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MEETING ON CRACKS FOUND IN DRESDEN 3 CONTROL ROD DRIVE COLLET RETAINER TUBES

Enclosed is a summary of a meeting held with General Electric (GE) in Bethesda on July 11, 1975, to discuss the cracks found in several of the collet retainer tubes of the Dresden 3 control rod drive mechanisms.

GE stated that these cracks were found for the second time on a test drive mechanism in March. Nineteen of the 52 Dresden 3 drives and one drive of the 26 spare drives for five other reactors which have been inspected have cracks. Oyster Creek and other reactors constructed since have the same drive design. Complete failure of the collet retainer tube would prevent the drive from withdrawing, inserting or scramming. Therefore, such a failure would be detected during the weekly exercising of each drive.

Commonwealth Edison stated that they will inspect 72 of the Dresden 3 drives for cracks in the collet retainer tubes and replace all the defective drives (with the possible exception of one to be used as a "test" drive) prior to the scheduled August 18, 1975, startup of Dresden 3. Commonwealth is expecting a GE report on the cracks July 17 and they will, in turn, submit it to the NRC one week later.

Original signed by:

L. N. Olshan
Reactor Systems Branch
Division of Technical Review

Enclosures:
1. Meeting Summary
2. List of Attendees
3. Presentation
4. Examination of Cracks

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Enclosure 1

SUMMARY OF MEETING ON CRACKS FOUND IN DRESDEN 3 CONTROL ROD DRIVE COLLET RETAINER TUBES

A meeting was held in Bethesda on July 11, 1975, with General Electric (GE) to discuss the cracks found in several collet retainer tubes of the Dresden 3 control rod drives.

GE made a formal presentation (Enclosure 3) which gave the status of inspection for cracks, investigation approach, GE's theory on the cause, and the proposed action. GE also submitted photographs of some cracks (Enclosure 4).

Following are the significant comments made during the meeting.

1. GE stated that the type of cracking detected in Dresden 3 could be present in the drives of all their reactors starting with Oyster Creek since all are of the same design.

2. The status of the inspections of drives made to date are presented in Slide 1. The cracks were observed in an inspection of test drives in March. This was the second time cracking was found in a test drive and because of this the drives at KRB were inspected in June. No cracks were observed, which is probably due to the different design of the KRB drives. During inspection for possible cracks at another location of the retainer tube, these cracks were inadvertently discovered. Except for Dresden 3, the inspection has been limited to spare drives. Commonwealth plans to inspect 72 of the 177 Dresden 3 drives.

3. A cross-section of a drive at the position of interest is shown in Slide 2. A sketch of the cracks discovered in a Dresden 3 collet retainer tube is shown in Slide 3. The location (at the change in section midway between the flow holes) and orientation (circumferential) are typical. The cracking observed in a test drive retainer tube is shown in Slide 4. Metallographic sections also revealed cracking in the material between the "ram's horn" pattern.

4. GE considers the probable cause (Slide 5) to be stress corrosion, the stresses induced by thermal gradients. During scram 400°F water flows down the outside of the retainer tube and 100°F cooling water flows up the inside of the tube, out the flow holes and mixes with the hot flow. (These temperatures were verified in a thermal test conducted by GE, where a collet retainer tube was instrumented with thermocouples.) Since the mixing is incomplete the flow down the outside is still hot between the flow holes and temperate directly below the flow holes. The resultant thermal gradient of about 300°F would induce elastic compressive stresses of 73,000 psi, or more than double the yield stress. After reaching thermal equilibrium a residual tensile stress remains in the outer portion of the tube. Cooling water comes from the condensate storage tank, and, therefore, has a high oxygen content. Furthermore, the nitriding of the tube ID results in the type 304 ss

being fully sensitized. Stress corrosion cracking results. Details of the cracks are presented in Enclosure 4.

5. If the cracks were to advance to the point where complete circumferential separation of the collet retainer tube occurred (GE does not think this will happen), the compressed collet spring would extend at least 0.9 inches. The spring would then be at the same axial location as the collet fingers. The radial clearance between fingers and spring is insufficient and the fingers would be locked in position. This would prevent any rod motion (insert, withdraw, or scram). GE verified this by removing the fillister-head screw (guide cap plug mounting) on a test drive and observing that the rod could be neither withdrawn nor inserted. This simulates a complete circumferential failure of the retainer tube. Scramming the rod was not attempted for fear that the test drive would be damaged. GE, however, analytically determined that scram would also be precluded if the reactor were at normal pressure. At low pressure the drive force would be double, but was not analyzed.

6. Every rod in the GE operating reactors is exercised (withdrawn and inserted) weekly and completely separated collet retainer tube would be detected by these tests. Since the greatest loads are imposed during withdrawal, incipient failures would be detected during withdrawal if at all.

7. All the cracks have been on the outside diameter of the collet retainer tube, at the axial location where the cross-section changes, and between the water ports. The most severe cracks were located above the cooling water inlet at the bottom of the drive. GE has not been able to determine any correlation between cracking and number of scram cycles, location in core, or drive manufacturer (San Jose or Wilmington). Material history of individual retainer tubes can not be established. GE is therefore unable to correlate it to cracking.

8. The collet retainer tube is made of type 304 stainless steel and portions of the ID are nitrided. The other surfaces, including the area where cracks have been detected, were copper plated prior to nitriding.

9. GE does not propose to replace all drives in which cracking has been detected. GE is presently developing a criterion to specify when collet retainer tube replacement is necessary. An outline of the proposed investigation is shown in Slide 6.

10. Failure of the retainer tube would result in a stuck rod. The drive could not be removed in the normal manner and would require removal of the vessel head in order to unlock the drive and rod. Removal of the drive might require unloading of the core and draining the vessel. GE is considering a "kit" which would limit axial motion of the tube if failure occurred, and permit drive motion. The staff stated that this may be undesirable since detecting separated retainer tubes would then be impossible during the weekly rod exercising.

11. Commonwealth Edison is planning to dye penetrant test 72 of the 177 Dresden 3 drives to detect possible cracks in the retainer tubes. Commonwealth will replace every cracked retainer tube, but is considering reinstalling one cracked tube. This cracked tube would then be inspected during a future outage to ascertain crack growth during reactor operation. Start-up of Dresden 3 is scheduled for August 18, 1975.

12. GE is planning to provide utilities with a field modification "kit" to prevent the cracking from occurring once design changes have been decided upon.

13. GE recommendations and conclusions are presented in Slide 7. GE is preparing a report (Slide 8) on the retainer tube cracks that it is scheduled to transmit to Commonwealth by July 17, 1975. Commonwealth will review the report and submit it to the NRC one week later. In addition to the contents listed, the staff requested that recommended surveillance requirements and criteria for acceptable cracking be including the report.

Enclosure 2

Meeting on Cracks in Collet Retainer Tubes Attendees

NRC
W. Minners
T.M. Novak
K.V. Seyfrit
R.D. Silver
P. Johnson
C.D. Sellers
F. Clemenson
W.S. Hazelton
W.J. Collins
I. Villalva
F.C. Cherny
W.R. Butler
R.R. Maccary
H. George
J.B. Henderson
S. Klein
D.L. Ziemann
L.N. Olshan
V. Stello*
S.A. Varga*

GE
R.L. Shipp
N.C. Shirley
R. Engel
A. Freemon
J.F. Stuart
D. Peterson

Commonwealth Edison
J. McGeachy
A.P. Galle

*Part-time Attendance

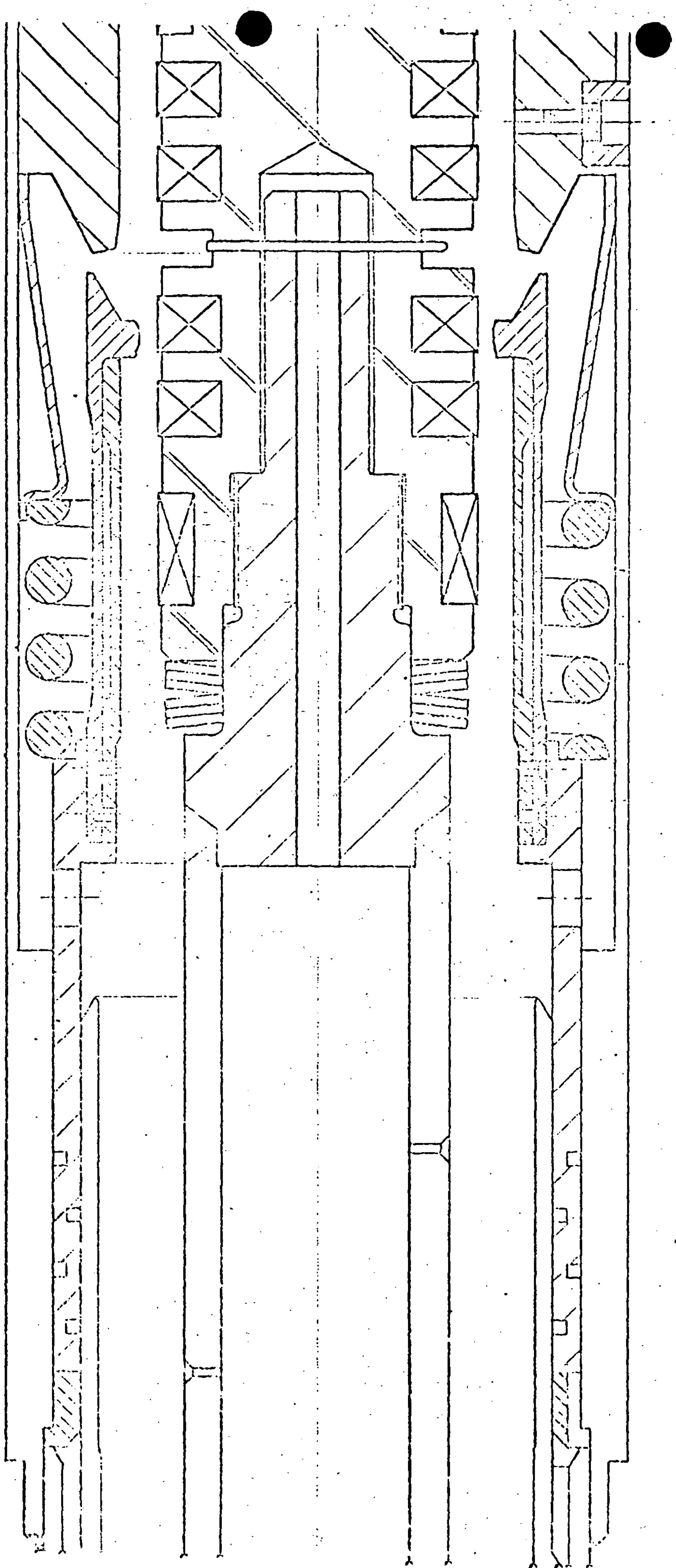
Slide #1

ENCLOSURE 3

STATUS OF INSPECTION

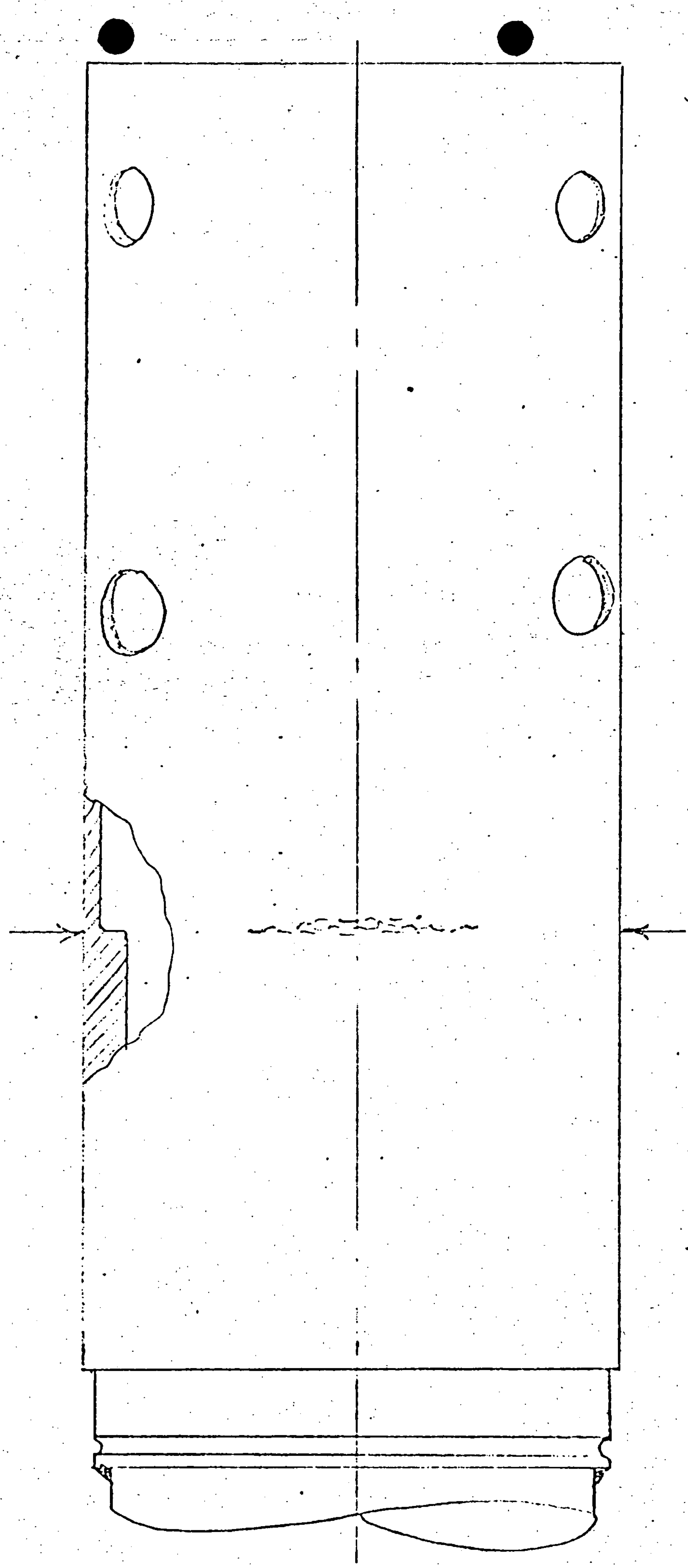
- DRESDEN 2 - ONE TUBE CRACKED (OTHER SPARES INSTALLED IN DRESDEN 3)
- DRESDEN 3 - ~~18~~ 19 PARTS CRACKED OUT OF ~~50~~ 52 PENETRANT TESTED
- TEST - TWO (LATEST) CRACKED, OUT OF 7
- KRB - 12 EXAMINED, 0 CRACKED
- QUAD CITIES - 5 EXAMINED, 0 CRACKED
- NINE MILE - 4 EXAMINED, 0 CRACKED
- OYSTER CREEK 4 ~~12~~ EXAMINED, 0 CRACKED
- VERMONT YANKEE - 1 EXAMINED, 1 CRACKED
- PILGRIM - EXAMINED, CRACKED
- OTHER PLANTS - NO RESULTS RECEIVED

MONTICELLO - 12 EXAMINED, 0 CRACKED

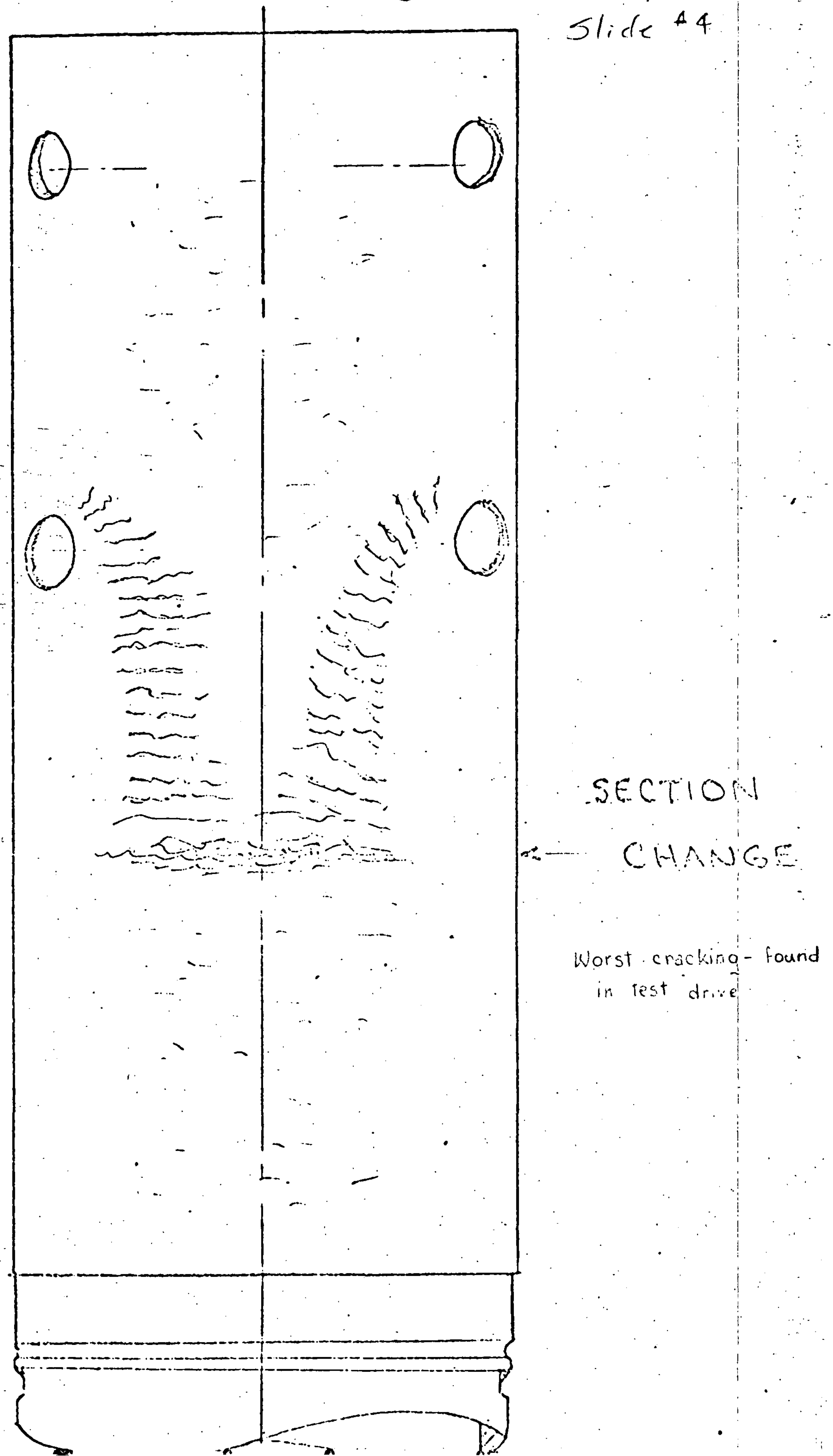


Slide #2

Slide #3



Cracks found in Dresden 3 (typical).


Slide #4
SECTION
CHANGE
Worst cracking - found
in test drive

Slide #5

PROBABLE CAUSES

- HIGH THERMAL GRADIENT DURING SCRAM
- DIFFERENTIAL EXPANSION AT SECTION CHANGE
- RESULTANT TENSILE STRESSES NEAR YIELD IN CERTAIN AREAS OF TUBE
- MATERIAL IN SENSITIZED CONDITION
- ENVIRONMENT CONDUCIVE TO INTERGRANULAR CRACKING

Slide #6

~~ENCLOSURE 3~~

INVESTIGATION APPROACH

- INSTITUTE DRIVE INSPECTION
  - DYE PENETRANT EXAM OF REMAINING DRESDEN 3 DRIVES
  - DYE PENETRANT EXAM OF REMAINING TEST DRIVES AT SAN JOSE
  - DYE PENETRANT EXAM OF SPARE DRIVES AT OTHER SITES
  - DYE PENETRANT EXAM OF THERMAL SLEEVE AT SAN JOSE FACILITY

- METALLOGRAPHY
  - EXAMINE CRACKED SITE DRIVES BY PT, UT AND SMACK
  - EXAMINE CRACKED TEST AND SITE DRIVES BY DESTRUCTIVE EXAMINATION

- ENGINEERING INVESTIGATION
  - PERFORM THERMAL ANALYSIS
  - INVESTIGATE PROCESSING HISTORY OF PARTS
  - FAILURE ANALYSIS
  - RUN TEST ON DRIVE WITH SIMULATED FAILURE
  - DETERMINE SEVERITY OF THERMAL CYCLING BY TEST
  - ATTEMPT CORRELATION OF CRACKED DRIVES TO OPERATING HISTORY
  - CONTINUE INVESTIGATION OF ALTERNATE MATERIAL
  - INVESTIGATE POSSIBLE DESIGN CHANGES TO IMPROVE PART OR REDUCE STRESSES

PROPOSED ACTION & JUSTIFICATION

Slide #7

- SHORT RANGE ACTION

  CONTINUE TO INVESTIGATE EXTENT OF PROBLEM

  EMPHASIZE WEEKLY SURVEILLANCE TESTING

  ADD PENETRANT EXAM TO ROUTINE MAINTANANCE

  ACCEPTANCE CRITERIA EQUAL TO OR LESS THAN THE CRACKS SHOWN ON TEST DRIVE

  ISSUE INSTRUCTIONS TO REDUCE SEVERITY OF THERMAL CYCLES

  REVIEW TESTING REQUIREMENTS WITH NRC TO REDUCE THERMAL CYCLES

- LONG RANGE ACTION

  COMPLETE INVESTIGATION OF NEW MATERIAL

  COMPLETE DESIGN IMPROVEMENT STUDIES

  MAKE FIELD MODIFICATION KIT AVAILABLE

  INVESTIGATE FEASIBILITY OF LOW OXYGEN WATER

- JUSTIFICATION

  3300 DRIVES WITH UP TO 10 YEARS OPERATION HAVE NEVER FAILED TO RESPOND TO WEEKLY TEST OR WHEN REQUIRED TO SCRAM.

  A GOOD CORRELATION EXISTS BETWEEN TEST, THEORY AND FIELD EXPERIENCE ON CAUSE OF CRACKS

  WE PREDICT AND OBSERVE CRACKING ONLY IN THE AREAS BETWEEN PORTS.

  THEREFORE WE BELIEVE TUBES WILL NOT FAIL WITH COMPLETE CIRCUMFERENTIAL PARTING

  AS LONG AS TUBE IS INTEGRAL, DRIVE FUNCTION WILL REMAIN NORMAL

~~ENCLOSURE 4~~

Slide #8

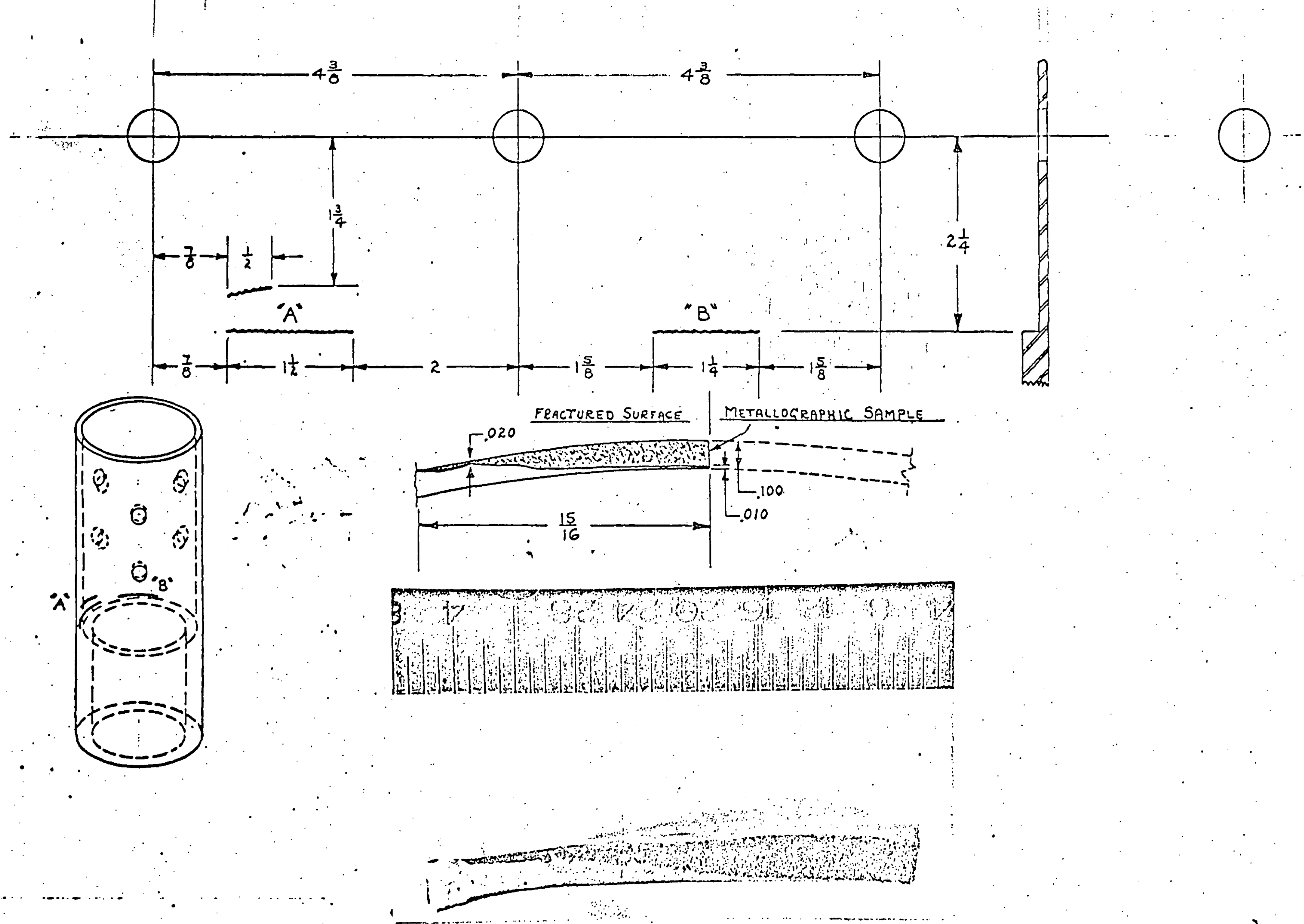
TABLE OF CONTENT

SECTION

ENCLOSURE 4

EXAMINATION OF CRACKS

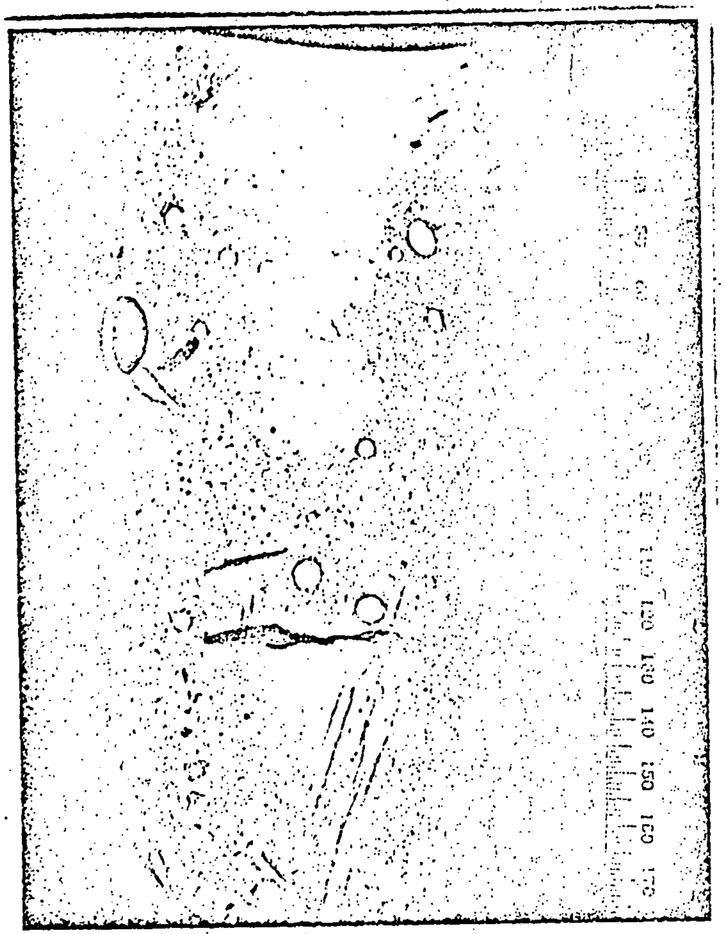
LIST OF ILLUSTRATIONS



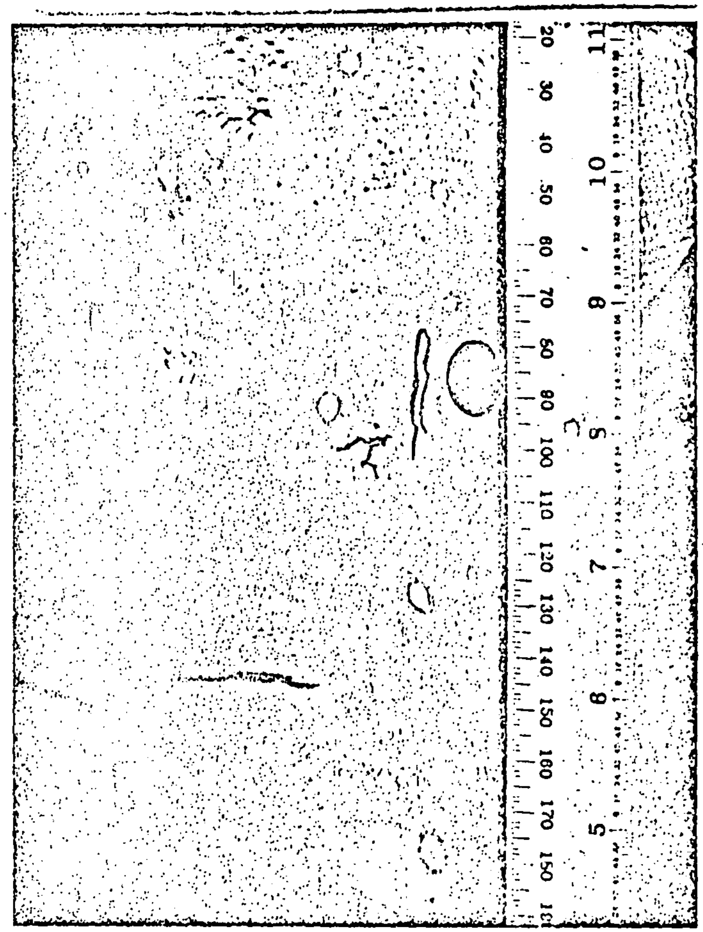
OD OF CIRCUMFERENTIAL CRACKS

CRD COLLECT HOUSING - #20

FIG. 1



A

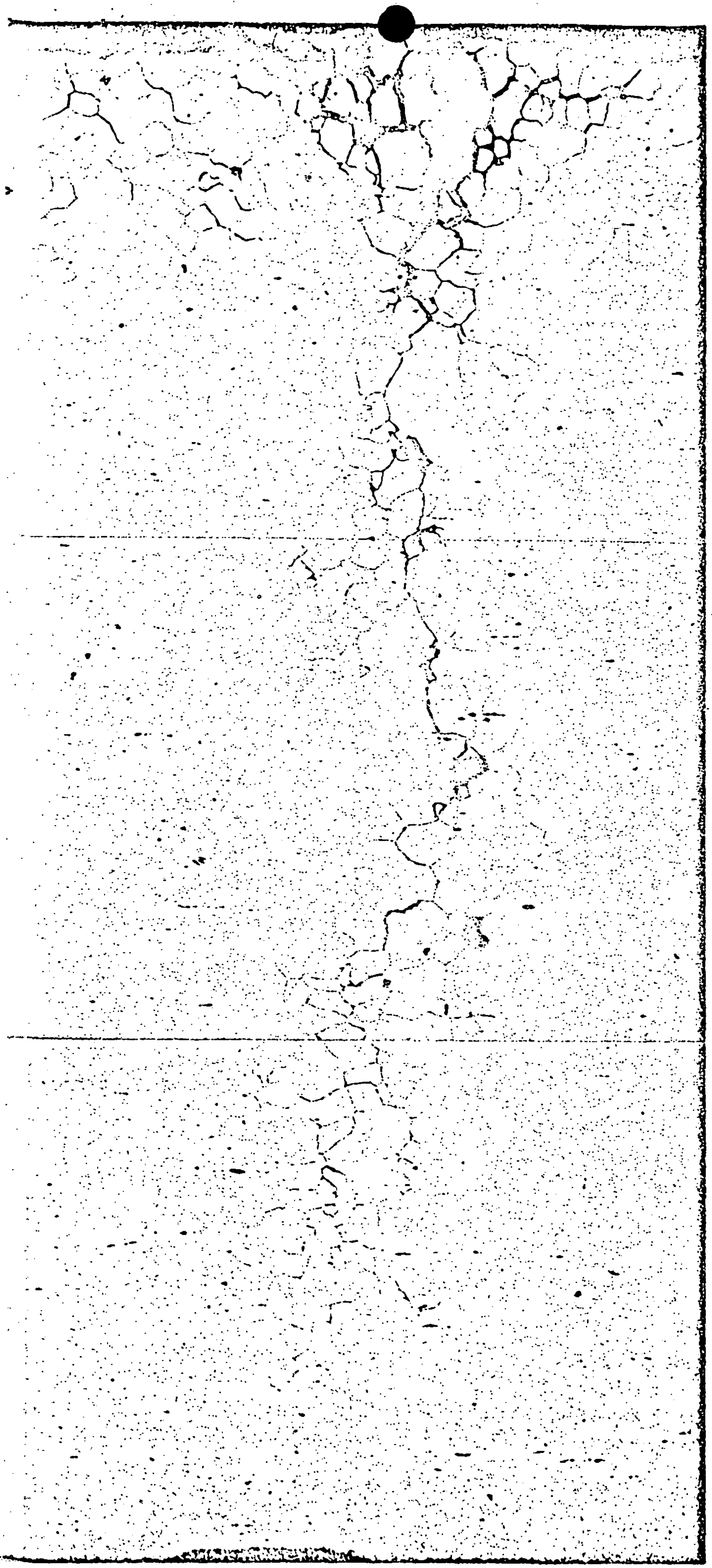


B

OD OF CIRCUMFERENTIAL CRACK

CRD COLLECT HOUSING - #20

FIG. 1A.

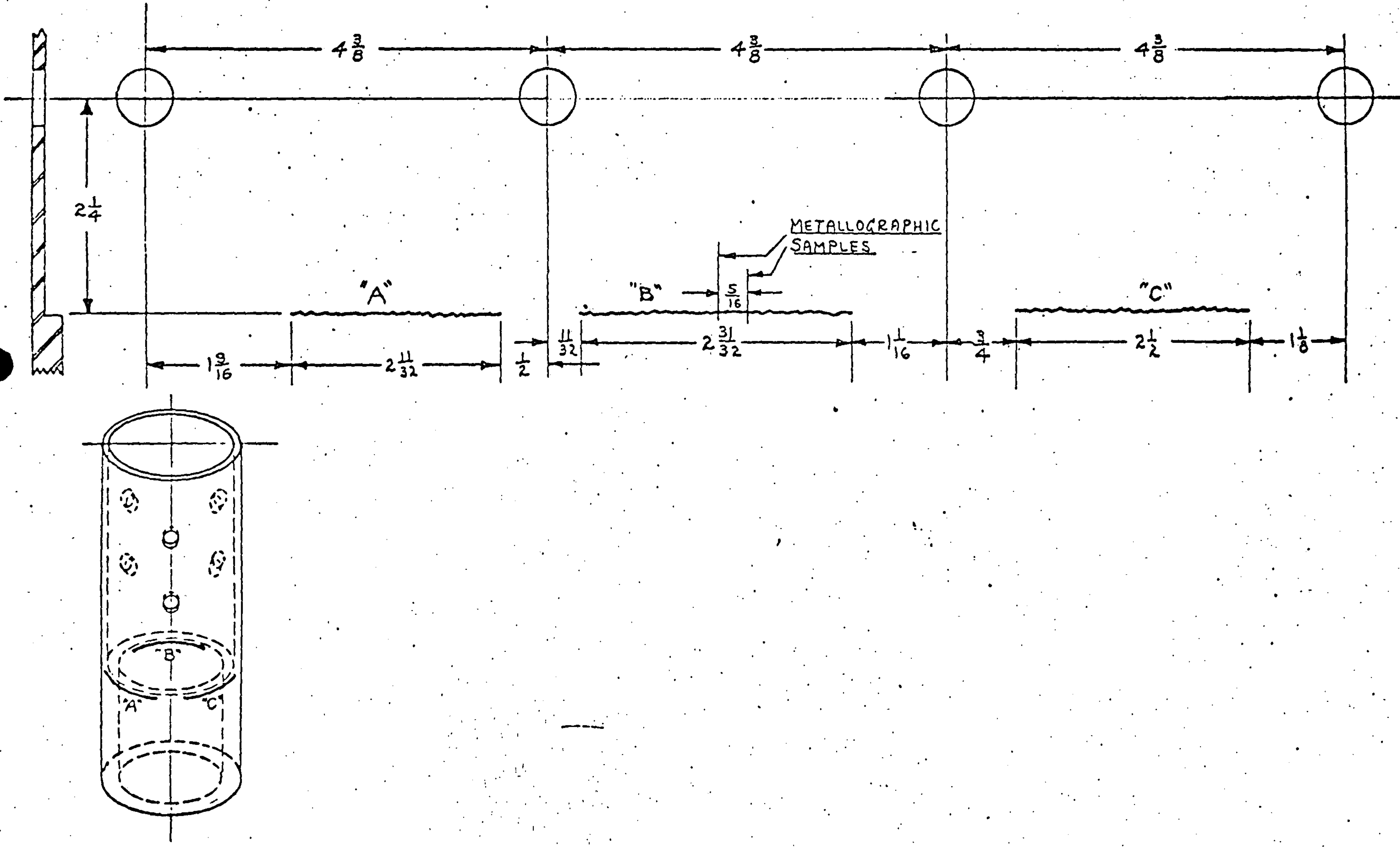


CROSS SECTION OF
CIRCUMFERENTIAL
CRACK B

CRD COLLECT
HOUSING - # 20

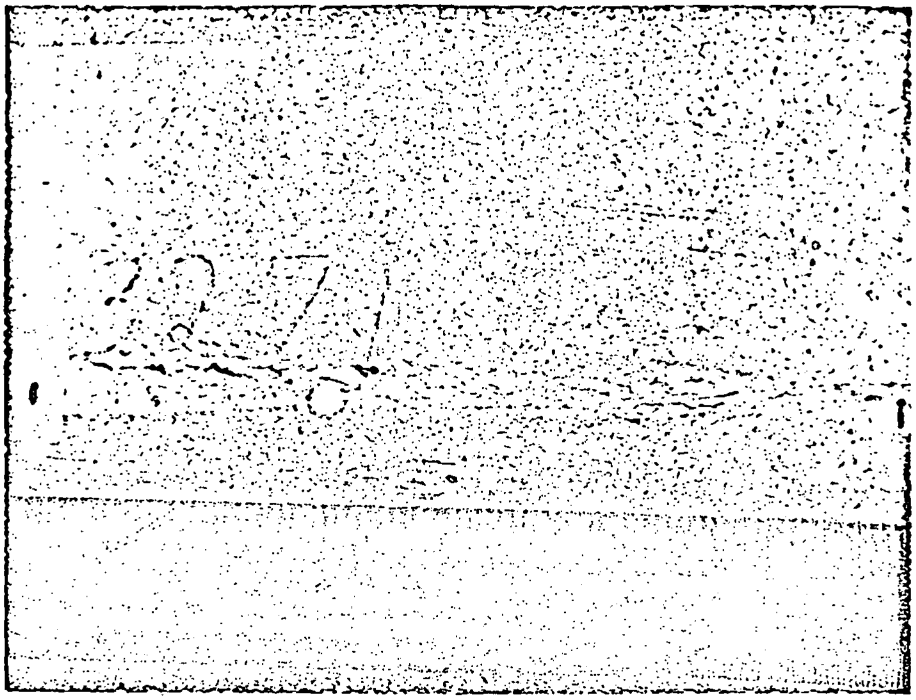
100X

FIG. 1B.

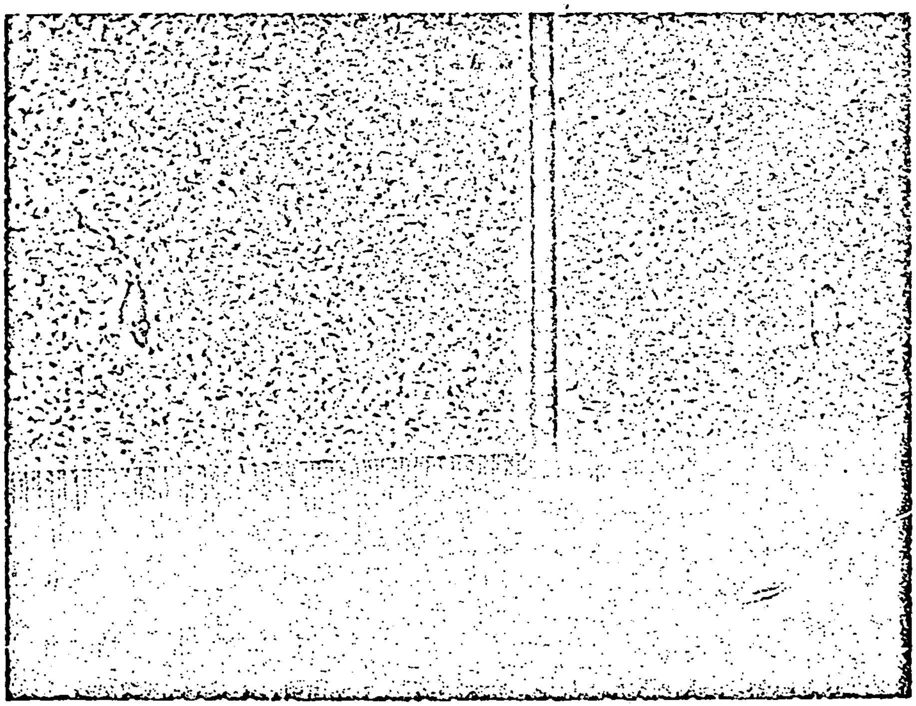


OD OF CIRCUMFERENTIAL CRACKS
CRD COLLECT HOUSING - #3271

FIG. 2



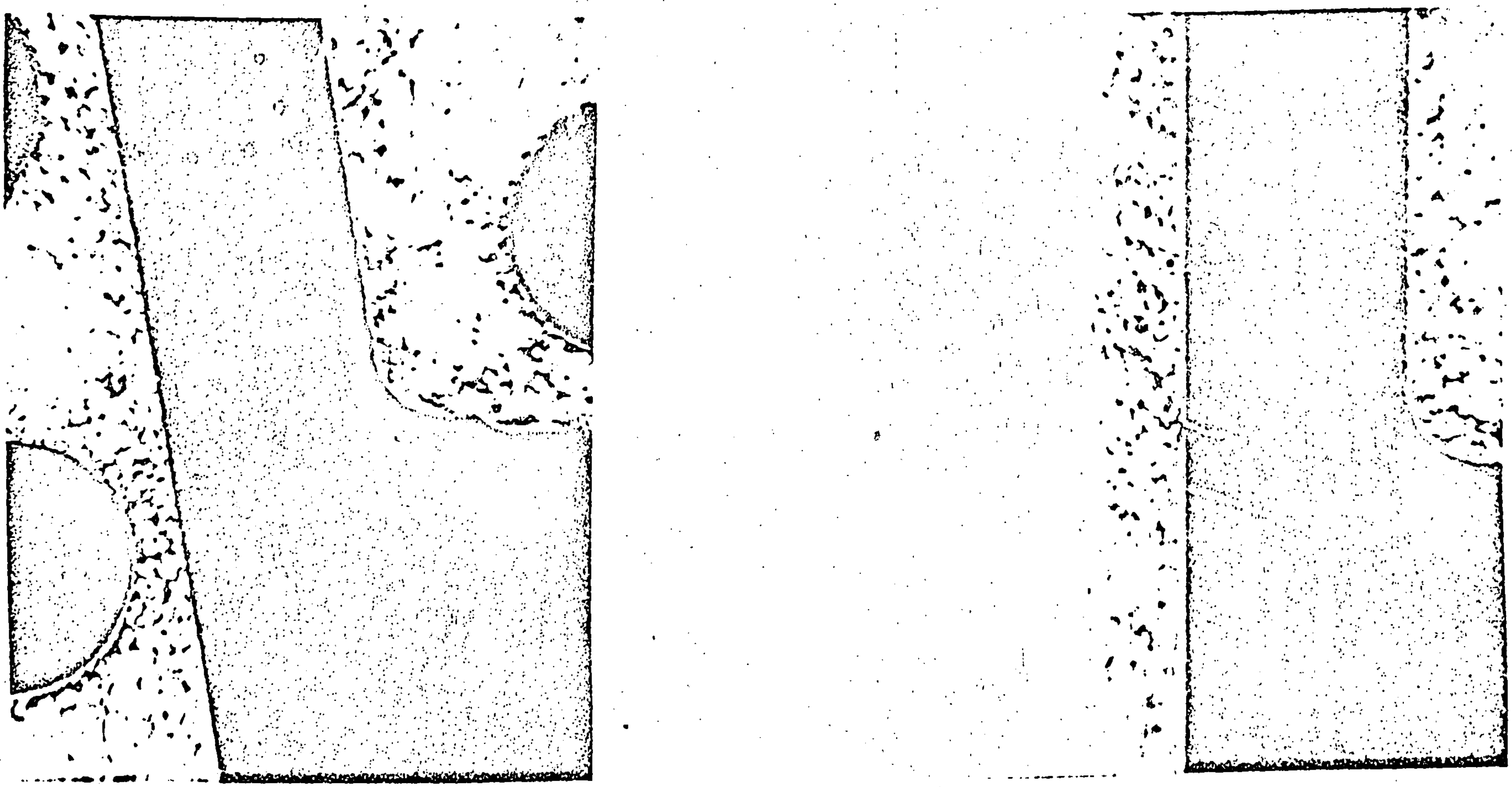
OD OF CIRCUMFERENTIAL CRACK A



OD OF CRACKS A AND B FROM CENTER OF HOLE

CRD COLLECT HOUSING - #3271

FIG. 2A

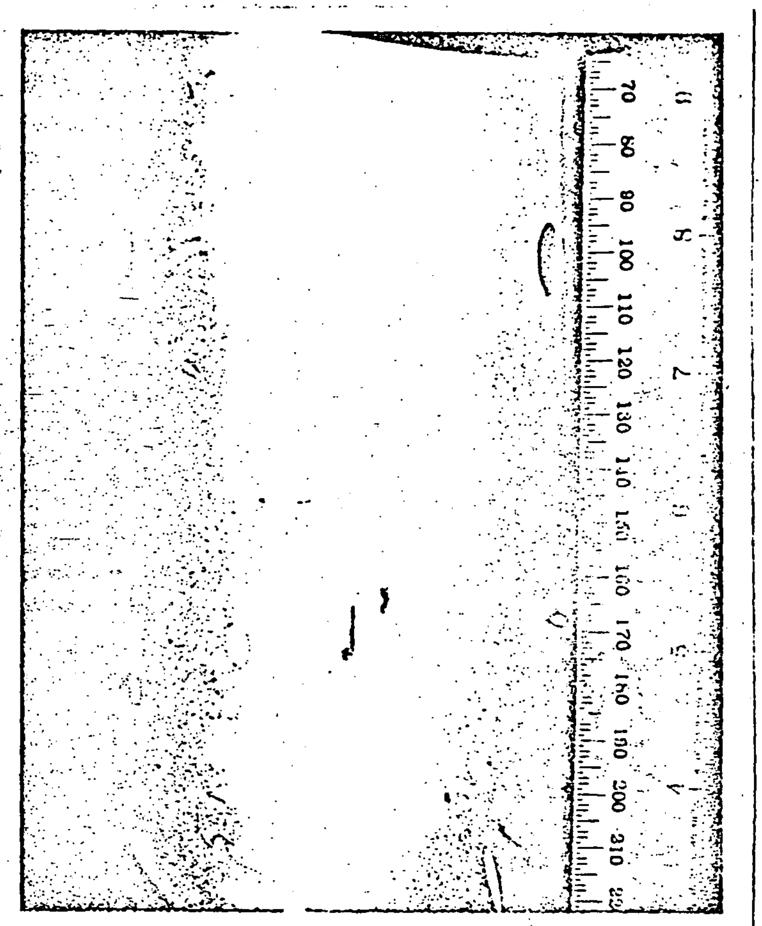


CENTER OF CRACK 15X 1/4-IN. FROM CENTER OF CRACK

CROSS SECTION OF CIRCUMFERENTIAL CRACK B

CRD HOUSING COLLECT - #3271

FIG. 2B.



OD OF LONGITUDINAL CRACK

CRD COLLECT HOUSING - #857

FIG. 3.