Enclosure 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUL 2 1981

MEMORANDUM FOR: Darrell G. Eisenhut, Director, Division of Licensing, NRR
Richard H. Vollmer, Director, Division of Engineering, NRR

FROM: James H. Sniezek, Director, Division of Resident and Regional Reactor Inspection, IE

SUBJECT: SANDIA CONNECTOR TEST RESULTS

Forwarded for your information is a preliminary IE Inspection Report covering a recently completed environmental test by the Sandia National Laboratory of an electrical penetration assembly (EPA) supplied by the Duke Power Company. The specific EPA was one of a batch of assemblies procured from the D. G. O'Brien Company for installation in the Catawba plant. Similar units are installed in the McGuire plant.

Testing resulted in a failure (electrical grounding) of three of the 208 individual conductors passing through the connector assembly. Thirteen of the remaining conductors also showed a reduction in resistance to ground but maintained electrical continuity. The failure was analyzed to have been caused by the extrusion of grommet sealing material which stripped insulation from the conductors and exposed the conductor to a metallic plug sleeve. The extrusion mechanism is attributed to the elevated temperatures utilized in the accelerated aging process.

We believe that the test results are inconclusive regarding the connector assembly suitability for service since the installed assemblies will not be exposed to the elevated aging temperatures during actual service life. Under lower temperature conditions, induced stresses in the assembled unit are lower; thereby, extrusion of the grommet material would not be expected to occur. Previous qualification tests provide adequate assurance that the extrusion mechanism should not cause failure during or following postulated LOCA conditions.

The Duke Power Company is currently initiating additional tests to further confirm that the failure mechanism was caused by the accelerated aging process and to further confirm that with proper adjustments that the EPA is suitable for its intended service.

IE plans to monitor these tests.

J. H. Sniezek
James H. Sniezek, Director
Division of Resident and Regional
Reactor Inspection
Office of Inspection and Enforcement

Enclosure: As stated

8107210197 810708
PDR ADOCK 05000369
G PDR

cc/w enclosure:

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Date: June 26, 1981

To: W. R. Rutherford

From: D. G. McDonald
J. R. Agee

Subject: Preliminary Assessment of D. G. O'Brien, Type K, Electrical Penetration Assembly (EPA)

The purpose of this memorandum is to provide a preliminary description and assessment of the failures which occurred during the verification test of the subject EPA. On June 23, 1981 a meeting was held with representatives of SNL, Duke Power Company (DPC), D. G. O'Brien, and Brand Rex Cable Co. to devise a disassembly procedure for the test specimen. The purpose of the procedure is to identify, isolate and determine the cause of failures which occurred during the test. This procedure, Attachment A, was revised on June 24 and 25 as the result of information obtained as the disassembly progressed.

Sequence of Events

1. The EPA was received by SNL and a visual inspection was performed. Each connector (coupling) ring required approximately one-quarter (1/4) turn re-torquing to achieve the specified twenty-five (25) ft-lbs torque.

2. Pre-test insulation resistance (IR) measurements were taken to establish baseline data. The readings were in the range of 10^9 ohms.

3. The EPA, including the cable connector assemblies, was aged for one-hundred-sixty-eight (168) hours at 150°C. All the connectors required approximately one (1) turn of re-torquing subsequent to the accelerated thermal aging process.

4. Post thermal aging IR measurements were taken. The readings were in the range of 10^9 ohms. Post radiation (approximately 240 hours at .75 MR/hr) IR measurements were approximately one-half the post thermal aging IR values. Also, about one-sixth turn of re-torquing was applied prior to the accident sequence.

5. The harsh environment portion of the test was initiated with 600V AC applied to all the circuits. Approximately three (3) hours into the test, at 120°C saturated steam, the 600V AC was removed and functional measurements (continuity and IR readings) were taken on all circuits. Initially, twelve (12) of the 104 circuits exhibited low or erratic readings. The 600V AC could not be re-established on two (2) of these circuits which were , pin "J" of connector assembly Nos. 10 & 15, and pin "K" of connector assembly Nos. 1 & 12. Both circuits drew excessive current which tripped the 600V AC power supply.

6. Prior to completion of the test a third failure occurred. The failure was on pin "G" of connector assembly Nos. 3 & 13 and required removal of the 600V AC.

7. Final IR readings, prior to termination of the test, were taken on all circuits. The readings were in the range of 10^6 to 10^7 ohms. Of the initial thirteen (13) circuits with IR readings of less than 10^6 ohms, seven (7) recovered, exhibiting readings greater than 5 x 10^6 ohms. Three (3) of the remaining six (6) were the previously identified short circuits which required removal of the 600V AC.

8. All circuits, excluding the three (3) short circuits mentioned above, were energized with 600V AC with leakage current in the range of 0.4 to 0.8 milliamps (ma) during the test.

9. The test was concluded and the following actions were performed:

a. All immersion heaters were turned off.
b. The water in the test chamber was pumped out and the test was vented to atmosphere.
c. The 600V AC power supply was disconnected.

10. Approximately twenty-four (24) hours after termination of the test, IR and continuity measurements were taken. Only seventeen (17) circuits had readings greater than 10^6 ohms,

and twenty-five (25 circuits could withstand the 600V AC while drawing less than five (5) ma of current.

Disassembly Procedure

Attachment A provides the detailed disassembly procedure used by the SNL staff to isolate the failures and provide detailed information to assist in determining the causes of the failures. The acceptance criteria identified in the test plan was that the circuits be capable of maintaining 600V AC power and periodic IR readings greater than 5×10^6 ohms.

A brief summary of the actions required by the procedure is:

1. Examination of the external connectors

2. Removal of the test chamber cover.

3. Performance of hi-pot testing of all circuits with the cable submerged in water to assure that no shorts existed in the internal jumper cables.

4. Detailed examination of the failed circuits.

5. Removal of the remaining internal cable connector assemblies.

Preliminary Findings

Attachments B through E provide details of circuit arrangements, connector pairs, cable connector assemblies, and test set-up details.

Attachment B identifies the failed circuits which include the three (3) circuits that appeared to be shorted. Determination was made to concentrate on the connector pair assemblies, which include the apparent short circuits and also some circuits exhibiting low IR readings.

Attachment C identifies the connector pair assemblies. The external cable and connector assemblies were disconnected and eliminated as a source of the faults. The test chamber lid was then removed, exposing the test specimen. The junction box which housed the cable connector assemblies was removed. The cables were then submerged in water and a hi-pot was performed to determine if my faults existed in the cable portion of the assemblies. No faults were found.

The next step was to isolate the location of the fault which would be in one (1) of the connectors of the connector pair assembly, or one (1) of the modules to which the connectors are mated.

Attachment E provides a view of a connector pair and its mating penetration modules. The faults were isolated to individual connectors with one (1) exception; pin "G" on module exhibited a low IR reading.

Attachment D identifies the component parts of the connector. It was determined that the cable grommet, which provides the seal for the back portion of the connector, was where the faults were occurring. One (1) of the connector assemblies was dried overnight in a vacuum oven to determine if a direct short existed or if the apparent direct short was the result of moisture ingress. All the low IR readings on that connector improved with the exception of the pin assumed to be shorted. This pin exhibited a low IR reading, indicating a partial but not direct short. During the removal of the connector cable assemblies from the modules, it was noted that the connectors which connected to the inner ring of modules (11 through 16) had moisture on the connector faces. However, with the exception of the modules, the surfaces of the penetration modules appeared to be dry. It should also be noted that the outer ring of modules (1 through 10) had no moisture at the connector faces. See Attachment C for the module locations.

Assumed Causes

The failure mechanism appears to be the cable grommet which provides the rear seal. The grommet material is a Dow Chemical Co. RTV silicone. It appears that the re-torquing of the connectors identified in the "Sequence of Events" section, resulted in extruding the silicone material and displacing the cable conductor insulating material (XLPE, cross-linked polyethylene) resulting in exposed or partially exposed conductors near the brass plug sleeve. The initial thickness of the grommet was 250 mils. Measurements taken indicate the grommets were compressed to about 150 mils after the re-torquing. As previously noted, the connectors required a full turn of torquing (60 mils) after the accelerated aging process.

Conclusions

As identified above, the extrusion of the cable grommet material, resulting in a weak point or bare wires in the cable conductors, was the probable cause of the failures. It was noted that during the disassembly that some cable clamps had broken and the rear connector coupling rings were loose. However the broken clamps did not contribute to any of the failures. The loose rear coupling rings were not the probable path for the moisture ingress at the interface of the cable connector and module. It is assumed the path for the moisture ingress was through the rear of the connector as the result of the rear seal failure.

Follow-Up Actions

SNL will perform the following:

1. Record IR reading on all cable connector assemblies, both wet and dry.

2. Evacuate EPA module No.3 and determine if the low IR reading on pin "G" is the result of moisture.

3. Perform IR readings on remaining modules.

4. Provide dimension/durometer measurements of the silicone grommet at the penetration module interface

SNL requested that D. G. O'Brien provide detailed information on the materials, tolerances, and assembly of the connectors. SNL also indicated that a preliminary report will be provided by July 15, 1981. We indicated to SNL and Duke Power Co. (DPC) representative that a meeting will be held at NRC headquarters following the receipt of the SNL report.

Copy to:

D. G. McDonald (2)
4440 G. R. Otey
4445 L. O. Cropp
4445 L. L. Bonzon (3)

MFD

Disassembly Procedure for Catawba
Penetration/Connector Assembly

Dated: June 23, 1981
Revised: June 24, 1981
Revised: June 25, 1981

Completed

1. Take Insulation Resistance (IR) readings (at 500V DC) while still at temperature (about 109°C).

2. Take IR readings when the unit reaches room temperature.

3. Take IR readings again before starting disassembly.

4. Disconnect #2 (14-pin) outboard connector.

   A. Cut cable 2-3 feet above the connector

   B. Check and record forward torque before removing the connector

   C. Take pictures documenting status

5. Disassemble #2 outboard connector

   A. Document status, condition

   B. Hilberg disassembles, to determine condition

6. Check reverse torque on all outboard connectors.

7. Disconnect all outboard connectors.

8. Take IR readings of all suspect pins/connectors.

9. Open test chamber, perform IR measurements and hi-pot tests on suspect pins/connector (limit to 600V AC and increase slowly) remove inboard junction box.

10. Visually inspect and document status of inboard connectors and cabling; note any abnormalities.

11. Suspend cables only in suitable water bath (e.g., the test chamber) to do low hi-pot tests and IR measurements. The cable clamps shall not be submerged.

12. Perform IR measurements and hi-pot tests on suspect pins/connectors.

    A. Limit hi-pot tests to 600V AC to prevent further damage; increase slowly

    B. Watch for flashes or bubbling in water as voltage is

Dated: June 23, 1981
Revised: June 24, 1981
Revised: June 25, 1981

<u>Completed</u>

13. Remove cables from water bath.

14. Remove cable clamps from inboard connectors; do not spread cables.

    A. Perform visuals and document

    B. Perform IR measurements and hi-pot tests (up to 600V AC and increase slowly) on suspect pins. (Attempt to detect ground connection in clamps)

15. Spread cables and repeat step 14.

16. Cut conductors (at middle of loop) and perform IR measurements on the suspect pins; this procedure will isolate the damaged connector modules.

17. Check and record forward torque on #2 inboard connector.

18. Remove #2 inboard connector (this is deemed a "good" connector).

    A. Visually inspect receptacle, record and document observations

    B. Do immediate IR measurement on module/penetration

    C. Bag and tape the receptacle to prevent moisture dryout of face

19. Disassemble #2 inboard connector.

    A. Visually inspect for moisture intrusion on sealing surface

    B. Check for damage; take pictures

    C. Hilberg disassembles, to determine condition

    D. Compare to #2 outboard connector condition. (Determine general condition of connector for use in further dis-assembles)

20. Measure reverse torque on #10 (or #15) inboard connector depending on previous steps. This is start of disassembly of a deemed "bad" connector.

Dated: June 23, 1981
Revised: June 24, 1981
Revised: June 25, 1981

Completed

21. Remove #10 (or #15) inboard connector.

    A. Visually inspect receptacle, record and document observations

    B. Do immediate IR measurements on module/penetration

    C. Bag and tape the receptacle to prevent moisture dryout of face

22. Perform IR measurement on #10 (or #15) inboard connector.

    A. If shorted, dry in vacuum oven at low temperature, for a period of time. Repeat IR measurement

    B. If not shorted, perform disassembly

23. Disassemble #10 (or #15) connector

    A. Visually inspect for moisture intrusion on sealing surfaces

    B. Check for damage; take pictures

    C. Hilberg disassembles, to determine condition

    D. Check for:

        - moisture between grommet and insulation

        - deformation of the conductors at grommet

        - grommet condition

        - other physical damage

24. Repeat steps 20-23 on #15 inboard connector.

25. Repeat steps 20-23 on the #3 inboard connector; as deemed necessary (some parts of 20-23 may be omitted).

26. Repeat steps 20-23 on #13 inboard connector; as deemed necessary (some parts of 20-23 may be omitted).

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Revised: June 24, 1981
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<u>Completed</u>

27. Repeat steps 20-23 on #1 inboard connector; as deemed necessary (some parts of 20-23 may be omitted).

28. Repeat steps 20-23 on #12 inboard connector; as deemed necessary (some parts of 20-23 may be omitted).

29. Remove all other inboard connectors; perform visual inspections, document all observations, bag and save all pieces.

ATTACHMENT D
FAILED CKTS

Division/Dept. ______

Subject ______ Gp 1

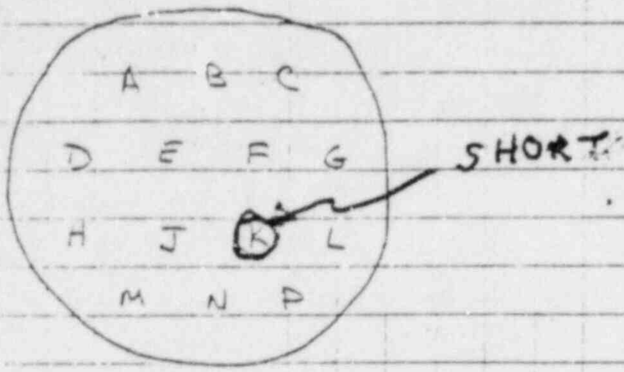
______ By ______ Date ______

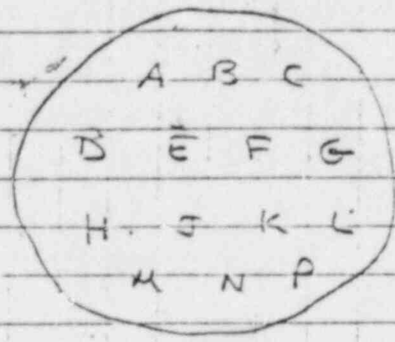
Sheet No. ___ of ___ Problem No. ______ Checked By ______ Date ______

1 & 12

2 & 11

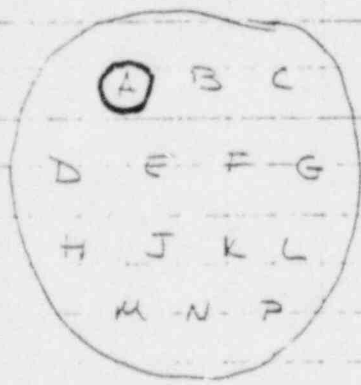
(CL)

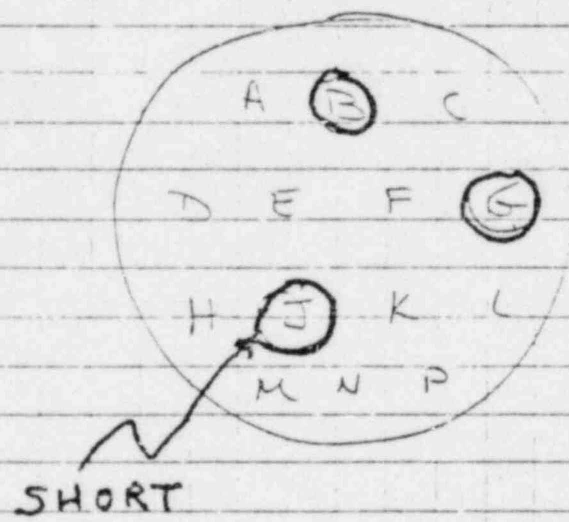




9 & 16

10 & 15





O = SHORT OR LOW IR READINGS

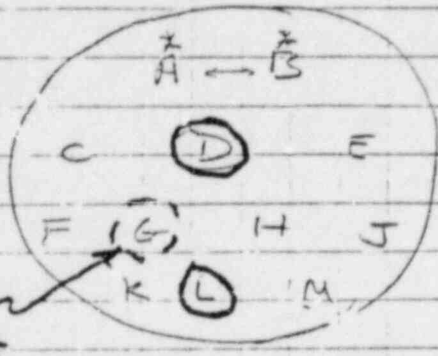
Unit ___ File No. ___

GP 2

By ___ Date ___

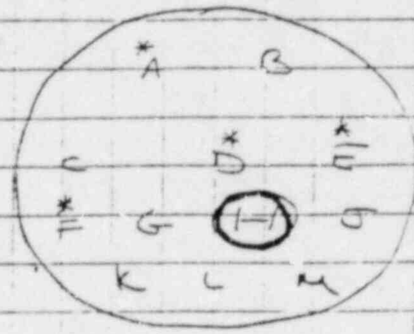
Sheet No. ___ of ___ Problem No. ___ Checked By ___ Date ___

3 & 13

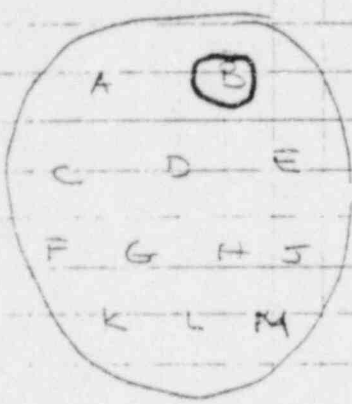


SHORT
(END OF TEST - LOW IR IN MODULE)

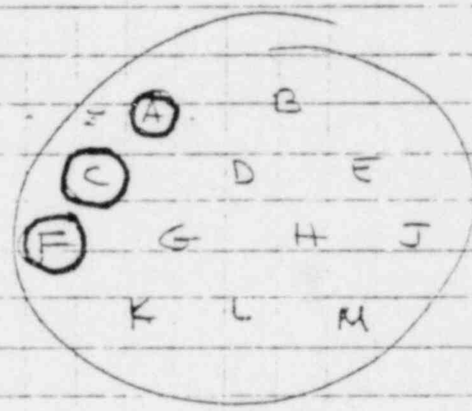
4 & 14



5 & 7



6 & 8

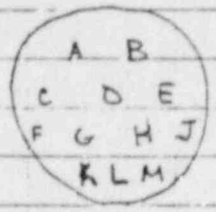


ATTACHMENT C

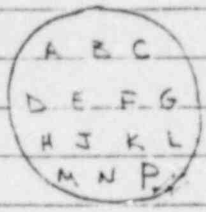
Station PIN ARRANGEMENTS Unit File No.
Subject AND CONNECTOR PAIRS

By Date
Sheet No. of Problem No. Checked By Date

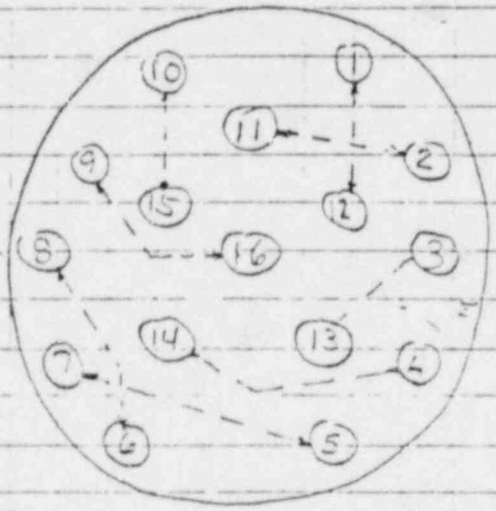
Gp 2



Gp 1



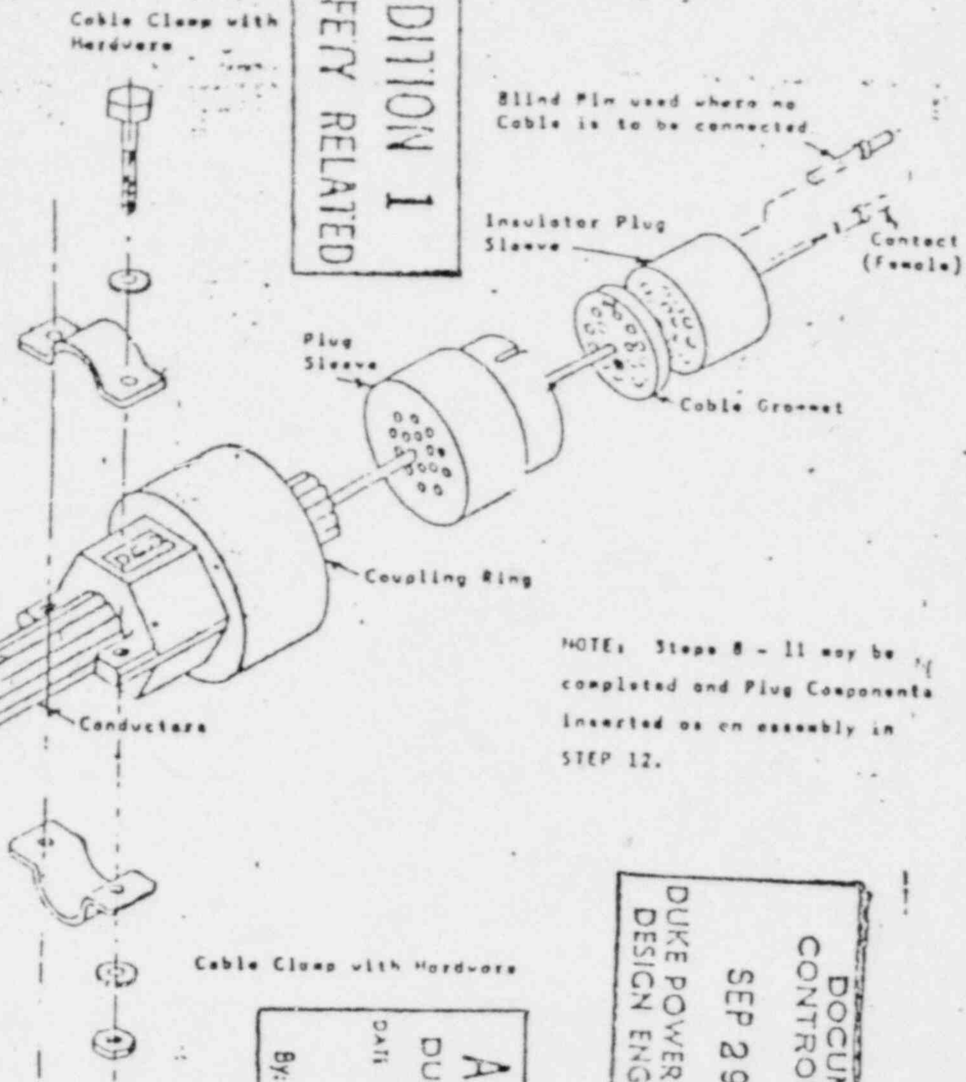
EPA



(CONNECTOR PAIRS)

CABLE/CONNECTOR ASSEMBLY

QA CONDITION 1
NUCLEAR SAFETY RELATED



NOTE: Steps 8 - 11 may be completed and Plug Components inserted as an assembly in STEP 12.

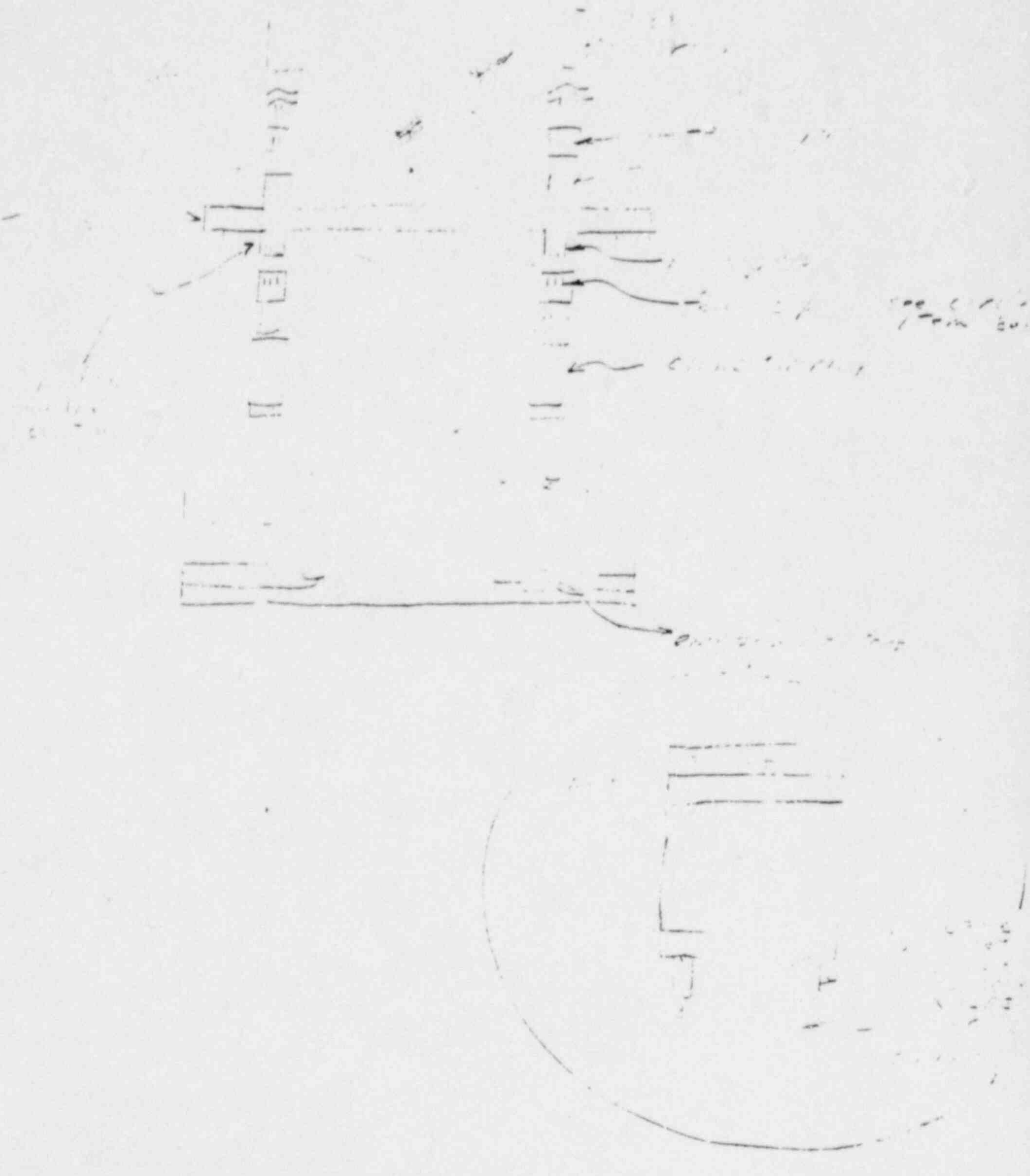
1. Position ring coupling on conductor bundle end and slide far enough back to complete first stages of assembly.
2. Insert conductors thru plug sleeve following appropriate wiring diagram.
3. Insert conductors thru grommet. Identifying information on grommet faces towards ring coupling and containment side ident (in or out) aligns with key way on sleeve.
4. Insert conductors thru insulator and extend approximately 3 inches.
5. Strip conductors according to wire size in Table.
6. Crimp contact (female) using crimp tool
7. Insert contacts onto module pins and bottom against contact flanges ' Optional - See NOTE.
8. Lightly coat the conductor insulation with Dow Corning DC-5 silicone grease.
9. Slide insulator down over contacts.
10. Slide plug grommet down to insulator.
11. Slide sleeve down over grommet and insulator aligning key way with key module.
12. Slide the coupling down and engage threads. Screw down by hand until pressure can be applied to grommet. Using tool No. C32C2067P03 torque coupling to 20 ± 10 ft. lbs.
13. Install cable clamp and tighten.

Cable	Plug Kit		Crimp Tool	Strip Length	Module No.*
	Inboard	Outboard			
#14 (Quad)	C32P1010G03	C32P1010G04	Buchanan 615708 with 615709 turret (Yellow Position)	5/16	A/R 3 thru 9 13,14
#16 (TSP)	C32P1010G07	C32P1010G10	Buchanan 615708 with 615709 turret (Yellow Position)	5/16	A/R 3 thru 9 13,14
#16 (TSP)	C32P1009G01	C32P1009G06	Buchanan 615708 with 615709 turret (Blue Position)	5/16	1,2 9 thru 12 15,16 A/R

DOCUMENT CONTROL DATE
SEP 29 1980
DUKE POWER COMPANY
DESIGN ENGINEERING

APPROVED
DUKE POWER C
DATE SEP 30 1980
C. J. WYLIE
CHIEF ENGINEER
By: ELECTRICAL DIVIS

TEST SETUP DETAILS



ATTACHMENT 1

ATTENDANCE LIST

COMPANY: Sandia National Laboratories DOCKET NO. 99900901

Date: June 23, 1981 [X] Pre-Inspection Conference [ ] Post Inspection Conference

NAME (Please Print)	TITLE (Please Print)	ORGANIZATION (Please Print)
DANIEL McDONALD	NRC CONSULTANT	LASL
J.R. Agee	Equip. Qual. Engr.	NRC, OIE, ARLINGTON T
Paul M McBride	Equip't Spec.	Duke Power
ED SALAZAR	CONSULTANT	SANDIA
Robert J Flaherty	Consultant	Life Cycle Engineering
[illegible] P. HILBERG	ENG MGR	D.G. O'Brien Inc.
DAVID JEPPESEN	SANDIA MTS CONSULTANT	
W.H. [illegible]	Sandia	
ED WALTON	Engr. Mgr. Brand-Rex Co.	
FRANK THOME	SANDIA -	
P.K. Das	Mg R/D Brand-Rex Co.	
GREG C. ROGERS	Ass Qual Testing Engineer	Duke Power
LLOYD BONZON		SANDIA

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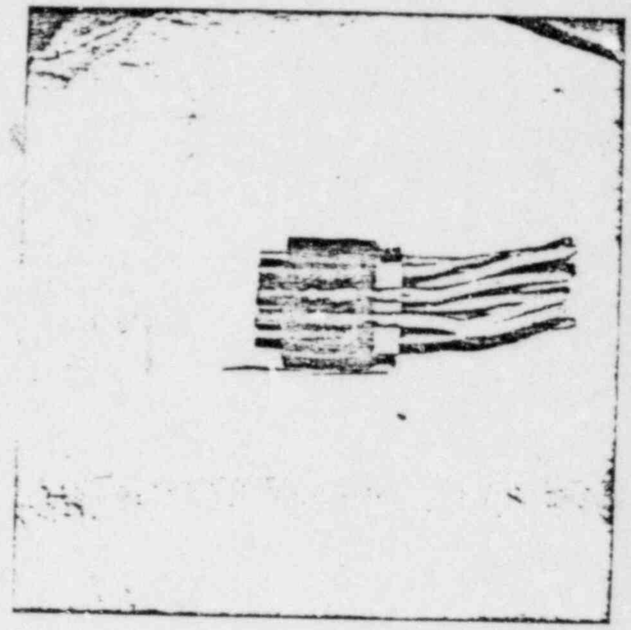

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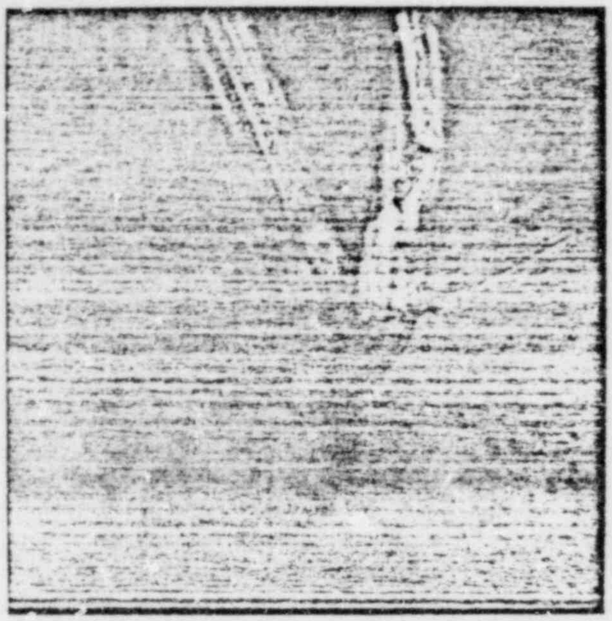
IN BOARD [illegible]
junction box [illegible] ③

Inboard [illegible]
removed ④



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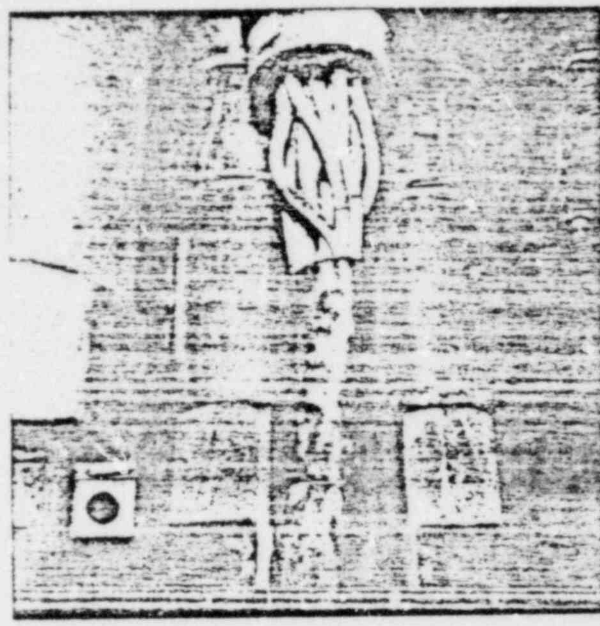

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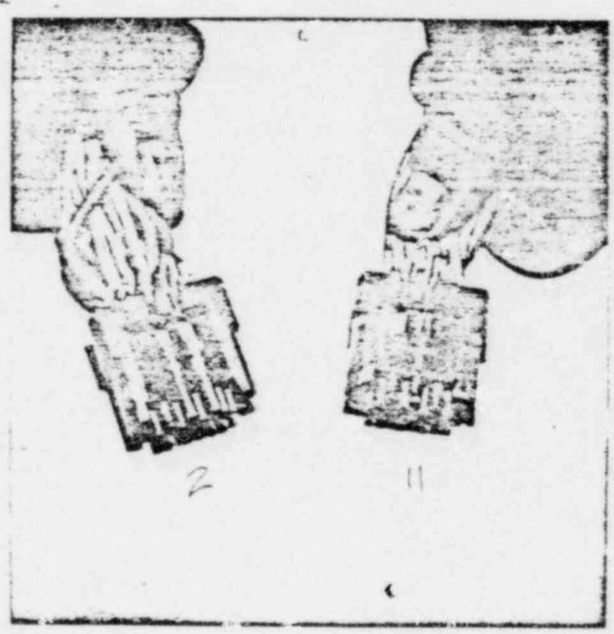

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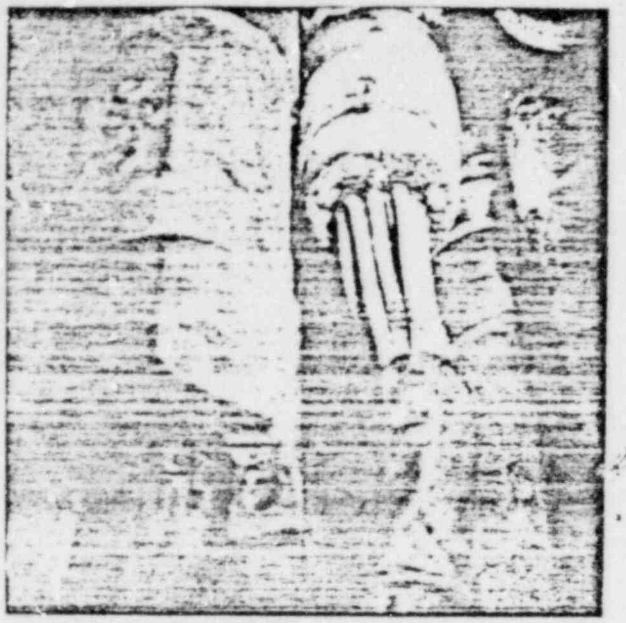

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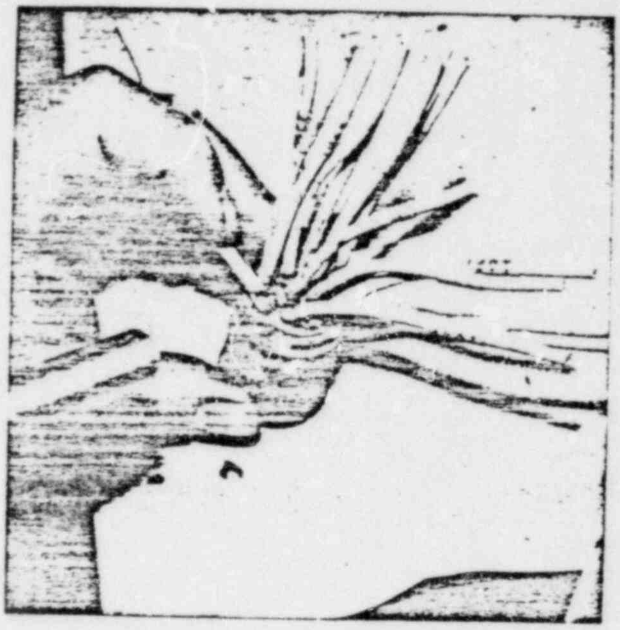

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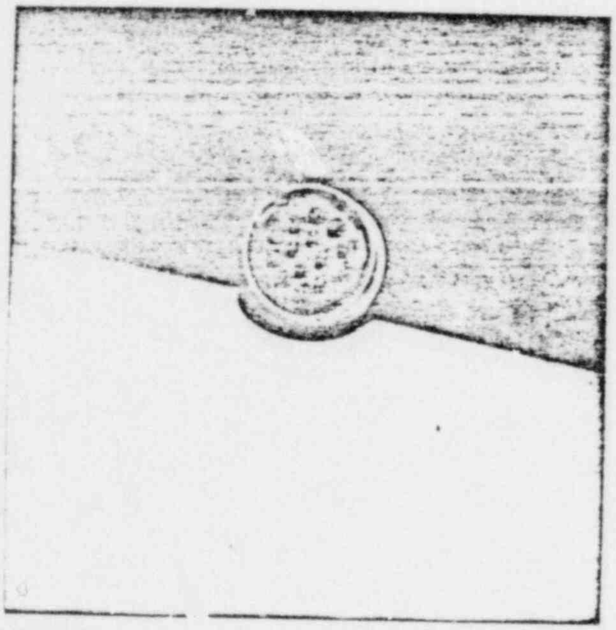

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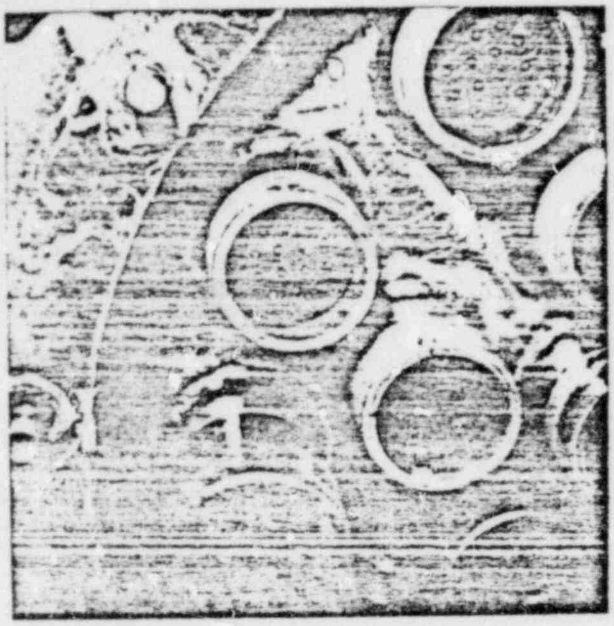
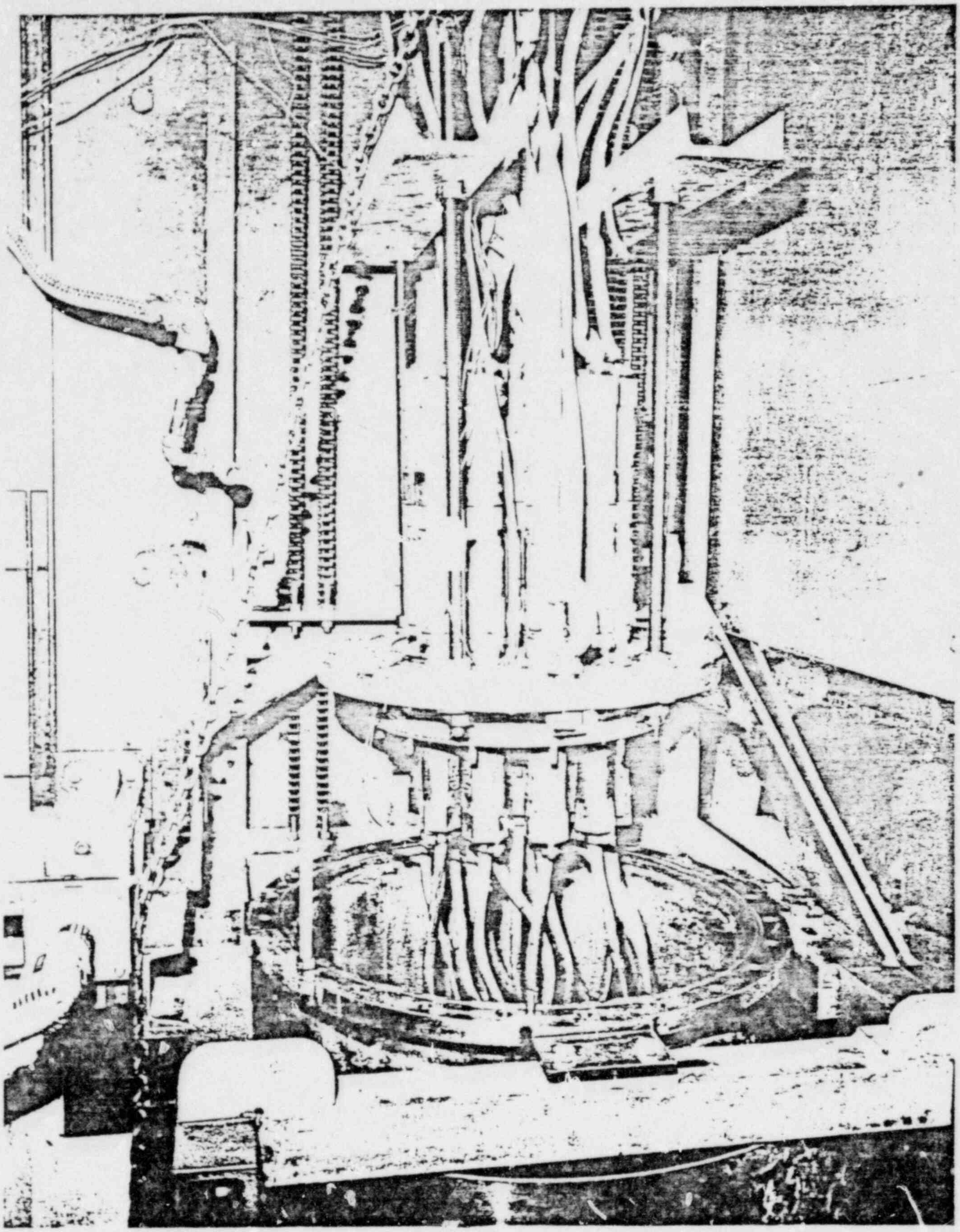


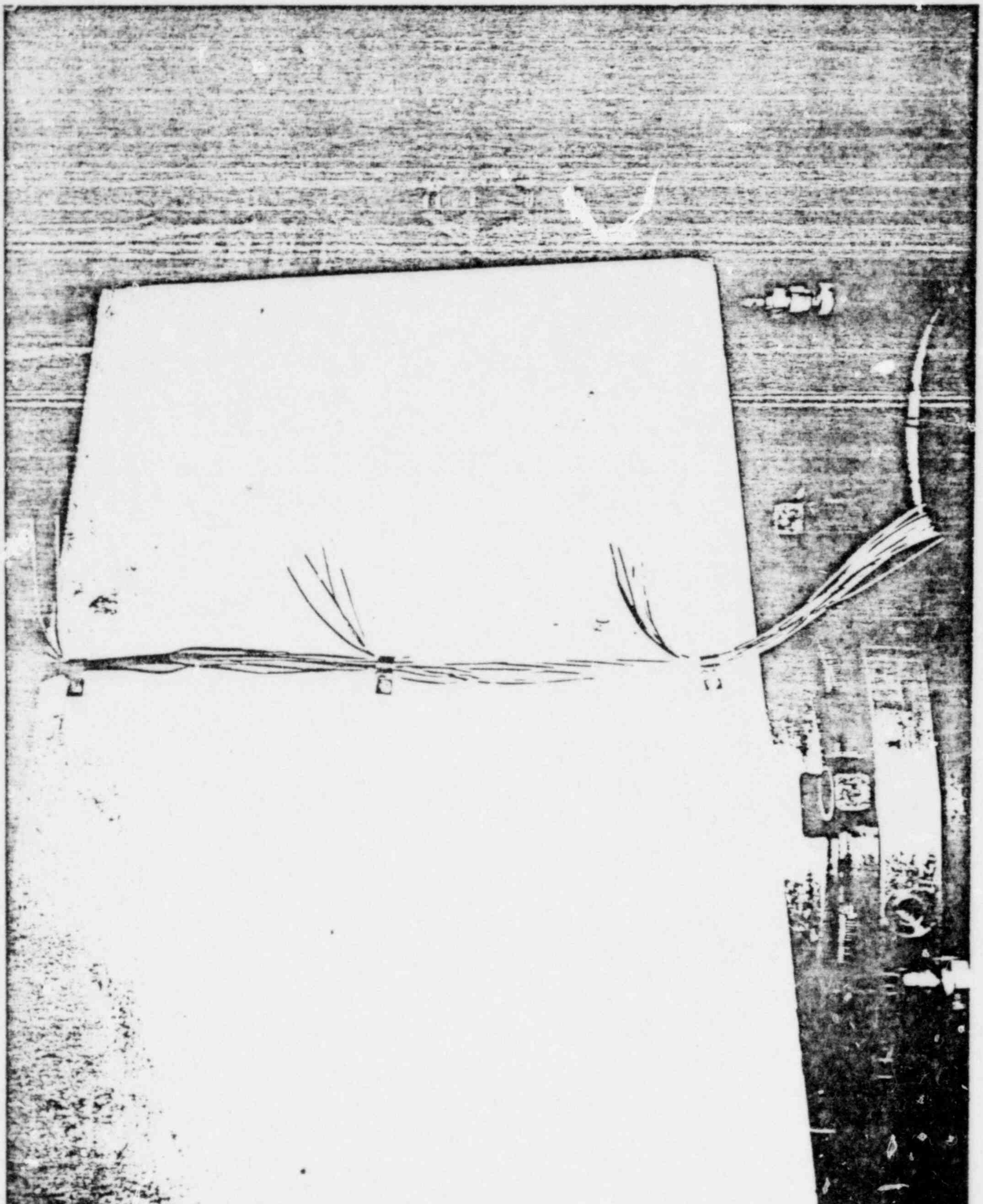
#9 INBOARD
6/25/

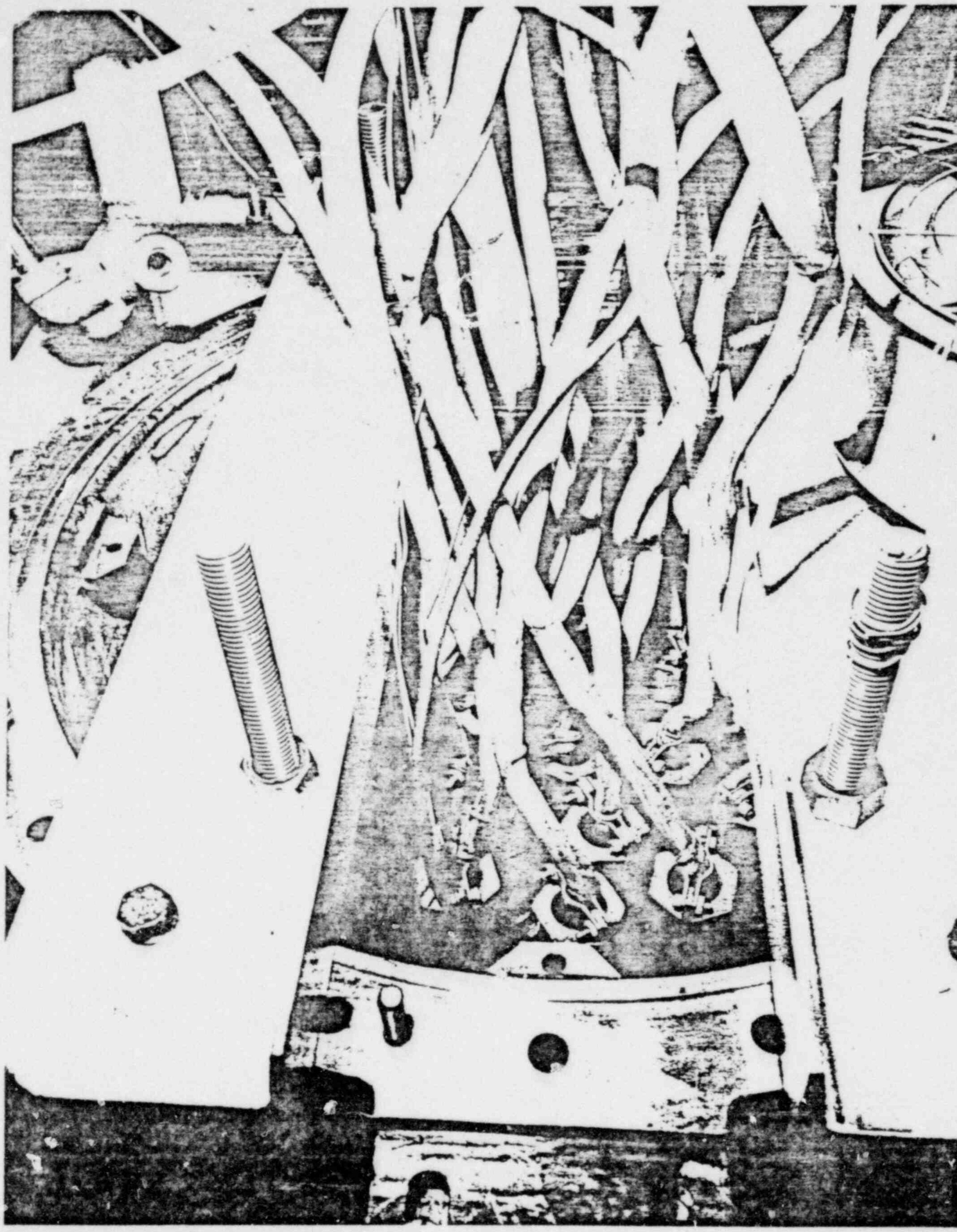
13

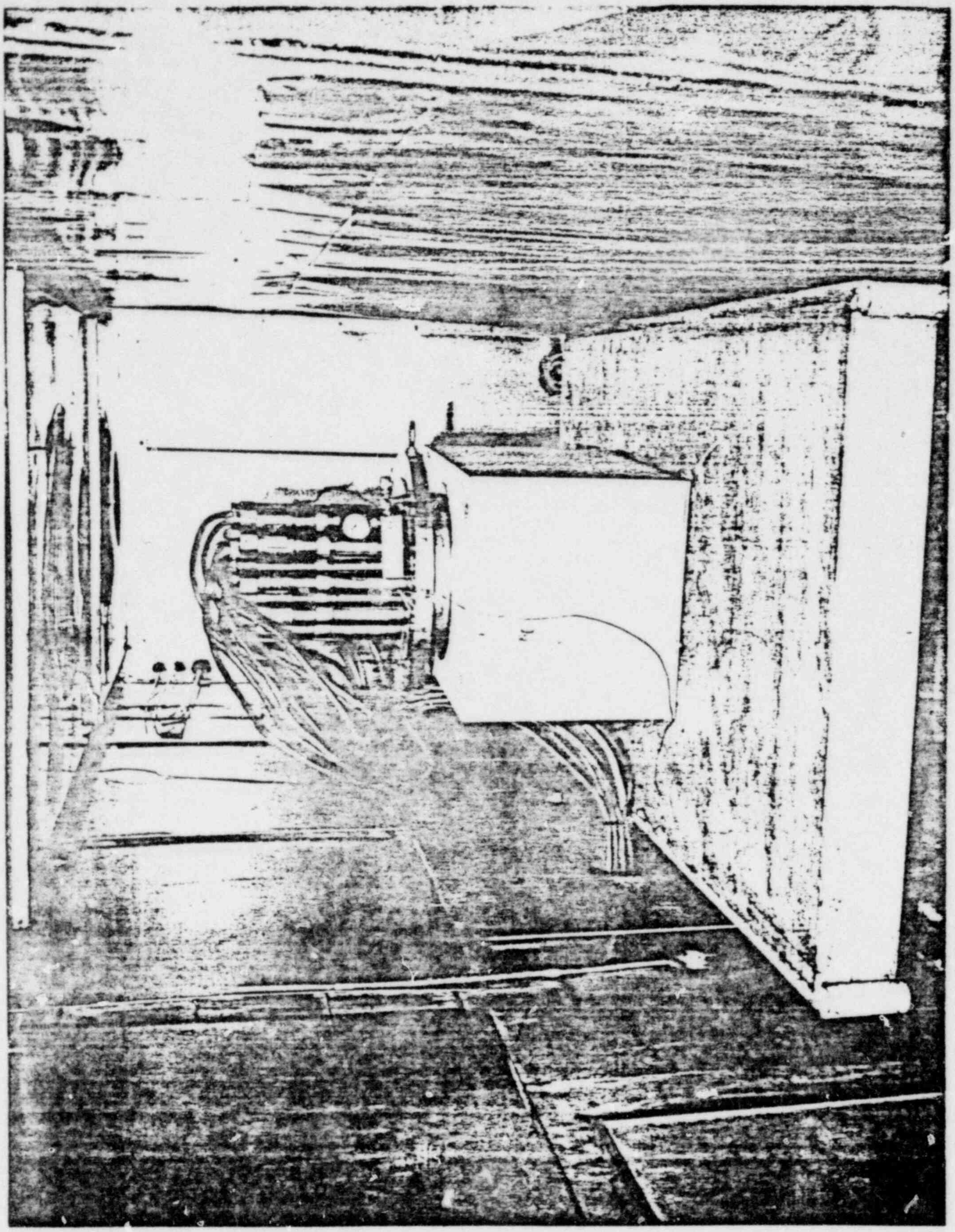
#[illegible] [illegible]

14










HOT
PIPES