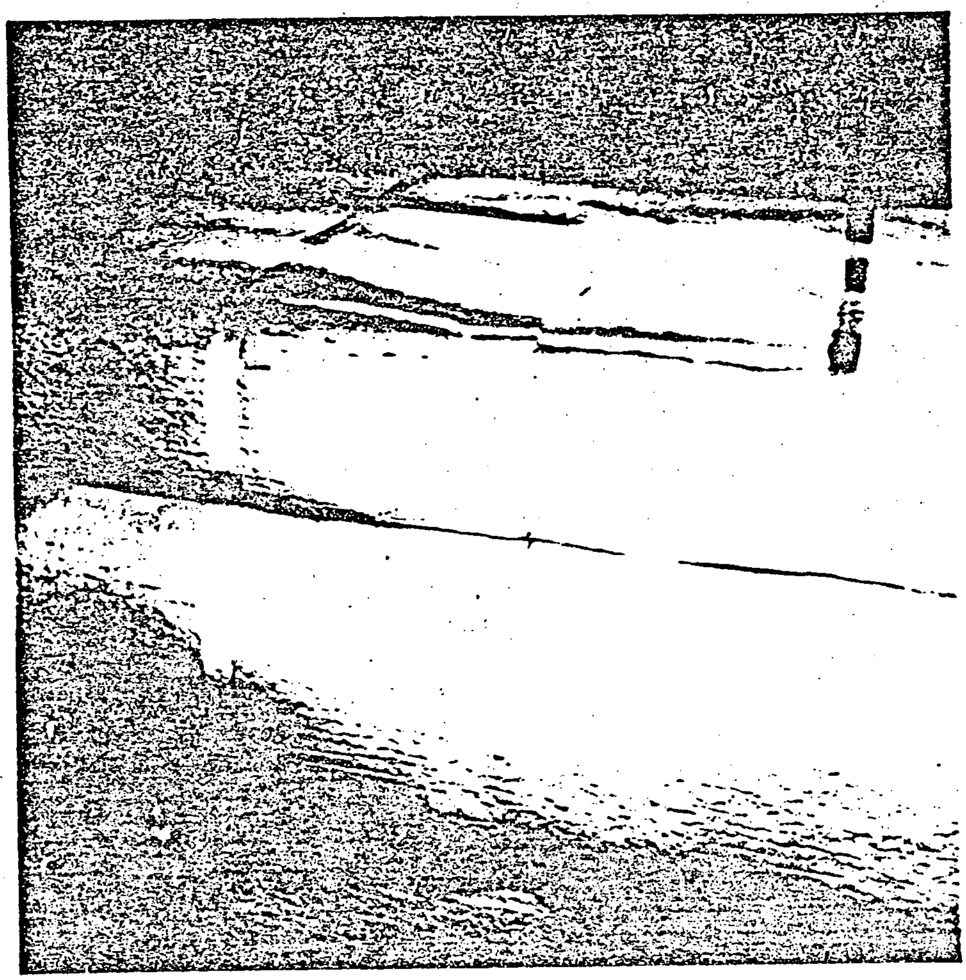


FIGURE 36

APPEARANCE OF INNER BUTT JOINT
AFTER TEST NO. 3B - 2" OF KAOWOOL BLANKET
WRAP WITH TIGHT BUTT JOINTS

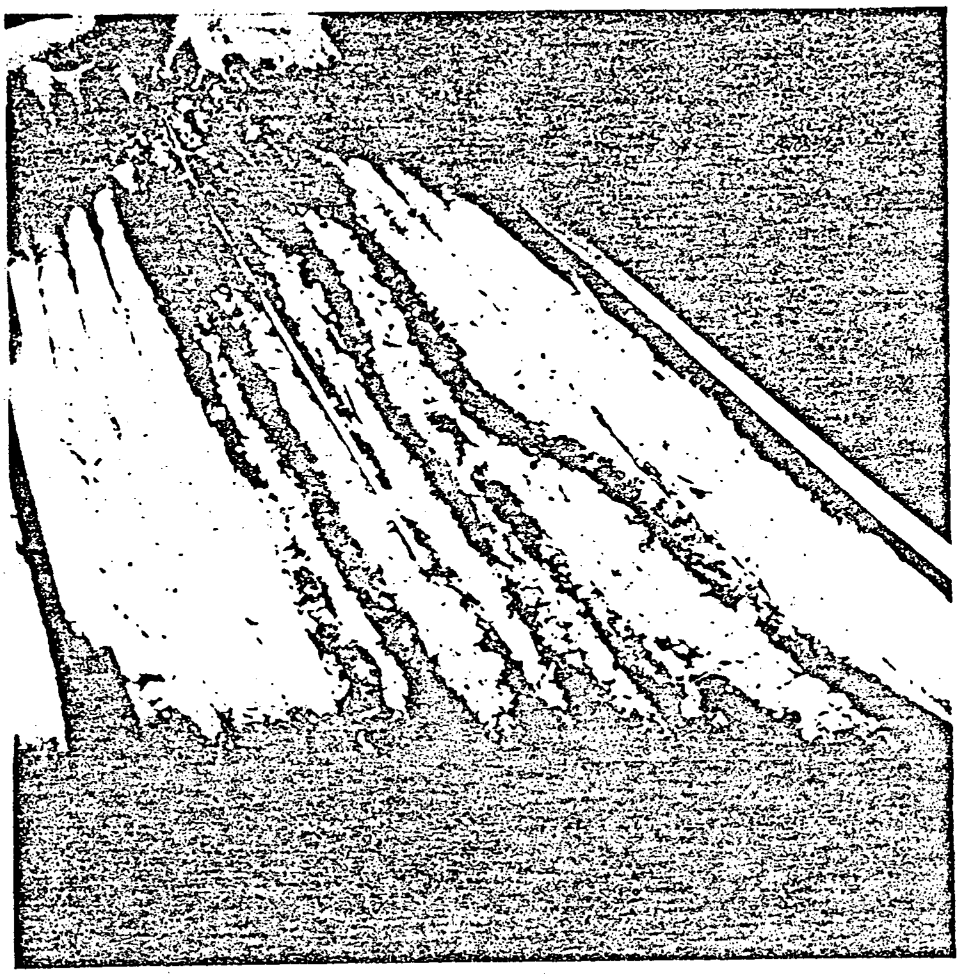
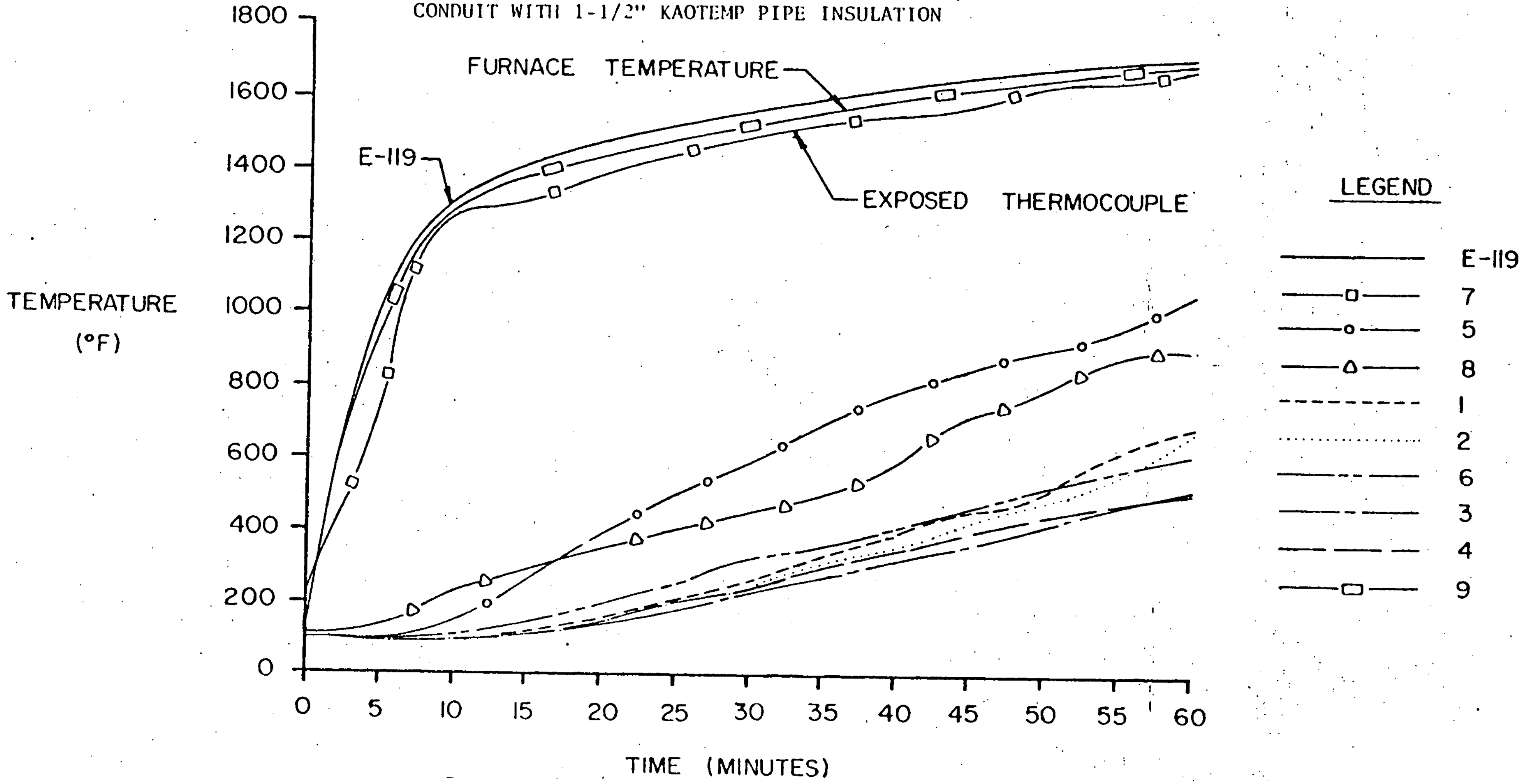


FIGURE 37

APPEARANCE OF CABLES IN CABLE TRAY AFTER TEST NO. 3B - WRAPPED WITH 2" OF KAOWOOL BLANKET INSULATION WITH TIGHT BUTT JOINTS

FIGURE 38

TEMPERATURE INCREASE IN VARIOUS LOCATIONS IN CABLE TRAY AND CONDUIT (SEE FIGURE 23) DURING TEST NO. 4 - STEEL SOLID BOTTOM TRAY WRAPPED WITH 1" KAOWOOL (4" OVERLAP STRIP OVER BUTT JOINT) AND STEEL CONDUIT WITH 1-1/2" KAOTEMP PIPE INSULATION



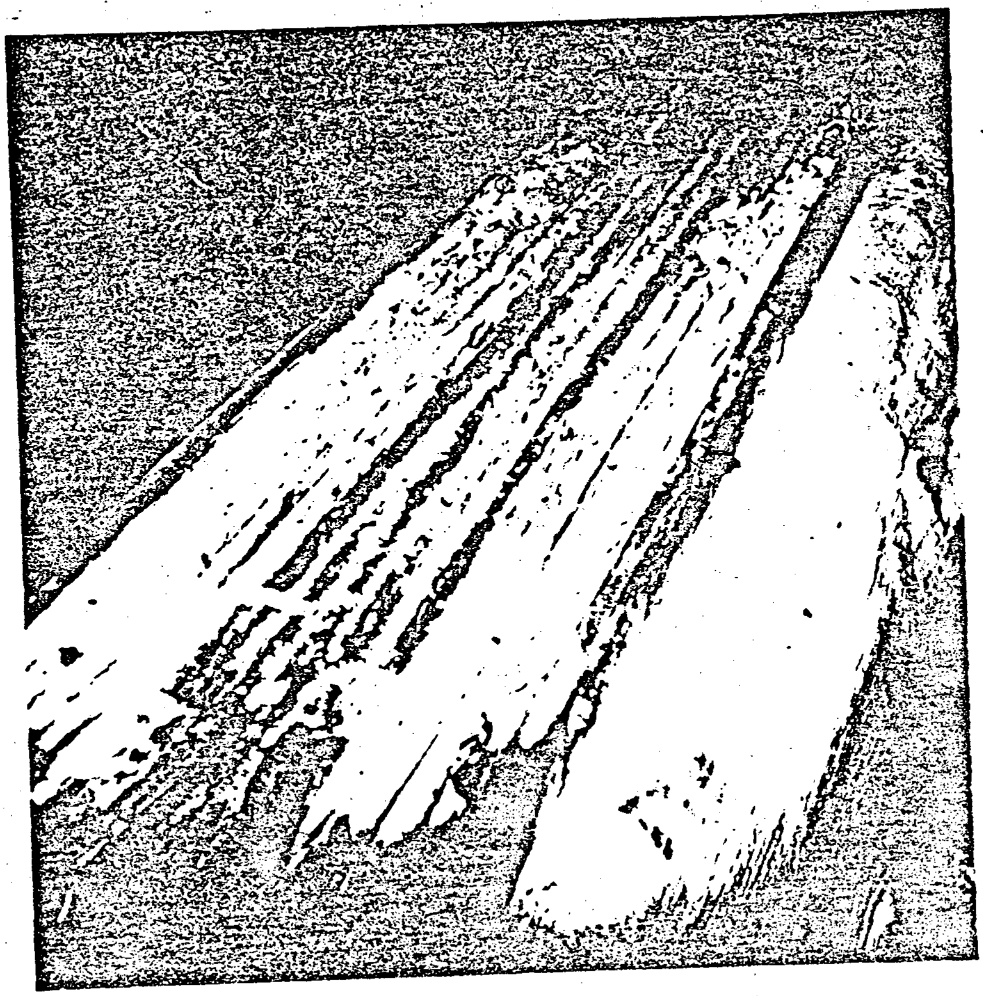


FIGURE 39

APPEARANCE OF CABLES IN CABLE TRAY AFTER TEST NO. 4 - WRAPPED WITH 1" KAOWOOL BLANKET (4" OVERLAP STRIP OVER BUTT JOINTS)

Attachment 2

October 30, 1979

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CINCINNATI GAS & ELECTRIC COMPANY	)	Docket No. 50-358
	)	
(Wm. H. Zimmer Nuclear Power Plant)	)	

Direct Testimony of Gregory A. Harrison
Bert M. Cohn, and Robert D. Barnes

Regarding Contention No. 17, Kaowool

As A Fire Barrier For Cable Trays

Gregory A. Harrison hereby states as follows:

I am employed as a Fire Protection Engineer in the Auxiliary Systems Branch, Division of Systems Safety, Nuclear Regulatory Commission, Bethesda, Maryland. My educational and professional qualifications are set forth immediately below:

Education

B.S. Fire Protection Engineering, University of Maryland 1966; M.S. Civil Engineering, University of Maryland 1970; and M.S. Engineering Administration, George Washington 1979. I have received a certificate from Oak Ridge University covering the Radiation Safety Training Program. In addition, I hold professional engineering registrations in California and Maryland in fire protection and civil engineering. I belong to the Society of Fire Protection Engineers, the National Fire Protection Association and have authored numerous publications.

Experience

I joined the USNRC in August, 1977 as a fire protection engineer. In this capacity I have performed inspections of power reactors during the construction stage to ascertain conformity with fire protection criteria, including the Zimmer facility; evaluated the adequacy of licensees' fire protection programs and its relation to the safety of operations. Finally, I have prepared fire protection sections of the Staff's safety evaluations, for both BWR and PWR plants including the Zimmer facility, the appropriate pages of which are attached hereto and made a part of this testimony.

Prior to joining the Commission I worked two years for the Arabian American Oil Company (ARAMCO) in Dhahran, Saudi Arabia. I held the position of Chief, Fire Protection Engineer for the Facilities Engineering Division.

From January, 1973, to July, 1975, I worked for the National Bureau of Standards in Gaithersburg, Maryland as fire protection engineer in fire research testing.

From July, 1969, to January, 1973, I worked as a general engineer with the Naval Ship Engineering Center, Washington, D.C.

From May, 1967, to July, 1969, I worked as a fire protection engineer for NASA at Goddard Space Flight Center, Greenbelt, Maryland.

Bert M. Cohn hereby states as follows:

I am a consulting engineer specializing in fire protection and safety, building code analysis, and physical security by Gage-Babcock & Associates (GBA), 135 Addison Ave., Elmhurst, Illinois, where I hold the positions of Senior Vice President and Treasurer. GBA is a consulting firm specializing in fire testing and fire protection. GBA is under contract with the U.S. Nuclear Regulatory Commission to provide technical assistance for nuclear power plant fire protection program reviews and evaluations. GBA has been providing fire protection consulting services and technical assistance to NRC since 1976. I have been the project director for a major portion of this work.

Robert D. Barnes of GBA who works under my direct supervision is the project engineer for the Zimmer Nuclear Power Station.

Education and Experience of Bert M. Cohn

I have a B.S. in Fire Protection and Safety Engineering, Illinois Institute of Technology, 1952 and a Registered Professional Engineer in Illinois, New Jersey, New York, Virginia, and Alabama. I am a Certified Protection Professional (American Society for Industrial Security) and Certified Fallout Shelter Analyst (Federal Emergency Management Agency).

I have been employed by Gage-Babcock & Associates since 1977 as Senior Engineer and fire protection and safety consultant. My major activities have been in the area of (1) life safety code compliance surveys of institutional properties, (2) design of fire detection systems, (3) municipal fire department evaluations, and (4) nuclear power plant fire protection program reivew and evaluation. Prior thereto I was employed by Insurance Services Office, Wisconsin (1969-75), National Fire Protection Association, Boston (1975), Insurance Company of North America, Midwest Region (1975-76), and Veterans Administration, Wood, Wisc. (1976-77).

I am a member of Society of Fire Protection Engineers, American Society of Safety Engineers, American Society for Industrial Security, and American Society for Testing and Materials; Chairman of subcommittee on Combustibility standards, ASTM Committee E5 on Fire Standards; Member of Record Protection and Firesafety Symbols committees, National Fire Protection Association; and Chairman of Board of Fire and Police Commissioners, City of Elmhurst, Illinois.

I have lectured at college and professional symposia and have been a frequent speaker at professional society meetings and conferences, and authored numerous articles and reports.

I have been employed by Gage-Babcock & Associates since 1957; its vice president since 1963 and treasurer since 1968. I have participated in and directed hundreds of projects, including design and specification of detection, alarm and fire extinguishing systems; risk analysis studies in industrial and institutional properties; loss investigations of equipment failures, fires and explosions; systems analysis for code trade-offs and equivalencies; and research and testing. Prior to being employed by GBA I was employed by the U.S. Army Forces Far East in Japan and Korea as chief of fire protection sections (1955-57) and served in the U.S. Army in fire protection engineering positions at the Army Engineer Research & Development Laboratories and Army Forces Far East headquarters (1953-55).

Robert D. Barnes hereby states as follows:

Education and Experience

I have a B.S. in Fire Protection Engineering, Illinois Institute of Technology, 1969. Registered Professional Engineer in Wisconsin. I am a member of the Society of Fire Protection Engineers. I have been employed by GBA as a fire protection engineer since 1976 specializing in reviewing fire hazard and fire protection programs for nuclear power plants. I work under the direct supervision of Bert M. Cohn. Prior to being employed by GBA I worked in fire protection analysis for several insurance companies. I have witnessed tests of Kaowool and am familiar with its fire resistant properties.

The Miami Valley Power Project has raised Contention 17, regarding fire protection, which is set forth at length below.

Contention 17

> Fire insulation material which is being used to protect the cables in the cable trays from fire is inadequate to protect the cables in light of the cable tray installation design and cable tray load. The tests of the fire insulation material were improperly performed in that conditions which will exist during operation were not adequately simulated.

This matter is addressed in the fire protection section of the Staff's Supplement No. 1 to the Safety Evaluation, the two pertinent pages of which are attached hereto and made a part of this testimony. In further amplification of the protective value of Kaowool we state as follows.

Mr. Cohn and Mr. Barnes are associated with Gage-Babcock & Associates, Inc. and act as consultants to the NRC in the evaluation of fire protection programs for nuclear power plants. Messrs. Robert D. Barnes and Bert Cohn have participated in the NRC review and evaluation of the adequacy of fire safety measures to be incorporated in the Zimmer Nuclear Power Station including measures to protect electrical cables and cable trays. This work was done for and in close cooperation with the staff of Division of Systems Safety, NRC and in particular with Mr. Greg Harrison of the NRC. Using NRC guidelines (BTP 9.5-1) and nationally recognized fire protection standards, Mr. Barnes and Mr. Harrison reviewed the fire protection evaluation report submitted by the applicant for the Zimmer plant, provided comments, questions, and evaluations as to the adequacy of the fire protection features and tests, and performed an on-site, 3-day survey at Zimmer, attended meetings with the applicant to resolve differences as to the need for protective measures. Mr. Cohn's involvement with Zimmer was periodically to review the progress of Mr. Barnes' review and assist in resolving technical issues. In addition, Mr. Cohn witnessed, at the request of the NRC, the test of Kaowool as fire protective insulating material on cable trays by Portland Cement Association at their Construction Technology Laboratories on June 6, 1979, a copy of which is appended to this testimony. This report was written by Melvin S. Abrams. All of us, Messrs. Cohn, Barnes, and Harrison recognize Mr. Abrams as an acknowledged expert in the testing of fire resistant materials. The test procedures, equipment, and results are, based on our professiona knowledge and expertise, accurately set forth in the report authored by Mr. Abrams. We fully concur in the conclusions reached by Mr. Abrams that the Kaowool material and the design tested offers a 1-1/2 fire resistant rating for cable trays.

Our principal concern in the review and evaluation process is to assist the NRC to assure that an adequate level of fire protection is provided in areas where wiring and equipment serve safety equipment and could be subject to damage from a single fire incident. In the situation of cable trays, the location of each tray to the other, the location of trays within the space, the separation between redundant divisions, the presence of materials and equipment creating a fire exposure, the accessibility of the space for firefighting, the presence of fire detection and fire suppression equipment, and other factors are considered in establishing whether additional protective measures, such as fire barriers or insulation are required, and if so, what those additional protective measures should be. These determinations are made based upon our expertise in this situation. Both Messrs Barnes and Harrison have inspected the Zimmer facility.

For Zimmer, Barnes determined, with Mr. Harrison concurring, that there were several areas requiring additional measures of protection. The applicant has agreed to the installation of fire barriers, protective insulation, automatic sprinklers, or combinations thereof in those places recommended by Barnes and Harrison for additional protection. The applicant proposed to use Kaowool as a protective insulation material upon cable trays and conducted tests to show its adequacy for the purpose (Revision 12 to Zimmer Fire Protection Evaluation Report). Both Mr. Cohn and Mr. Barnes recommended to the NRC staff that these tests be rejected because they did not simulate standard ASTM E119 fire test conditions. In a memo to the Zimmer project manager dated April 19, 1979, from Stoltz to Bergman, the NRC staff stated that all fire tests todate submitted by Zimmer did not support a 1-1/2 hour fire rating and, hence, an open item existed (see staff legal filing 5/7/79).

An additional test was then scheduled by Zimmer, at the request of the NRC, to be conducted under standard test conditions, using the ASTM E119 procedures, at PCA Laboratories. Mr. Cohn reviewed the test procedures and equipment prior to the test and was satisfied that the test would represent at least as severe a condition as could reasonably be envisioned under actual use conditions in the Zimmer facility. PCA Laboratories and its manager of the fire research section (Mr. Abrams) are known by us to be experts, thoroughly familiar with standard fire test procedures and able to conduct such tests impartially and objectively. This test, using four fully loaded cable trays, each individually wrapped with Kaowool insulation, was conducted on June 6, 1979. Every few minutes during the test, Mr. Cohn checked the temperature recorders and observed the test specimens in the furnace for indications of premature failure. There were none. The protected trays successfully resisted the effects of the exposure fire for a period of not less then 90 min. This test is described in the report by Melvin S. Abrams, entitled "Fire Protective Cable Tray Fire Test," dated June, 1979, copy attached hereto. Mr. Cohn subsequently submitted his approval to the NRC via a letter "FIre Test of Cable Trays, Zimmer Nuclear Power Station," dated 12 June 1979. Although the cables did not carry full electrical loads, which would liberate some heat internally to the trays, we know that this parameter is not a major one because the issue involves an external fire exposure. The degree to which energized cables could hasten a test failure is well within the range of the normal variances one could expect from tests of this nature and, hence, externally minimal, e.g. a few minutes.

We are familiar with the fire test conducted under the auspices of Sandia Laboratories at Underwriters Laboratories on September 15, 1978, reported in NUREG/CR-0596, A Preliminary Report on Fire Protection. This test was to demonstrate the effectiveness of Kaowool and automatic sprinklers in protecting cables in vertical cable trays. We assisted in developing some of the criteria for this test. The fuel, 2 gal. of a flammable liquid (heptane), was poured on the floor, and some of it seeped under and through the Kaowool which was wrapped around the vertical cable tray.

Because of this, some of the heptane burned within and inside the Kaowool blanket and damaged some of the electrical cables. The Kaowool is totally noncombustible [composed primarily of silica and alumina compounds (SiO_2 and Al_2O_3)], cannot burn, and did not contribute to the fire. The effectiveness of this material as a fire protective insulation was not challenged by this test, and it did not fail. An adhesive material and a simple curb or sheet metal shield around the base of the insulating material would have prevented the liquid from seeping under and into the insulation. The applicant has agreed to provide curbs or shields and an adhesive coating wherever this situation exists at Zimmer.

The fire protection Section IV SER Supplement No. 1 (copy attached hereto) for Zimmer states that the PCA fire test conclusively demonstrates the adequacy of the Kaowool design and that Kaowool is acceptable as a fire barrier. All of us signing this testimony concur with that conclusion. We further conclude that a 1 inch layer of Kaowool wrapped around a cable tray will provide a 30-minute effective fire resistant barrier, a 2 inch will provide a 60-minute barrier, a 3 inch will provide a 90-minute barrier. By an effective barrier, we mean that the cables contained in the tray will be able to perform their function without failure for the quoted time period.

Gregory A. Harrison

Bert M. Cohn

Robert D. Barnes

Dated at Bethesda, Maryland,
this 30th day of October, 1979.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CINCINNATI GAS AND ELECTRIC COMPANY, et al.	)	Docket No. 50-358
	)	
(Wm. H. Zimmer Nuclear Power Station, Unit No. 1)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "Direct Testimony of Gregory A. Harrison, Bert M. Cohn, and Robert D. Barnes Regarding Contention No. 17, Kaowool As A Fire Barrier For Cable Trays" and "Direct Testimony of Frederico A. Maura Regarding Metal Chips in Control Rods" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class, or, as indicated by an asterisk by deposit in the Nuclear Regulatory Commission internal mail system, this 30th day of October, 1979:

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Statement of Issue

Section III.G of Appendix R to 10 CFR 50 requires that fire protection features be provided for structures, systems and components important to safe shudown. This includes protection of redundant trains of cables and equipment. Protection of safe shutdown power cables was provided. However, alternate shutdown capability was provided, rather than analyzing and protecting all control and instrumentation cabling in all fire areas.

Basis to Support Deviation Request

1. By condition of the Unit 3 Operating License issued in November, 1982, SCE was required to comply with Appendix R, Section III.G.

2. To provide remote hot shutdown capability that is electrically and physically independent of the control room and cable spreading room, fire isolation switches are provided to electrically isolate shutdown equipment controls on the remote shutdown panel from circuits in the cable spreading and control room.

3. All control and power circuits required for hot shutdown during or after operation of the isolation switches are identified and routed to insure electrical and physical independence from the control room and cable spreading room. The isolation switches insure that the remote shutdown panel and second points of control which are located in separate fire areas are not subject to the same design basis fire.

4. A control room fire could damage instrumentation circuits in both the control room and the remote safe shutdown room. Therefore, a non-safety related Essential Plant Parameters Monitoring (EPPM) Panel has been provided in the electrical penetration area. The EPPM Panel is independent of control room and remote shutdown panel indication. Parameters are provided on the EPPM Panel to provide the minimum required indication for the operator to safely shutdown the unit.

5. Cold shutdown can be achieved from outside the control room through the use of suitable procedures and by virtue of local control of equipment in conjunction with the instrumentation and controls described above.

6. NRC acceptance of the above design approach is provided in the NRC's SER; particularly in Sections 7.4 and 7.4.2.

Statement of Issue

Section III.G of Appendix R to 10 CFR 50 requires analysis and protection of associated non-safety circuits that could prevent operation or cause maloperation due to hot shorts, open circuits or shorts to ground, of redundant trains of systems necessary to achieve and maintain hot shutdown conditions. The design of associated circuits is in accordance with IEEE-384 and Regulatory Guide 1.75 as described in the Updated FSAR. However, NRC clarification letters to licensees provided additional definition of associated circuits. No reassessment was conducted.

Basis to Support Deviation Request

1. When promulgated, Appendix R, was applicable to plants licensed prior to January 1, 1979. Subsequent clarification letters in February, 1981 and March, 1982 were likewise addressed to licensees with plants licensed prior to January 1, 1979.

2. By condition of the Unit 3 Operating License issued in November, 1982, SCE was required to comply with Appendix R, Sections III.G, J and O.

3. The design of associated circuits in accordance with IEEE-384 and Regulatory Guide 1.75 is identified in Appendix R as an acceptable method of complying with Appendix R requirements related to associated circuits. Since that was the method utilized and further, since the NRC had not sent the subsequent clarification letters on the Units 2 and 3 Project docket, no reassessment was deemed necessary.

4. A reanalysis of associated circuits in accordance with the recent NRC guidance would not enhance to a significant degree the protection afforded by the current installation. The non-Class 1E instrumentation and control circuits originating from Class 1E equipment are treated as non-Class 1E circuits and are run in non-Class 1E raceways together with other non-Class 1E instrumentation and control circuits. The potential of these low energy circuits to provide a mechanism whereby a failure could be communicated to Class 1E circuits, because of the proximity of the non-Class 1E circuits to Class 1E circuits, is so low that it was not considered necessary to treat them as Class 1E circuits, or to provide an analysis to show that the Class 1E circuits are not degraded below an acceptable level.

5. Design measures were taken to assure that once the non-Class 1E circuits leave or become nonassociated with one Class 1E separation group, they are not routed in such a manner as to become associated with another redundant Class 1E separation group.

6. Within some instrumentation cabinets, non-Class 1E wiring is bundled with the Class 1E wiring. At the request of the NRC an analysis was provided to demonstrate that faults imposed on the non-Class 1E circuits routed with Class 1E circuits inside the safety-related cabinets would not degrade the safety systems below an acceptable level.

7. NRC acceptance of the above design approach is provided in the NRC's SER; particularly in Sections 7.8 and 8.3.4.

Statement of Issue

If Section III.G.2 of Appendix R to 10CFR50 is met by enclosing cable, equipment, and associated non-safety circuits in a fire barrier, the barrier is to have a 1-hour rating. The barriers in use at SONGS 2 and 3 are fabricated from Cerablanket, (a Johns-Manville product). Cerablanket is similar to Kaowool (a Babcock & Wilcox product) which has been tested, and found acceptable as a fire barrier with a minimum of 51 minutes of protection.

Basis to Support Deviation Request

1. Kaowool has been tested, in accordance with the heating rate specified in ASTM E-119 as a fire protective wrap around cable trays and conduit. The test results are provided in Attachment 1.

2. Kaowool is in use at other nuclear facilities. The NRC has accepted two 1" layers of Kaowool for use as a 1-hour barrier (Attachment 2).

3. A comparison of Kaowool versus Cerablanket is provided in Table 1. From this comparison of key properties, it can been seen that the products are almost identical.

4. The installation of Cerablanket is similiar to the tested configurations. A comparison is provided in Table 2.

5. The replacement of Cerablanket with Kaowool (a product consisting of the same basic properties) would not enhance to a significant degree the protection afforded by the current installation.

TABLE 1

Comparison of Kaowool Blanket and Cerablanket

Properties	Kaowool Blanket [1]	Cerablanket [2]
Melting Point (^oF)	3200	3200
Normal Service Temperature (^oF)	2300	2400
Specific Heat, Btu/lb-^oF at 1800^oF Mean	0.255	0.26
Specific Gravity	2.56	2.65
Thermal Conductivity (Btu-in/hr-ft^2-^oF)		
@ 500^oF Mean Temp.	0.32	0.38
1000^oF Mean Temp.	0.68	0.72
1500^oF Mean Temp.	1.20	1.24
Chemical Analysis, %		
Alumina, Al_2O_3	47.0	47.0
Silica, SiO_2	52.9	52.8
Ferric Oxide, Fe_2O_3	0.05	0.02
Titanium Oxide, TiO_2	0.07	0.01
Magnesium Oxide, MgO	0.07	0.02
Calcium Oxide, CaO	0.07	0.05
Alkalies, Na_2O	0.15	0.15
Boron Oxide, B_2O_3	0.07	0.01

1 - Kaowool Ceramic Fiber Product Catalog, Babcock & Wilcox

2 - Cerablanket 2400°F Alumina-Silica Refractory Fibers in Blanket Form, Johns-Manville Refractory Products, Sec. 110, Part 20, Dated 6-78. (IND-3194, 6-78).

TABLE 2

Comparison of Test and SONGS 2 and 3 Installation

Key Items	Test	SONGS 2 and 3
Insulating Material for Cable and Conduits	Kaowool blanket, 2 1-inch thickness, manufactured by Babcock & Wilcox	Cerablanket, 2 1-inch thickness, manufactured by Johns-Manville
Banding Material for Cable and	1. Stainless Steel 2. Carbon Steel	Stainless steel type 304 with minimum 3/4 inch wide and 0.020 inch thick.
Cable Trays	1. Steel Solid Bottom 2. Aluminum open ladder	Steel Solid bottom with ladder
Cable Tray Bracket Location from outer butt	1. 3" on one side of the outer and inner butt joint 2. 3" on both sides of the butt joint on the outer blanket	minimum 4" on both sides of the butt joint on the outer blanket
Cable Tray bracket spacing	Brackets were spaced 24" apart	maximum 14" apart
Conduit Bracket Location from outer blanket	2" on both sides of the butt joint on the outer blanket	maximum 14" apart, minimum of 4" on both sides of the but joint on the outer blanket
Distance between inner blanket butt joint and outer blanket butt joint	for conduit 8" for cable tray 18"	for conduit 12" minimum for cable tray 12" minimum

Statement of Issue

Section III.G of Appendix R to 10 CFR 50 provides criteria for protection of redundant trains of safe shutdown cables of equipment. Alternative separation criteria was utilized.

Basis to Support Deviation Request

1. NRC question FQ 015.38 provides the criteria to be followed inside containment. The stated criteria is essentially those of Appendix R although Appendix R was not identified.

2. SCE's response to FQ 015.38 as provided in the FHA provides a technical basis for concluding that the existing design within the containment is adequate. The technical basis provided is as follows:

   a. Upgraded seismically qualified standpipes have been added to the containment and three hose stations exist at most levels.

   b. Concrete floors between elevations separate redundant cable. Some redundant cable comes within 20 feet of each other as the cable approaches the equipment it serves.

   c. Access to the containment is limited during operations by strict administrative control which minimizes the possibility of transient combustibles accumulating in the containment. Further, before significant access could occur for refueling, the plant would be placed in a cold shutdown condition.

   d. The only source of substantial flammable exposure fire material is the reactor coolant pump oil and this is contained by the slope of the floors. Fire in the reactor coolant pump would be extinguished by an automatic deluge system installed around each pump. (Note: Subsequent to this response, SCE installed a reactor coolant pump lube oil collection system in compliance with Appendix R, Section III.O.)

   e. High voltage ionization smoke detectors are provided for containment levels 63, 45, 30 and 15 feet for early warning of fire.

   f. The addition of a 30-minute barrier to the containment could add debris to the ECCS sumps which could decrease reliability of the ECCS pumps.

3. The NRC's Safety Evaluation Report, Section 9.5.1.8(3) states that the containment fire protection features include: hose stations, fire detectors, and fire extinguishers. The SER also states that the NRC reviewed the FHA for areas inside the containment building and concluded that the fire protection meets the guidelines of Appendix A to BTP ASB 9.5-1 and is therefore acceptable.

4. There is no basis for the additional NRC statement in the SER that "The applicants have committed to implement the provisions of III.G.2 of Appendix R to 10 CFR 50 for areas inside containment." At the time the SER was issued (February, 1981) Appendix R, Section III.G was not applicable to Units 2 and 3.

Statement of Issue

Section III.L of Appendix R to 10 CFR 50 requires that alternative shutdown capability shall accommodate the post fire condition where offsite power is not available for 72 hours. In the FHA, postulated fires were not considered concurrent with loss of offsite power.

Basis to Support Deviation Request

1. The safe shutdown logic diagrams, Figures II-24 and II-25 of the Fire Hazards Analysis, identify those plant features necessary to achieve and maintain a safe shutdown in the event of a fire. As noted, these logic diagrams did not assume loss of offsite power.

2. By condition of the Unit 3 operating license, the NRC required SCE to meet the requirements of Appendix R, Sections III.G, J and O. Section L requirements, which require the assumption of loss of offsite power were not imposed. Thus, no reassessment was conducted by SCE.

3. The San Onofre Nuclear Generating Station switchyard is a high reliability design, in that it is a double bus arrangement, supplied by both the Southern California Edison Company (SCE) and San Diego Gas and Electric Co. (SDG&E) grids. The breaker control DC power for the SCE side of the switchyard is separate from the SDG&E side, and the breakers can be remotely operated from the San Onofre Units 2 and 3 Control Room. There are six tie lines (four SCE and two SDG&E) connecting the switchyard to the SCE and SDG&E grids. The SCE and SDG&E rights-of-way are separate and preclude any interaction between the rights-of-way. SCE has over 36 years of continuous system operation without a blackout and the Western Grid System is very stable and capable of handling large faults. Additionally, San Onofre Units 2 and 3 has four Diesel Generator Trains, two trains per unit, one train of which is capable of supplying the power necessary to safely shutdown each unit.

4. The San Onofre Units 2 and 3 operating instructions have incorporated two hours as the criterion for restoration of AC power. The vital bus batteries that supply IE instrument and required equipment power are sufficiently sized to operate for at least two hours. During the two hours allowed by procedures for restoration of AC power, the plant is maintained subcritical in a condition as close to hot standby as possible. It is considered that the two hour criterion is more than adequate for restoration of AC power (either offsite or onsite) based on the highly reliable switchyard design, highly stable grid system, and two redundant Diesel Generator Trains per unit.

5. The NRC staff reviewed SCE's offsite power system as well as the provisions for safe shutdown outside the control room. The NRC's SER Section 9.5.1.5 provides the results of the staff's review and concludes that "...the applicant's alternate safe shutdown system meets the requirements of Appendix A, and also meets Secton III.L of Appendix R to 10 CFR Part 50 and, therefore, is acceptable."

Statement of Issue

NRC IE Information Notice No. 84-09 (IN 84-09) lists the minimum monitoring capability the NRC staff considers necessary to achieve safe shutdown in accordance with Appendix R, Section III.L. The Essential Plant Parameters Monitoring (EPPM) panel is not equipped with either a source range flux monitor or Reactor Coolant System (RCS) cold leg temprature indication.

Basis to Support Deviation Request

1. By condition of the Unit 3 operating license, the NRC required SCE to meet the requirements of Appendix R, Sections III.G, J and O. Section L requirements were not imposed.

2. The EPPM panel was designed to allow monitoring of essential parameters while bringing the unit to cold shutdown in the unlikely event of a fire that disables circuits in both the control room and on the remote shutdown panel. The EPPM panel is equipped with the minimum parameters required for the operator to safely shutdown the unit.

3. Prior to control room evacuation, by procedure the operations are required to trip the reactor and to verify that the control rods are fully inserted. By virtue of local control of equipment, additional negative reactivity is inserted into the RCS in the form of boric acid, charged from either the boric Acid Makeup System or the Refueling Water Storage Tank. The minimum boric acid concentration, and the corresponding negative reactivity, is established by the Technical Specifications. The boric acid concentration existing in the RCS at the time of reactor trip can be determined from the previous sample. Additionally, the minimum charging pump flow rate is also established by the Technical Specifications. Thus, boron concentration can be evaluated based upon the charging rate for a given time duration. This procedure is consistent with the Technical Specification Limiting Conditions for Operation regarding shutdown margin, thus precluding the necessity for neutron flux monitoring .

4. Monitoring only RCS hot leg temperature during plant cooldown under natural circulation conditions from the EPPM panel fulfills the intended function of this panel and provides the operator with sufficient information when used with the other indications available on the panel. Temperature indication on this panel is required to monitor the cooldown process and determine when RCS conditions are such that shutdown cooling can be initiated. In addition, steam generator pressure is used to indirectly infer RCS cold leg temperature under subcooled natural circulation conditions. To accurately correlate steam generator pressure to cold leg temperature, the following three parameters are used by the operator at the EPPM panel:

   a. Sufficient inventory in the steam generators to cover at least the first one-third of the tube bundle height.

   b. Sufficient auxiliary feedwater flow to maintain steam generator inventory.

   c. At least 20°F of subcooling exists in the RCS (as measured using highest hot leg temperature and pressurizer pressure).

This is consistent with the current San Onofre operating instruction on natural circulation which requires monitoring of both RCS subcooling and steam generator inventory to insure adequate natural circulation flow.

5. NRC acceptance of the above design approach is provided in the NRC's SER; particularly in Sections 7.4, 7.4.2 and 9.5.1.5.

6. The lack of RCS cold leg temperature indication on the EPPM panel was previously addressed in SCE's response dated November 29, 1983 to a Notice of Violation from NRC Region V on this subject. In addition, the same information was provided to NRR by SCE's letter dated January 6, 1984.

Statement of Issue

Section III.J of Appendix R to 10CFR50 requires "emergency lighting units with at least an 8-hour battery supply be provided in all areas needed for the operation of safe shutdown equipment and in access and egress routes thereto." Eight-hour emergency lighting units have been provided in and to those areas required to achieve hot shutdown. However, 8-hour emergency lighting units have not been provided in and to those areas required to achieve cold shutdown.

Basis to Support Deviation Request

1. Hot shutdown can be achieved within eight hours of evacuation of the Control Room. According to Section III.G.1.b of Appendix R to 10 CFR 50 cold shutdown equipment must be capable of repair within 72 hours.

2. One train of equipment necessary to achieve and maintain hot shutdown remains free of fire damage (Section 7.0 Updated Fire Hazards Analysis). In the event of loss of normal ac lighting, hot shutdown can be achieved using the 8-hour emergency lighting units and can be maintained until lighting is restored.

3. The San Onofre Nuclear Generating Station switchyard is a high reliability design, in that it is a double bus arrangement, supplied by both the Southern California Edison Company (SCE) and San Diego Gas and Electric Co. (SDG&E) grids. The breaker control DC power for the SCE side of the switchyard is separate from the SDG&E side, and the breakers can be remotely operated from the San Onofre Units 2 and 3 Control Room. There are six tie lines (four SCE and two SDG&E) connecting the switchyard to the SCE and SDG&E grids. The SCE and SDG&E rights-of-way are separate and preclude any interaction between the rights-of-way. SCE has over 36 years of continuous system operation without a blackout and the Western Grid System is very stable and capable of handling large faults. Additionally, San Onofre Units 2 and 3 has four Diesel Generator Trains, two trains per unit, one train of which is capable of supplying the power necessary to safely shutdown each unit.

4. The San Onofre Units 2 and 3 operating instructions have incorporated two hours as the criterion for restoration of AC power. The vital bus batteries that supply IE instrument and required equipment power are sufficiently sized to operate for at least two hours. During the two hours allowed by procedures for restoration of AC power, the plant is maintained subcritical in a condition as close to hot standby as possible. It is considered that the two hour criterion is more than adequate for restoration of AC power (either offsite or onsite) based on the highly reliable switchyard design, highly stable grid system, and two redundant Diesel Generator Trains per unit.

5. Lighting lost as a result of the fire will not impair hot shutdown. Seventy-two hours is allowed to repair lighting for areas necessary to achieve cold shutdown. Eight-hour emergency lights are not required to achieve cold shutdown, since normal ac lighting is assumed to be restored to allow cooldown of the unit in the allotted time. If normal ac lighting cannot be reestablished in an emergency, compensatory measures, such as use of hand held lights, and use of portable generators and lights are available to provide additional emergency lighting.

Statement of Issue

Sections III.G.2 and III.G.3 of Appendix R to 10 CFR 50 specify four alternatives that may be implemented outside of primary containment to assure that one redundant train of equipment and cabling necessary to achieve and maintain hot shutdown remains free of fire damage. Contrary to the above requirements, common walls of rooms containing redundant trains of certain safe shutdown equipment have open (unsealed) penetrations.

Basis to Support Deviation Request

1. By condition of the Unit 3 Operating License issued in November, 1982, SCE was required to comply with Appendix R, Section III.G.

2. The existing common walls in these rooms are either fire walls rated in excess of the fire loading or walls of massive concrete construction. The acceptability of walls of massive concrete construction with unsealed penetrations as suitable separation barriers between redundant safe shutdown equipment is based on the following:

   a. There are minimal fire loadings in these rooms,

   b. Unsealed penetrations in walls have a small cross-sectional area compared to the total wall surface area and provide little or no path for fire propagation, and

   c. Transient combustibles are controlled by administrative procedures.

3. It was believed that this design had been discussed with, and examined by NRR during the licensing process and found by them to be acceptable. SCE's July 22, 1982 letter to NRR identified exceptions to the guidelines provided by Branch Technical Position 9.5-1. In the July 22, 1982 letter, on page 2, SCE states that, "Because of the vintage of SONGS 2 and 3..." the design had "...not provided three hour fire rated barriers in all areas...", "However, fire barriers have been provided, as detailed in the Fire Hazards Analysis, which have been reviewed by the (NRR) staff with respect to fire loading and safe shutdown capability and found to be acceptable...."

4. SCE's understanding that NRR had accepted this design was based on meetings with NRR which included a walkdown and examination by NRR representatives in August 1979. During this walkdown, the NRR representatives examined the fire barrier walls and, although they commented and took exception to other areas of the plant during the walkdown, no exception was taken to the non-sealed massive concrete walls.

5. This basis for acceptability of the present design was previously addressed in SCE's response dated November 29, 1983 to a Notice of Violation from NRC Region V on this subject. In addition, the same information was provided to NRR by SCE's letter dated January 6, 1984.

Enclosure 2

Deviations to NRC fire protection requirements that have been approved previously by the NRC as documented in the NRC Safety Evaluation Related to the Issuance of Operating License NPF-15, San Onofre Nuclear Generating Station, Unit 3, Docket No. 50-362, dated November 15, 1982.

As discussed in the Safety Evaluation Related to the Issuance of Operating License NPF-15 for San Onofre, Unit 3, dated November 15, 1982, the NRC has reviewed the following requests for deviations, from the recommendations of BTP CMEB 9.5-1, which include those previously approved in the SER, and has found them to be acceptable.

a. The fire brigade leader's qualifications will not be as recommended by Item C.3.b; however, a sixth member will be added to the fire brigade who will be an assistant operator.

b. The doors to the computer rooms on the 30' elevation will not be electrically supervised as recommended by Item C.5.a. Instead, this area is continuously manned by the control room operators.

c. Fire detectors will not be installed in 18 areas identified in the SCE's July 27, 1982 letter containing safety-related equipment, as recommended by Item C.6.a. These areas do not contain significant amounts of combustible materials.

d. The remote shutdown panels will not be separated by a three-hour rated fire barrier as recommended by Item C.7.f. Instead, they will be electrically isolated from the control room and separated by a two-hour barrier.

e. The fire extinguishing system for the diesel generators is not designed for operation without affecting the diesel, as is recommended by Item C.7.i. Redundant diesel generators are provided, protected by separate extinguishing systems.

f. The auxiliary feedwater pumps are not separated by three-hour rated barriers. However, a metal shroud will be provided between the steam driven pump and the newly installed motor driven pump, and a one-hour barrier and a sprinkler system is provided between the steam driven pump and existing motor driven pump.

g. The fire pumps are not separated by three-hour rate fire barriers as recommended by Item C.6.b. Instead a cross tie is provided between units.

h. The oil collection system for the reactor coolant pumps is in accordance with our guidelines. Approval of a deviation is not needed.

i. Hose standpipes will not be installed in fire zones 28 and 45 as recommended by Item C.6.c. Instead, fire detectors will be provided.

j. Only one of the three charging pump rooms will be provided with a fire damper instead of all three as recommended by the guidelines in Item C.5.a. However, only one pump is needed for safe shutdown.

k. An adequate number of sectionalizing valves have not been provided for the fire main recommended by Item C.6.b. Instead, a backup system is provided.

l. Three-hour fire rated barriers are not provided in all areas of the plant as recommended by Item C.5.a. Fire barriers of lesser fire resistance are accepted in the various plant areas listed in paragraph 9.5.1.3 of the SER based on the fuel load in the area.

m. Approved fire door assemblies are not provided in fire zones 44, 83 and 50 as recommended by Item C.5.a. Alternative doors are provided which provide adequate fire resistance.

n. Not all redundant trains are separated by three-hour rated fire barriers as recommended by Item C.5.b. One-hour rated fire barriers in conjunction with automatic suppression systems have been accepted for those plant areas listed in paragraph 9.5.1.6 of the SER, based on the fuel load in the area.

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