MASTER

DUQUESNE LIGHT COMPANY

SHIPPINGPORT ATOMIC POWER STATION

TEST RESULTS

DLCS 3330101

1B HEAT EXCHANGER LEAK TEST

CORE I SEED 1

Section 1 of 1 Section

First Issue, February 3, 1961
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DISCLAIMER

TEST RESULTS

DLCS 3330101

1B HEAT EXCHANGER LEAK TEST

CORE I SEED 1

Purpose

Tests were performed to determine which tubes of the 1B heat exchanger were leaking primary coolant water into the secondary water system. Different testing methods were used to locate the leak source in the tubes and to determine, if possible, the cause of tube defects.

Conclusions

The air pressurization test determined the heat exchanger leakage and leak rate of individual tubes. On the basis of this method 9 tubes were plugged prior to returning the 1B boiler to service, after the refueling operation. This brought the total number of plugged tubes in the 1B heat exchanger to 26.

The leak location detector probe is a promising method of locating defects along the length of a tube, however, due to sludge deposition after shutdown, only one crack was located in four tubes. Results of the probolog test, dye penetrant test and ultrasonic test were inconclusive in determining the location of leaks. No definite reason for tube leakage could be determined from the results of this test.

Description of Test Equipment and Test Procedure

The following are descriptions of tests performed:

A. The air pressure test has been the basic physical method by which heat exchanger tubes have been tested for leakage of radioactive primary system water into the secondary system. With the hydraulic stop valves of the loop closed and water drained from both sides of the heat exchanger, air pressure of 75 psig was applied to the secondary (shell) side. Each tube was then filled with water on the primary side and observation made at both the inlet and outlet end of the tube to detect emission of air bubbles as leakage evidence. Leaky tubes were marked by inserting a solid rubber stopper in the heat exchanger outlet and inserting a rubber stopper with a small hole in the tube at the heat exchanger inlet.

In order to determine the leak rate for defective tubes, a plastic hose was inserted into the rubber stopper of the heat exchanger inlet. The other end of the hose was placed under the open end of a glass graduate which had been filled with water and inverted in a bucket of water. Air entering the defective tube from the secondary side (75 psig) was led into the graduate where a volume of water displacement could be measured over a period of time.

B. The probolog test was done with insertion into the tube of an eddy-current probe where magnetic flux is used to indicate failures. This probolog equipment is specialized apparatus which was supplied by Westinghouse Electric Corporation, Bettis Plant, and operated by Westinghouse personnel during testing.

C. The leak location detector probe was designed to locate the position of a crack along the length of a heat exchanger tube. Prior to testing, the solid rubber stopper in the outlet end of the tube was replaced by a one hole stopper with a short piece of plastic tubing, the end of which was placed in a bottle of water. The probe, as shown in Figure 1, was inserted into a dry tube after the secondary side had been pressurized to 75 psig. When a crack in the tube was located between the two rubber seals of the probe, pressurized air entering this space escaped through the tubing and was detected by bubbles issuing from the end under water.

During testing, the probe was advanced into a leaking tube in 5 inch increments with a waiting time of at least 20 seconds between increments, depending on the leak rate of the tube. Bubbling in the bottles at both ends of the tube was used to determine when all cracks in the tube had been located. If the crack was not located within 26 feet of the inlet tube sheet, the probe was removed and the test procedure repeated from the outlet end of the tube.

D. The boregage test was used to determine the inside diameter of selected tubes at the heat exchanger inlet. The boregage equipment, furnished by Westinghouse Electric Corporation, Bettis Plant, consisted of a split measuring head bearing on the tube inside diameter and producing an axial deflection of tapered extension rods. Rod movement actuated a dial indicator from which inside diameter readings were taken. During testing various length extension rods were used to permit gaging of selected tubes up to 11 13/16" from the tube sheet.

E. Ultrasonic testing of selected tubes was accomplished with special equipment supplied by Westinghouse Electric Corporation, Bettis Plant. A special 5 megacycle search unit, Figure 2, was coupled with an Immerscope from which readings were taken at various distances up to 9 1/2 inches from the face of the inlet tube sheet. Westinghouse personnel operated the Immerscope and recorded data accoding to interpretation of the observed signals.

F. Dye penetrant inspection was used to check the inlet end of selected heat exchanger tubes. Tubes were cleaned with cloth patches, blown dry with air and dried with an electric heater inserted into the tube. Dye penetrant was swabbed on the inside surfaces of the tubes up to 15" from the end and left for 15 minutes. The surface was then swabbed to remove excess penetrant and a 15" section of rubber tubing closed at the end, was inserted into the tube. The tubing was inflated with 20-30 psig air and held in place for 5 minutes. Air pressure was then removed and the rubber tubing removed for examination of dye penetrant transferred from defects in the metal to the surface of the tubing.

Results

DLCS 3330101, 1B Heat Exchanger Leak Tests, was performed at various periods during 1959 and up to March 28, 1960. When this performance began, there were 11,804 service hours on the 1B Heat Exchanger.

Initial plugging of tubes in the 1B heat exchanger was done, during February 1958 on the basis of air pressurization and probolog tests which indicated defects in 17 tubes. These tubes are shown in Figure 3. Examination of tubes removed from the boiler indicated that cracks were due to a form of caustic stress corrosion. For additional information on the defected tubes, see B and W. Co. Report No. 7089. After installation of two additional risers, the heat exchanger was returned to service with a change in boiler water chemistry to prevent free alkalinity.

During April, 1959, iodine activity was detected in the secondary water of the 1B heat exchanger and this activity continued during plant operation until October 1959, when the loop was removed from service prior to Core I, Seed 2 refueling. Probolog testing of 140 tubes was performed and results indicated defects in 114 tubes. Further investigation showed the presence of ferromagnetic sludge on the sides of the tubes. This sludge rendered results of the probolog tests inconclusive and data were not taken by Duquesne Light Company. Data accumulated during this test may be found in Westinghouse letter WAPD-PWR-2160 of March 18, 1960.

Air pressurization tests were conducted to determine leaking tubes and leak rates. Figure 4 notes the tubes for which leakage was detected per Table I. Rechecks of the suspected leaking tubes in Table I determined that tube 20 row 12, tube 21 row 20 and tube 22 row 24 did not leak. The leak rates for the remaining tubes were determined to be as follows:

Row	Tube Number	Leak Rate (ml/min)
2	9	11.0
2	20	0.025
3	21	3.75
6	26	0.025
8	26	8.68
12	13	0.009
12	29	0.005
13	4	0.009
19	15	0.001

It will be noted that three tubes provided most of the leakage, the other 6 having a very low leak rate.

In order to determine the cause of tube leakage it was decided to locate the defect position in the above tubes having measureable leak rates. Refueling operations delayed grinding of the tube lips, to permit entry of the leak location detector probe, for two months. Table II presents the test data and shows that only one tube indicated leakage. Blowing tube 9, row 2 with air on the primary side still did not produce leakage when the secondary side was pressurized. These results indicated that the defects were so small that they were closed by boiler sludge during the dry layup of 2 months.

Consideration was given to pulling tubes through the tube sheet for examination. It was necessary, however, to first determine if the tubes were expanded beyond the 8" tube sheet thickness. A boregage instrument was used on selected tubes as noted in Figure 5. The data in Table III showed that tube rolling extended a minimum of 8 3/4" from the face of the tube sheet for all tubes checked. It is logical to assume this fabrication method was used for all tubes and that special techniques would be required to collapse the expanded tube section before pulling a tube through the sheet.

The dye penetrant method was utilized to determine if cracks within the tube sheet area could be detected. Twelve tubes, shown in Figure 6, were tested and the dye penetrant pattern on the rubber tubing are indicated in Figures 7-16. Results of these data can be summarized as follows:

		Indications		
Tube	Row	Location (Inches from tube sheet)	Length (inches)	Direction
*9	2	12;13	1/16;1/8	Longitudinal
*26	8	3 1/4; 5 1/2; 6 1/4	1/4;-;1/2	Longitudinal
*29	12	1 3/4; 10 3/4	1/16;1/16	Circumferential
13	12	10 1/2	3/16	Diagonal
14	21	11 1/4	3/16	Diagonal
*15	19	12 5/16	1/16	Diagonal
23	19	12 1/4	---	Diagonal
10	30	4 1/4; 11 5/16	---	Longitudinal; Circumferential
14	30	9	5/16	Longitudinal

* Leaking tubes per air pressurization test

Indications on the rubber tubing were a thin crack type from 1/6" to 5/16" long laying in various directions. The fact that defects are indicated in tubes that did not previously show leakage casts doubt on the interpretation of the tubing dye penetrant patterns. Since none of the defects in leaking tubes were accurately located, there was no standard by which this penetrant technique could be judged. Repetitive tests on various tubes were inconclusive as to whether a defect indication would be repeated. From these results no conclusions could be drawn as to whether cracks were present in the tubes.

Ultrasonic tests were also made to determine if tube defects could be located by this method. The tubes tested are noted on Figure 17 and data tabulated in

Table IV. This ultrasonic equipment was of specialized design and required interpretation by personnel experienced in its application. These data were taken and recorded by Westinghouse personnel. Communications received by Duquesne Light Company from Westinghouse have indicated that results of this ultrasonic testing were not conclusive in determining the location of leaks in those heat exchanger tubes tested.

On March 3 and 4, 1960 a film badge survey was made of the tube sheet and hemispherical head area of the 1B Steam Generator to determine the radiation levels. These radiation levels were taken at two and six inches from the tube sheet at the inlet side of the steam generator. The locations of the film packets were: (1) Row 7, Tube 22, (2) Row 26, Tube 3, and (3) Row 21, Tube 16. The tube locations correspond to 7 o'clock, 2 o'clock, and the center respectively with the tubes numbered from right to left and the rows from bottom to top. The film packets in special holders were exposed at the above positions with the following types of shielding: (1) no shielding (2) 1/6 in. thick plastic (3) 5/16 in. thick plastic (lucite) (4) 20 mil thick cadmium. The shielding covered both sides of the film. The exposed film was developed by Westinghouse Electric Corporation, Bettis Plant, and the results are shown in Table V.

In comparing the various methods used for detecting tube leakage and locating these leaks, satisfactory results were obtained only from the air pressurization test and the leak location detector probe test. However, it was shown that leak detection is impaired by boiler layup periods which permit residue to plug existing cracks. Although a layup period prevented demonstration of the full capabilities of the leak location detector test, this method should prove to be adequate. No definite reason for the tube leakage could be postulated since the location and nature of the cracks were not determined. Probolog tests were affected to such a great extent by tube surface conditions that results were inconclusive. Likewise, location of tube defects by dye penetrant and ultrasonic testing require refinement of technique to provide reliable results.

On the basis of the air pressurization test 9 tubes were plugged in the 1B heat exchanger. Figure 3 represents the state of this heat exchanger as it was returned to service with Core I, Seed 2.

When the boiler was returned to power, it had a higher leak rate than when it was removed from service for the refueling period. The leak rate was determined by the following equation.

$$1 = \frac{A_b}{A_c} \frac{(b + \lambda)\, V}{\left[1 - e^{-(b + \lambda)\, t}\right]}$$

1 = leak rate, ml/min

A_b = boiler water I^{133} activity, dpm/ml

A_c = Reactor Coolant I^{133} activity, dpm/ml

b = loss due to sampling, 7.6×10^{-5} 1/min

λ = decay constant, I^{133} 5.54×10^{-4} 1/min

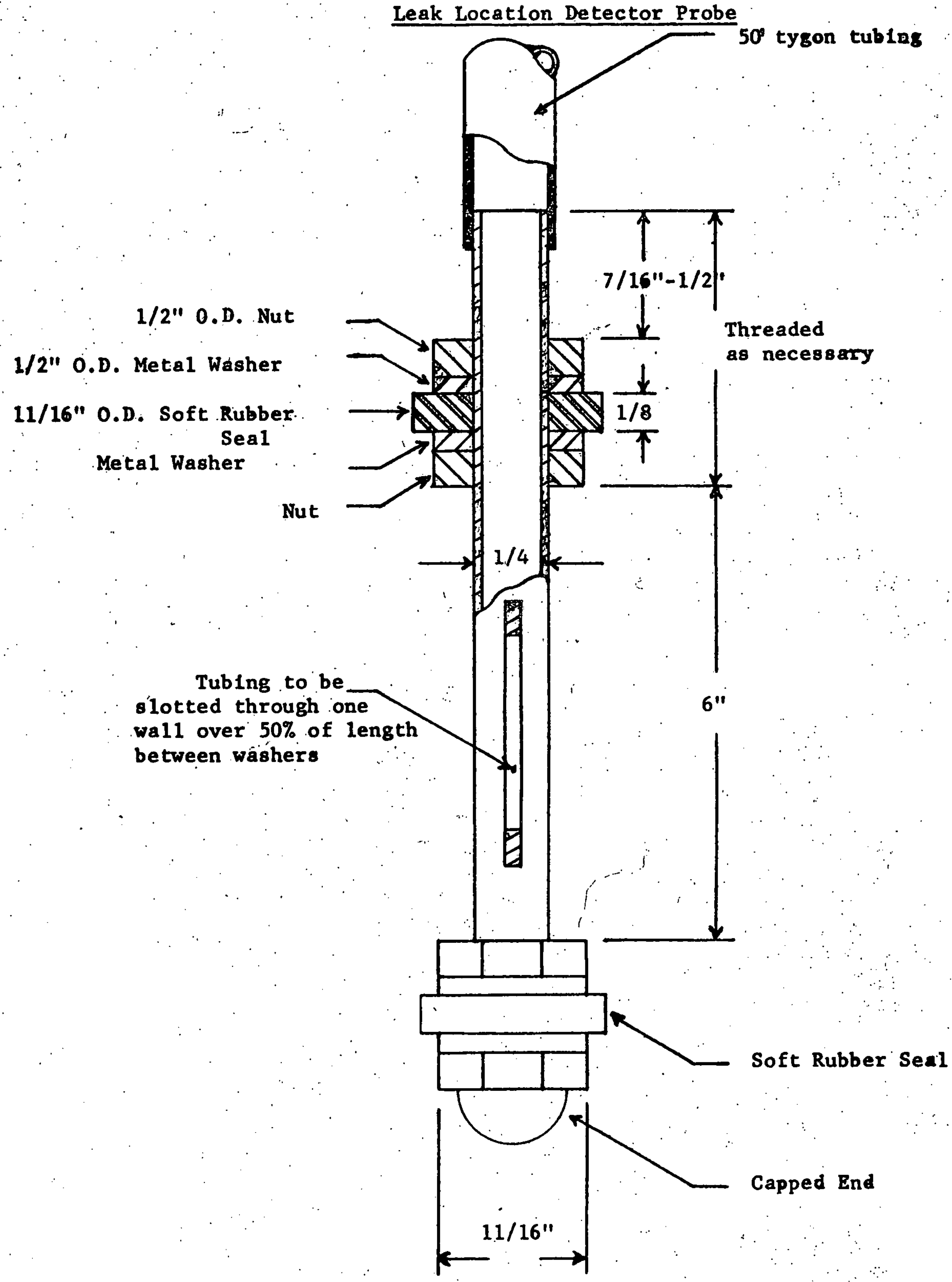
V = boiler volume, 5.9×10^{6} ml

t = time, minutes

The leak rates obtained from this equation are listed in Table VI. As shown by the data the leak rate is higher after refueling when the nine tubes were plugged than before refueling. This rise in the leak rate points to two possibilities: (1) A new leak could have occurred on the start-up of the plant after refueling (2) The limitation of any of the present means of determining leaking tubes. From Table VI it can be seen that the leak rate is tending to decrease as the operating time increases on the heat exchanger. No conclusion can be obtained at this time from this trend.

FIGURE 1

Leak Location Detector Probe



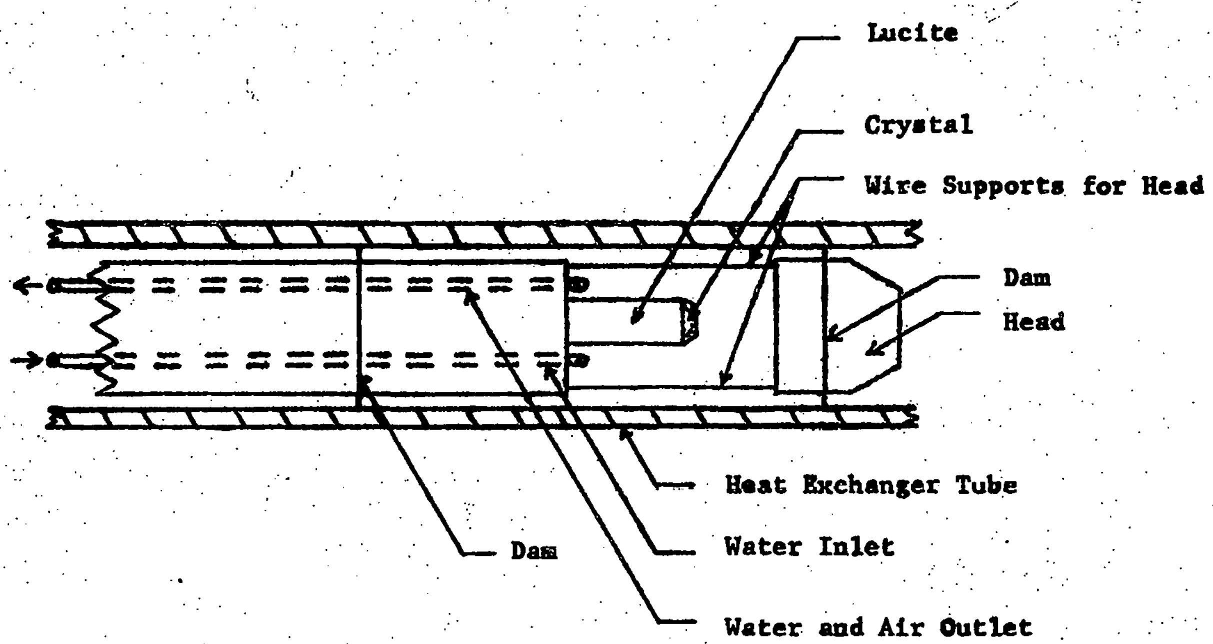


FIGURE 2
Ultrasonic Search Unit

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FIGURE 3

1B Heat Exchanger Plugged Tubes

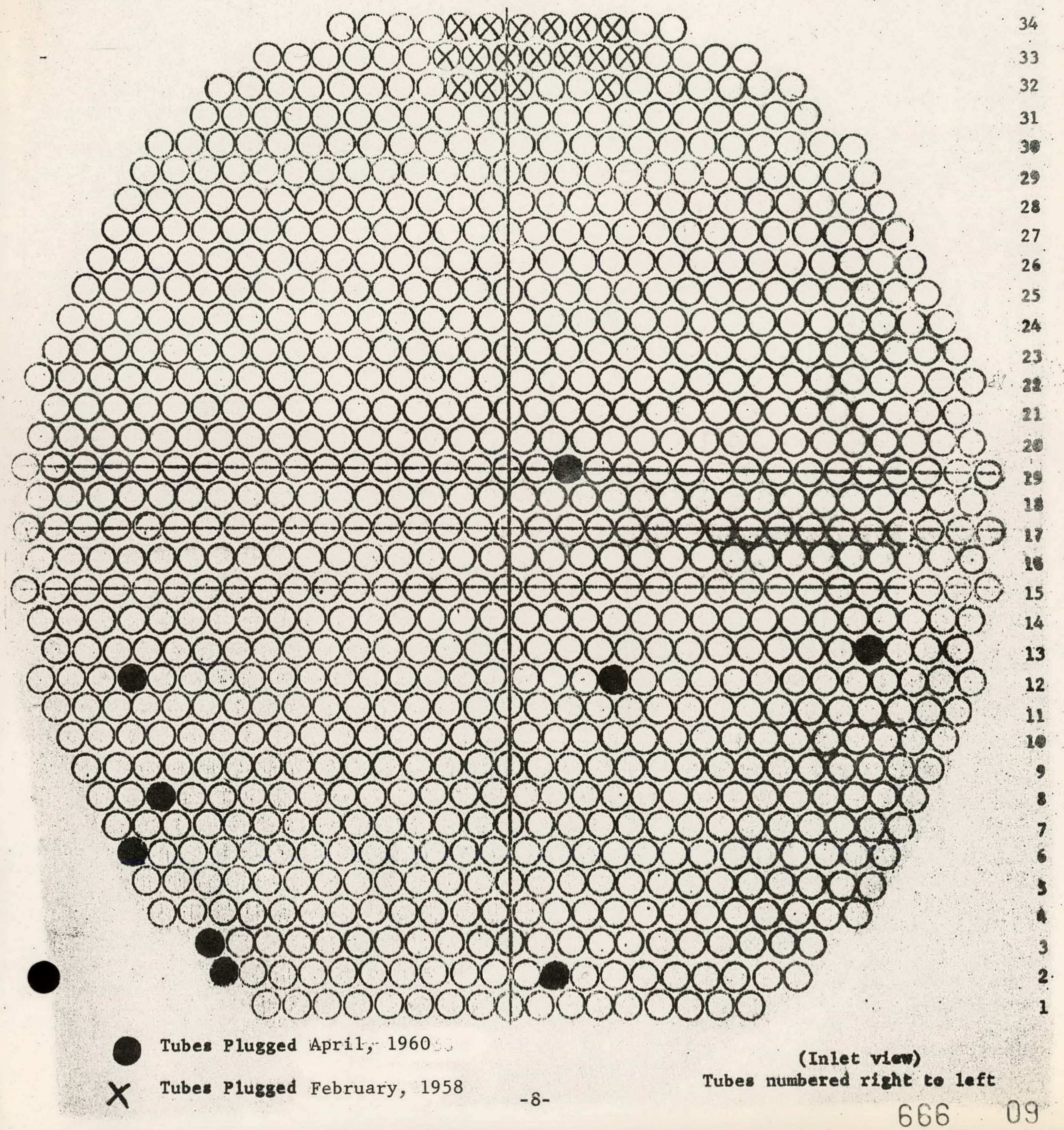

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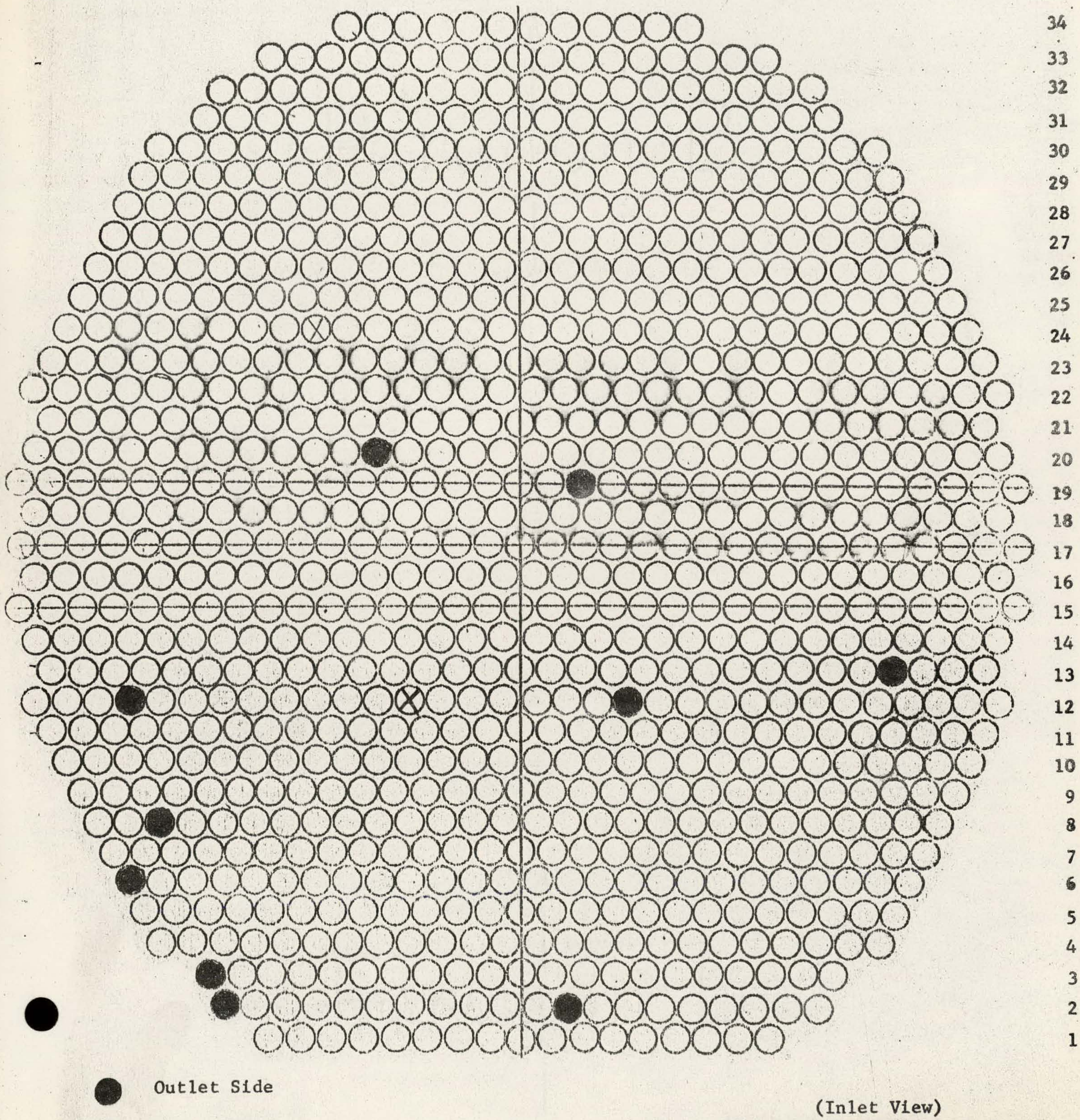
FIGURE 4

Air Pressurization Test



(Inlet View)
Tubes numbered right to left

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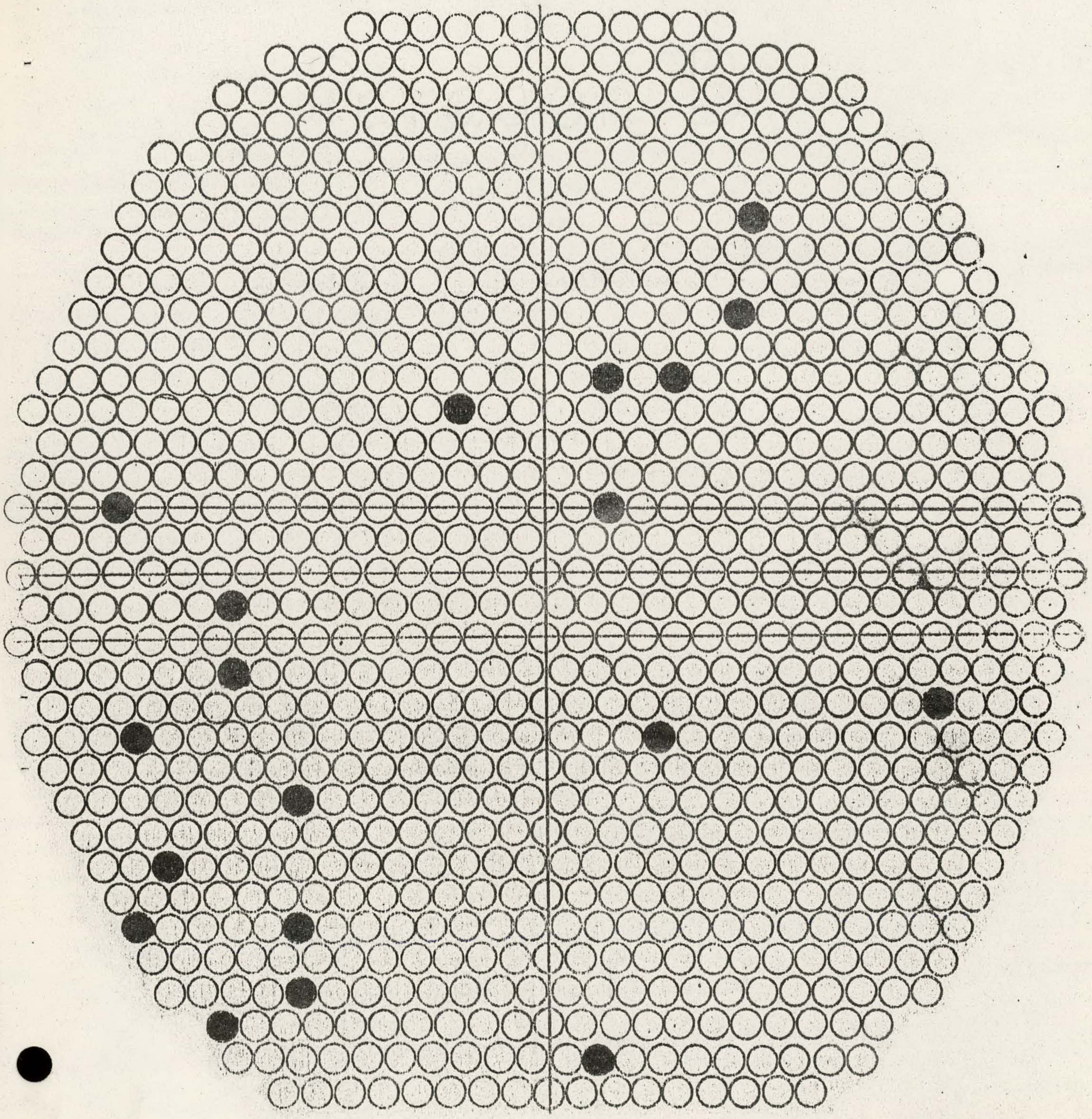
FIGURE 5

Boregage Test Tubes



(Inlet view)
Tubes numbered right to left

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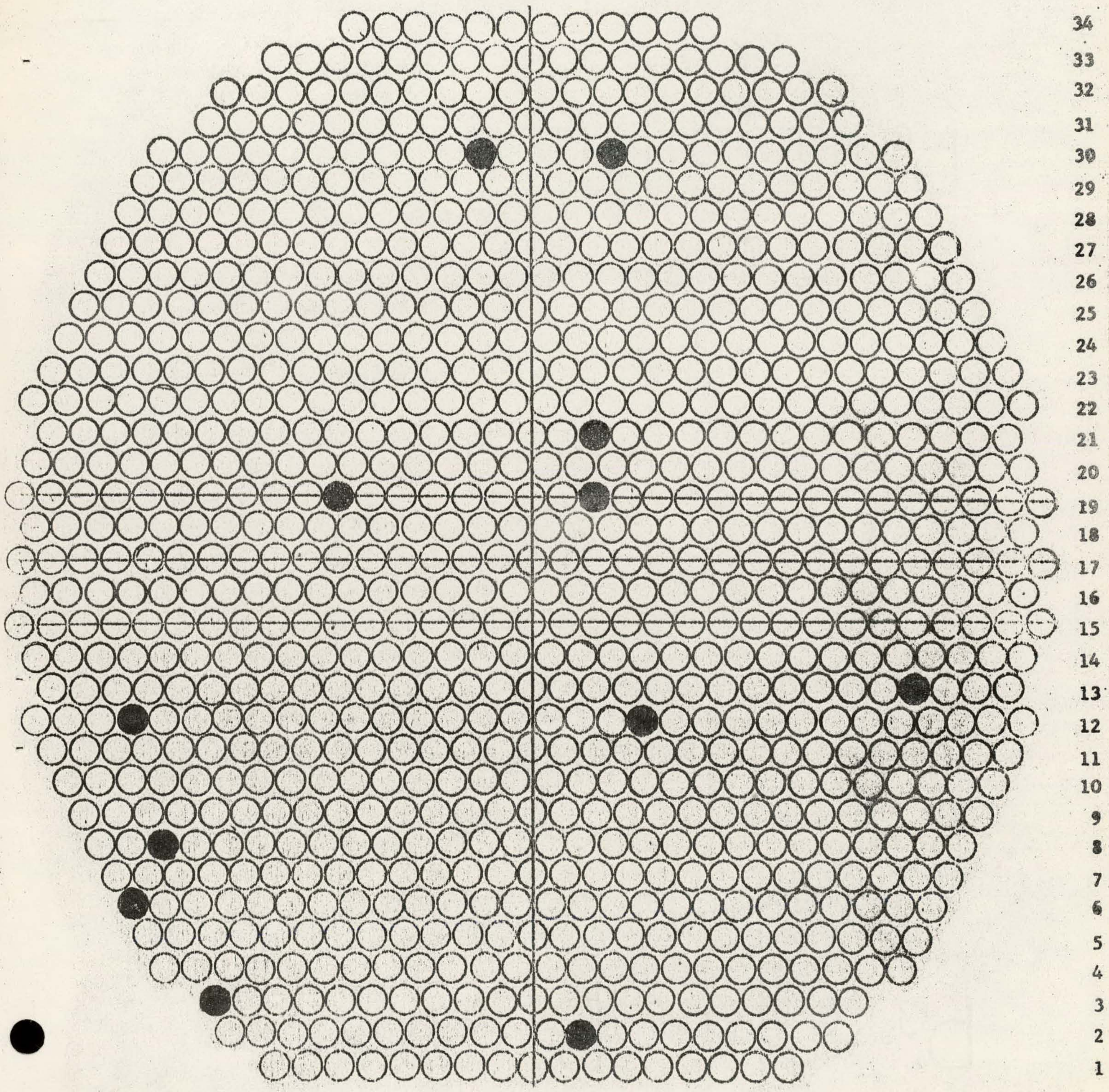
FIGURE 6

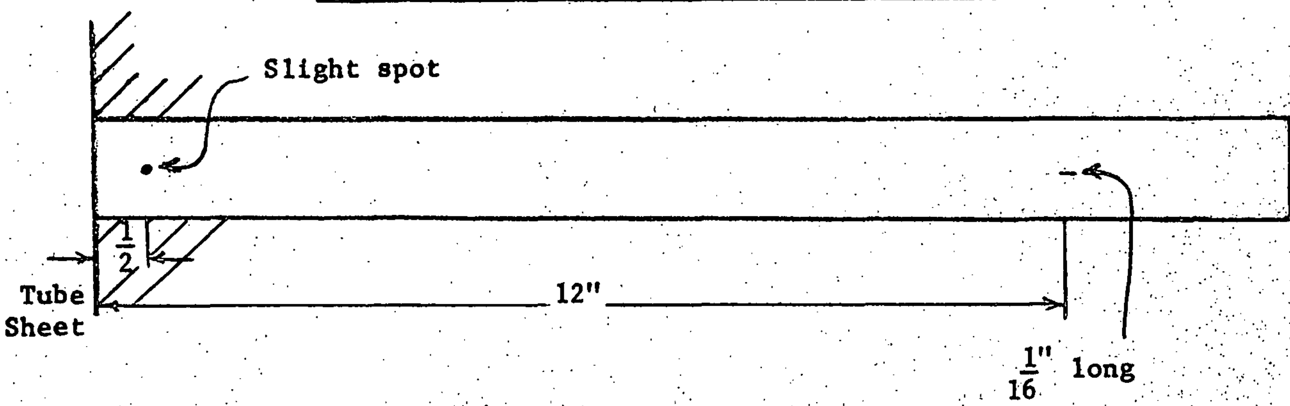
Tubes Tested with Dye Penetrant



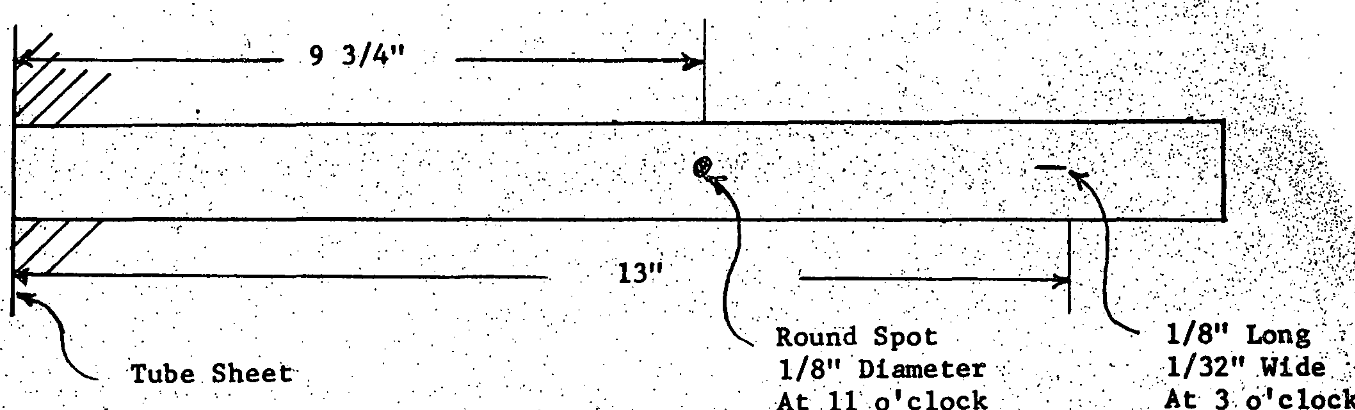
Tubes numbered right to left

(Inlet view)

FIGURE 7
Dye Penetrant Indications of Tube 9, Row 2



Checked 3-20-60

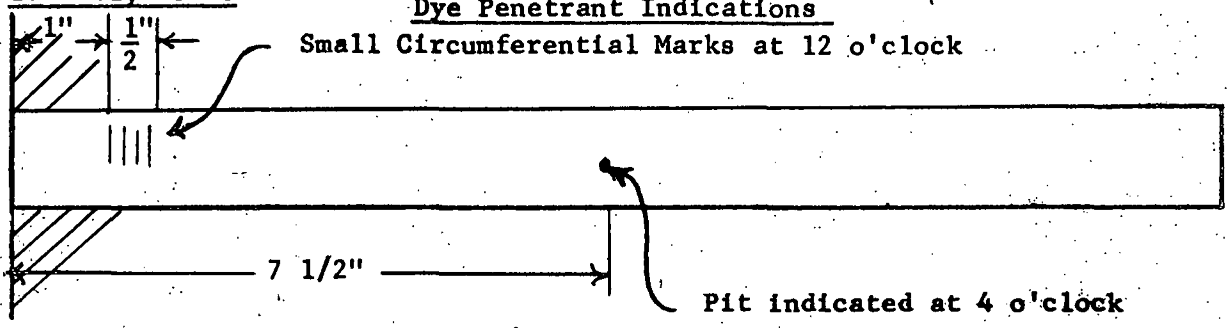


Checked 3-28-60

FIGURE 3

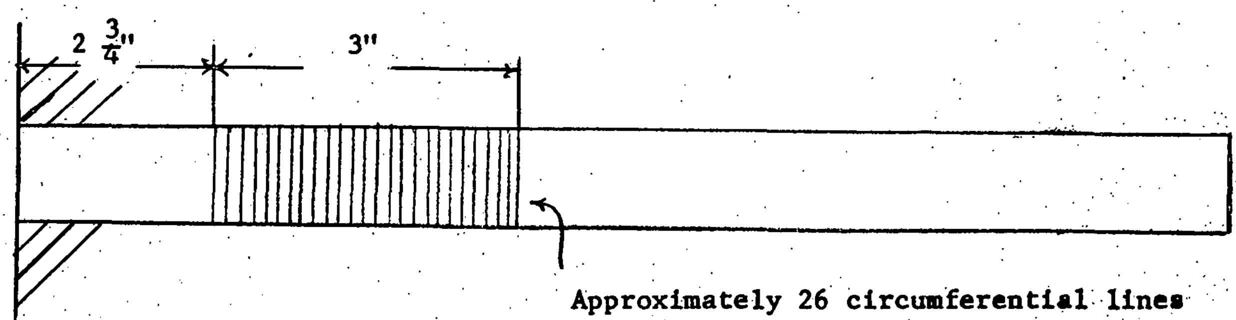
Tube 21, Row 3

Dye Penetrant Indications



Checked 3-23-60

Tube 26, Row 6



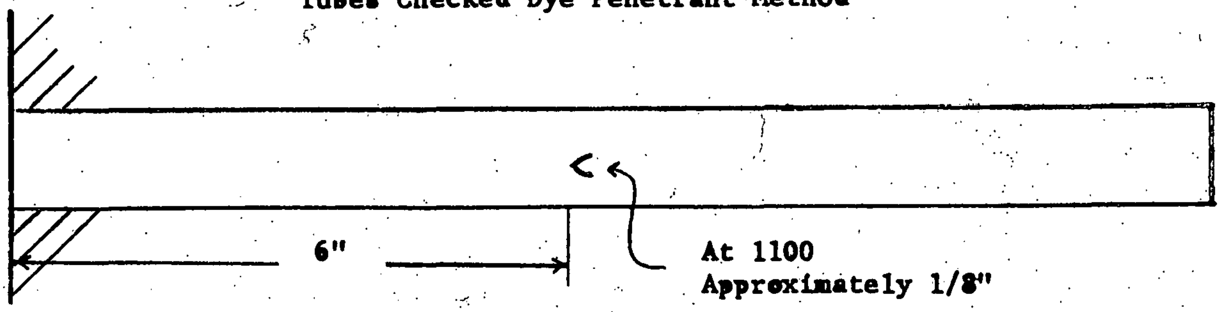
Approximately 26 circumferential lines around the tube. The line are nearly evenly spaced.

Row 6 Tube 26
Date checked 3-23-60
No indications 3-28-60 Recheck

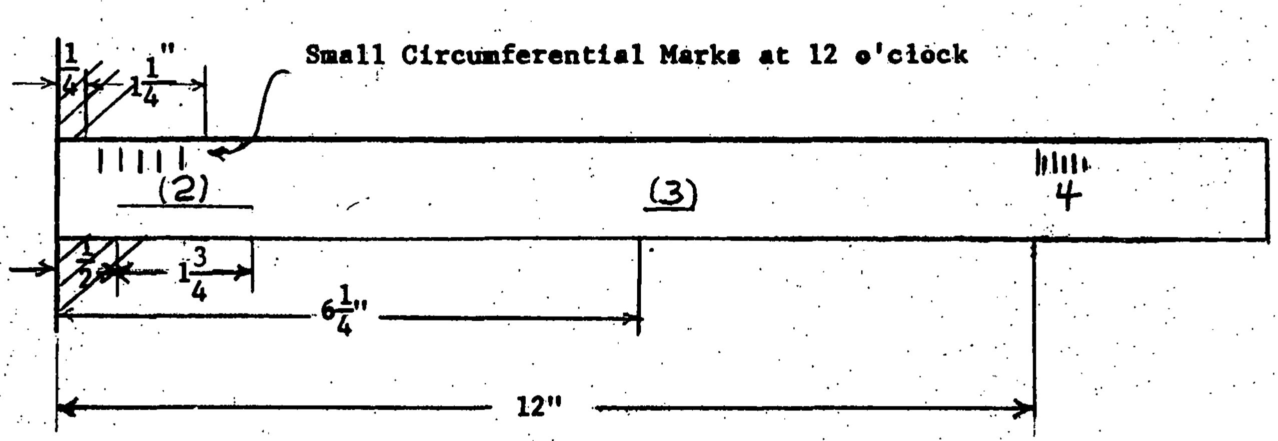
FIGURE 9

Dye Penetrant Indications of Tube 26, Row 8

Tubes Checked Dye Penetrant Method



Checked 3-23-60



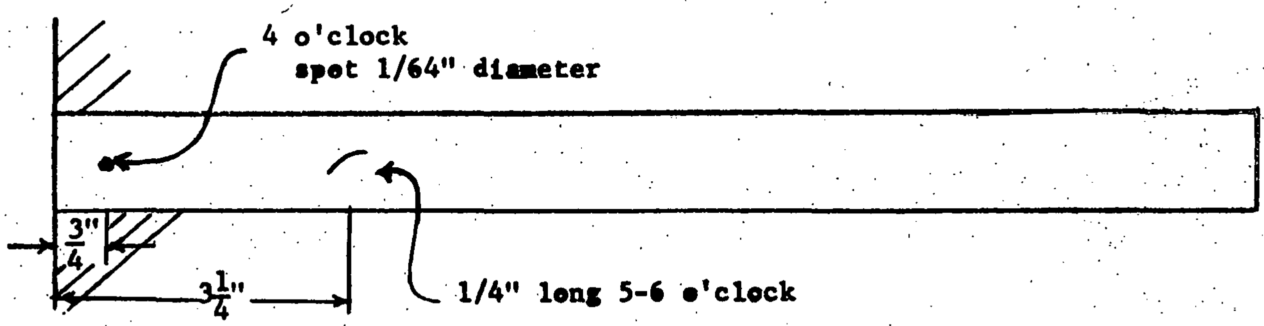
(2) Horizontal Mark at 1200
Light 3/4" becomes deeper for the next 1"
(3) Deep grove at 12 o'clock, 1/2" long
(4) Fine circumferential marks at 12 o'clock

Checked 3-23-60

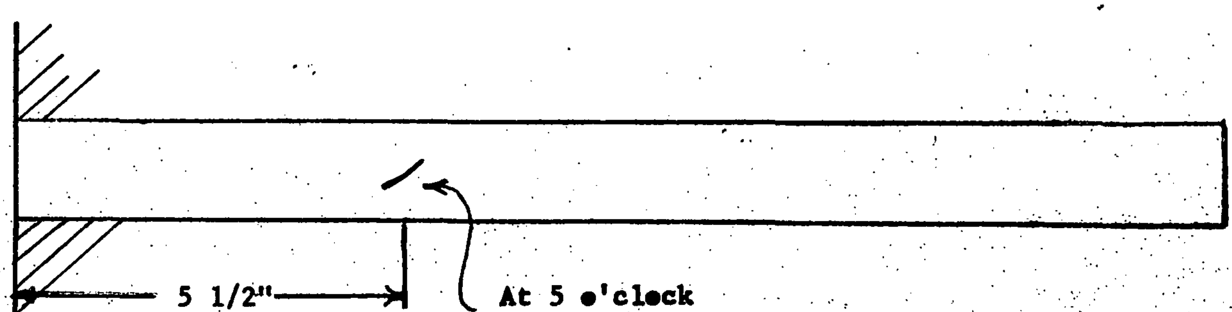
FIGURE 10

Dye Penetrant Indications of Tube 26, Row 8

Tube Checked Dye Penetrant Method



Checked 3-28-60

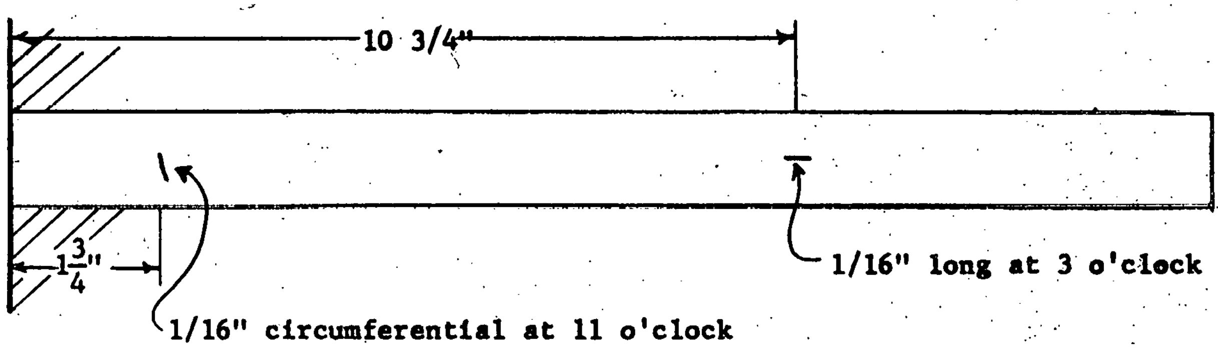


Checked 3-28-60

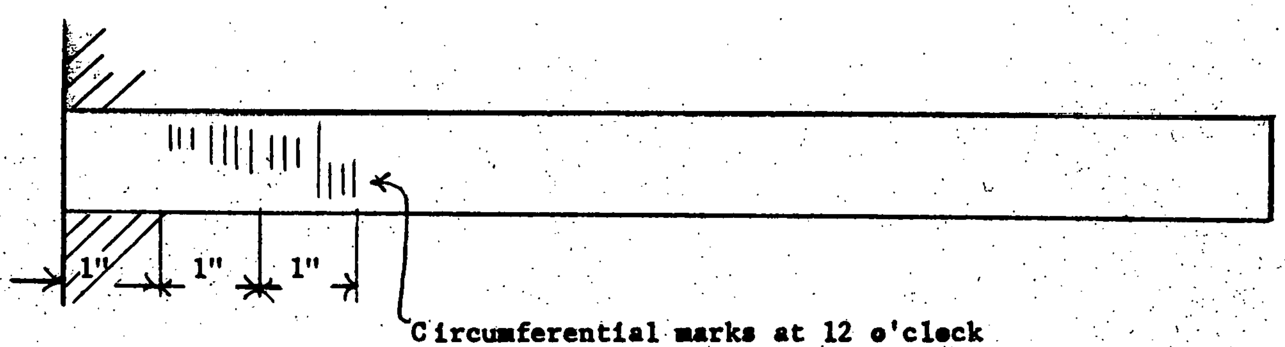
A third test made 3-28-60 showed no indications.

FIGURE 11

Dye Penetrant Indications of Tube 29, Row 12



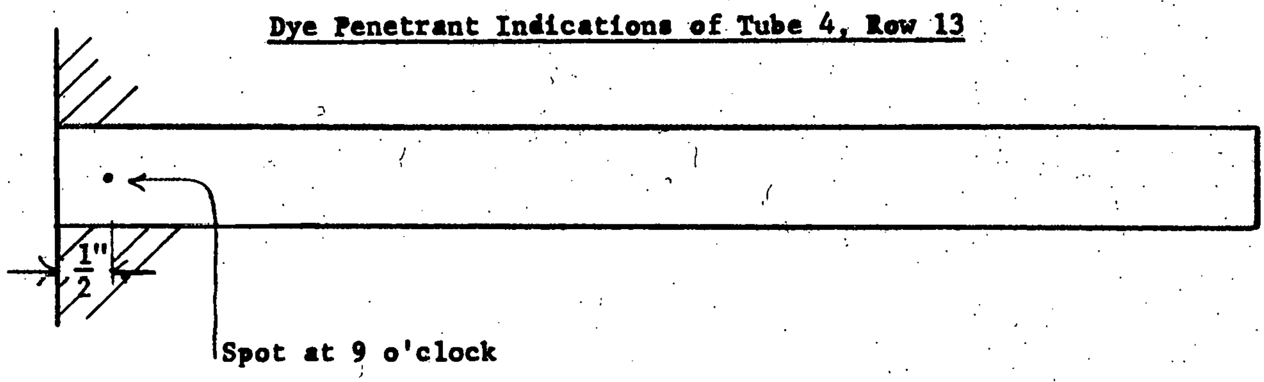
Checked 3-28-60



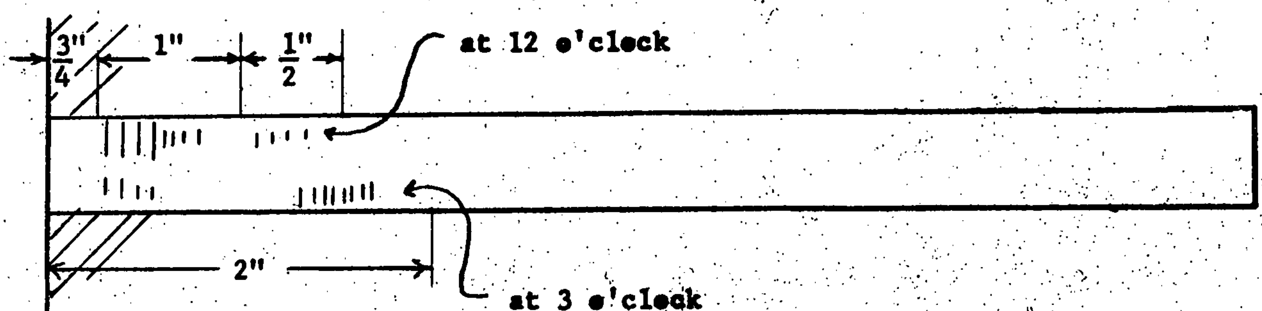
Checked 3-23-60

FIGURE 12

Dye Penetrant Indications of Tube 4, Row 13



Checked 3-20-60

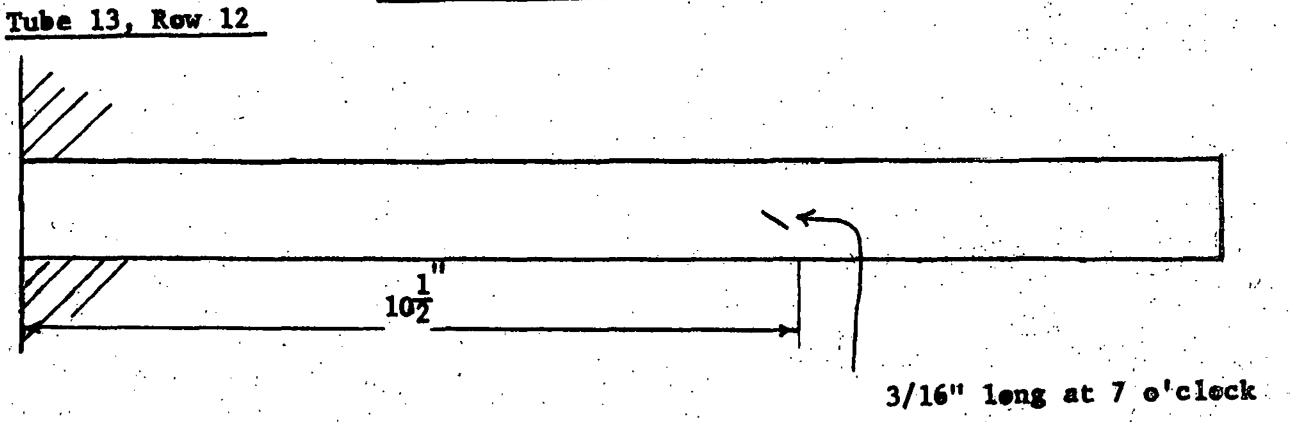


All lines were small approximately 1/8" long

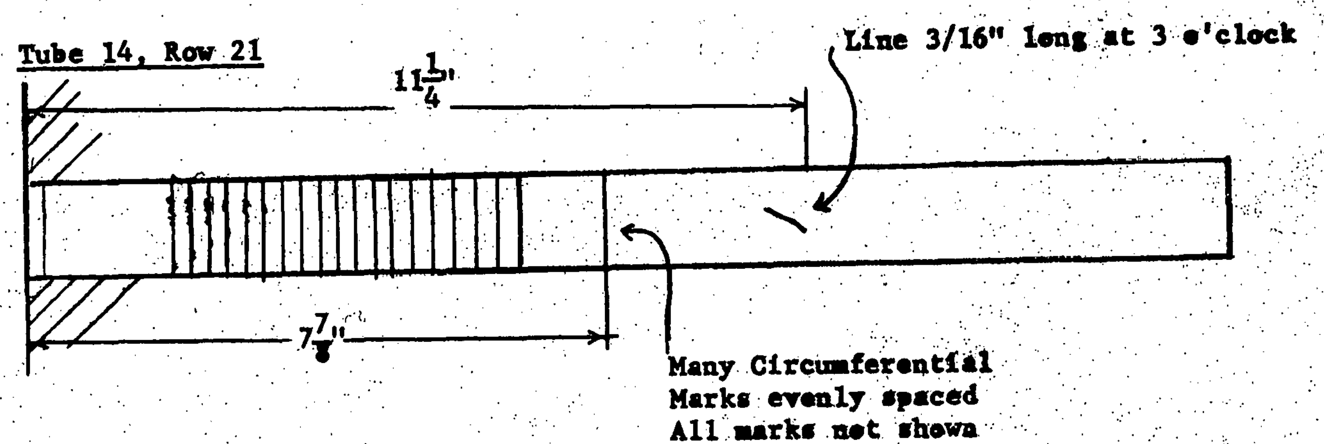
Checked 3-28-60

FIGURE 13

Dye Penetrant Indications



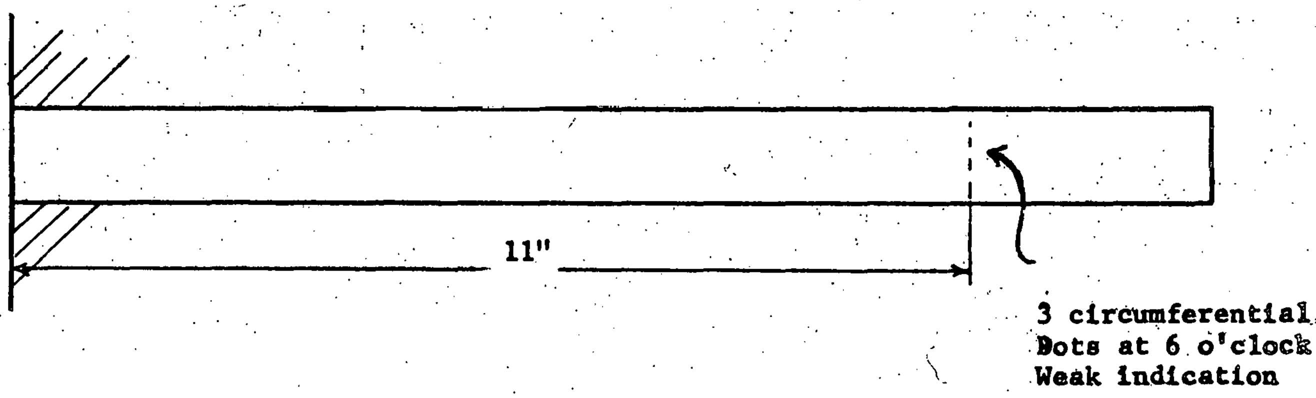
Checked 3-20-60



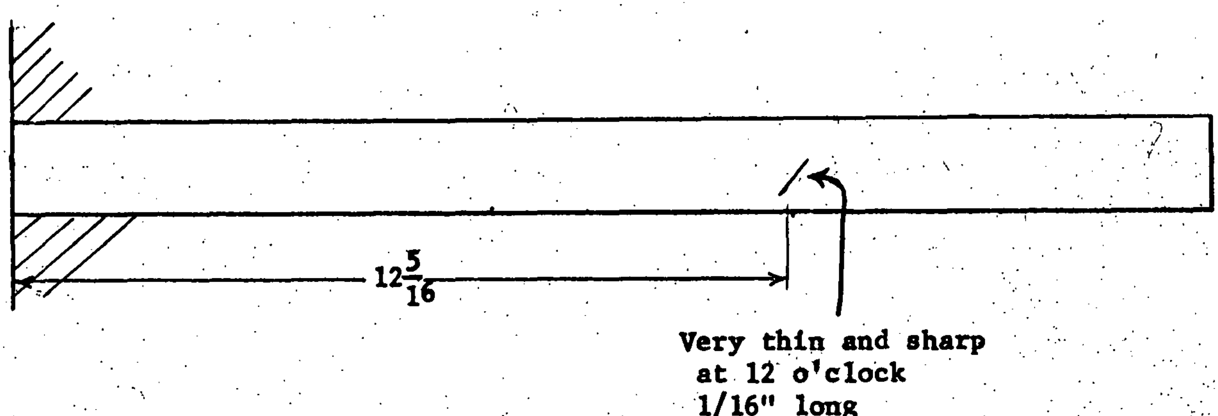
Checked 3-28-60

FIGURE 14

Dye Penetrant Indications of Tube 15, Row 19



Checked 3-20-60



Checked 3-28-60

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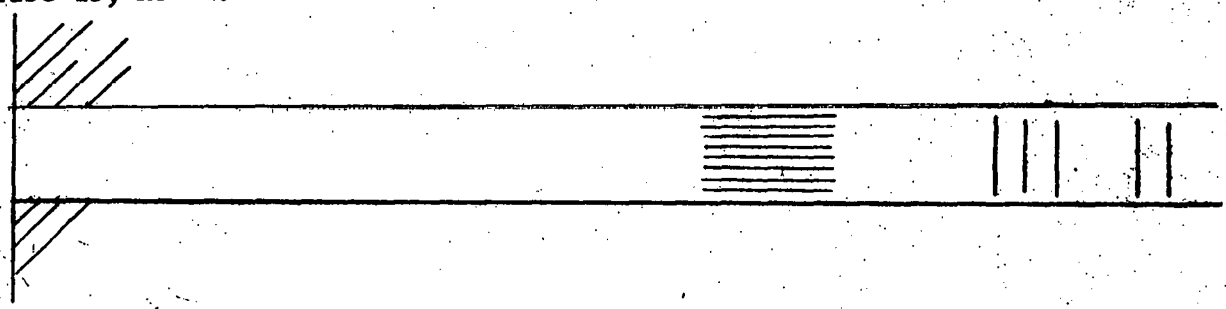
FIGURE 15

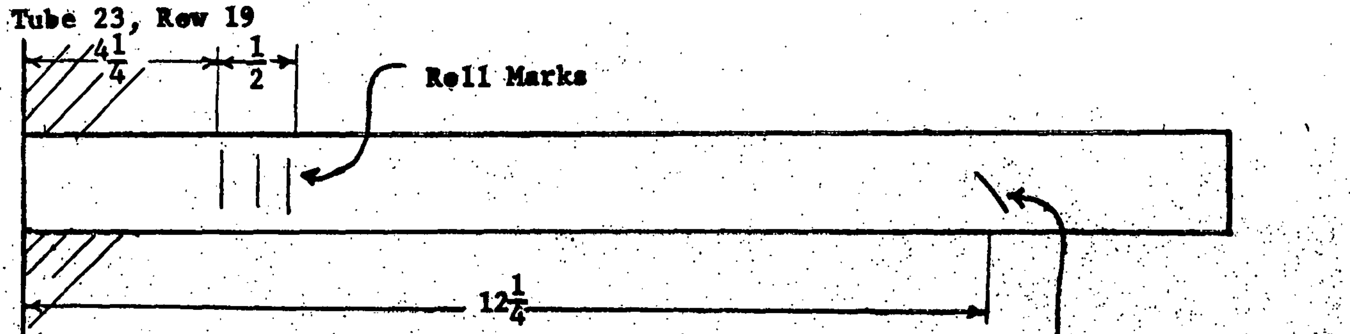
Dye Penetrant Indications

Tube 15, Row 19



Checked 3-28-60

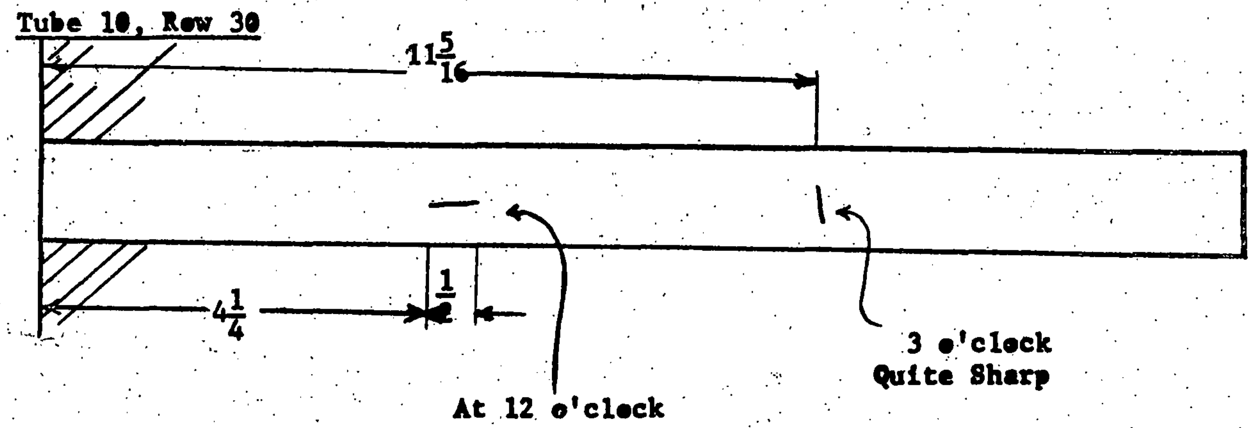
Tube 23, Row 19



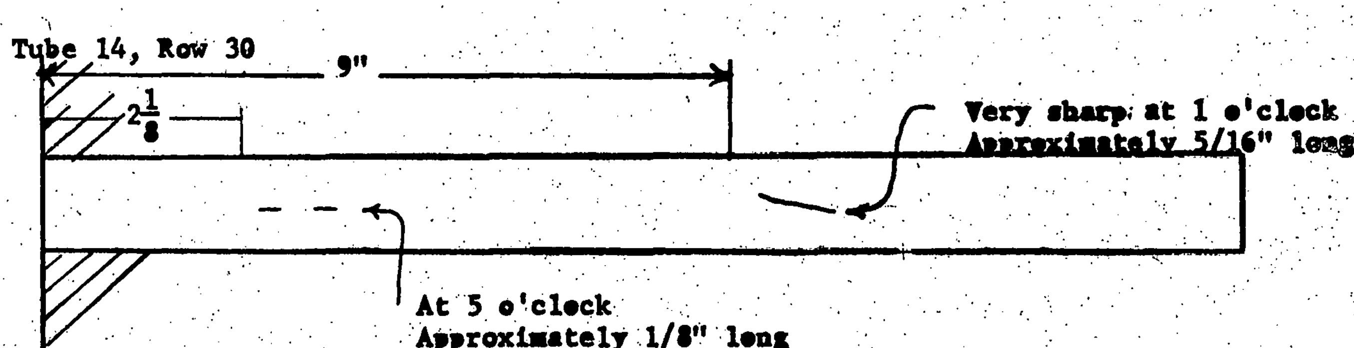
Checked 3-28-60

FIGURE 16

Dye Penetrant Indications



Checked 3-20-60



Checked 3-28-60

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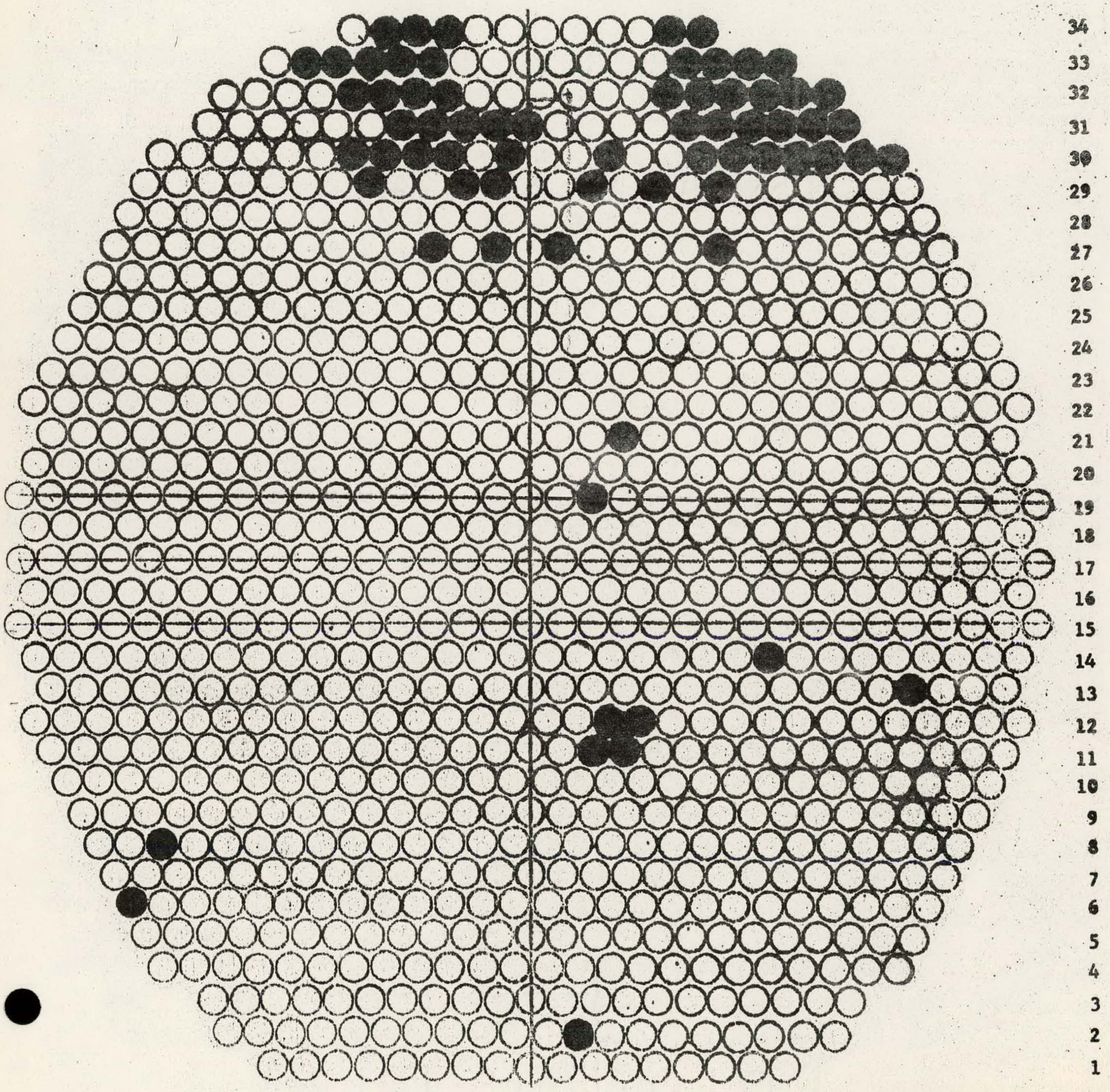
FIGURE 17

Tubes Tested By Ultrasonic Method



(Inlet View)
Tubes numbered right to left

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TABLE I

Tubes Indicating Leakage During Air Pressurization Test

Observation: Row	Tube Inlet Tube No. and Leakage	Tube Outlet Tube No. and Leakage
1	No leakers	No leakers
2	9:20 110 ml/10 min: slight leakage indication	No leakers
3	21 30 ml/8 min	No leakers
4	No leakers	No leakers
5	No leakers	No leakers
6	26 Slight leakage indication	No leakers
7	No leakers	No leakers
8	26 27.5 ml/3 min 10 sec.	No leakers
9	No leakers	No leakers
10	No leakers	No leakers
11	No leakers	No leakers
12	13:29 Slight leaking indication	20 Possible leakage
13	4 Slight leaking indication	No leakers
14	No leakers	No leakers
15	No leakers	No leakers
16	No leakers	No leakers
17	No leakers	No leakers
18	No leakers	No leakers
19	15 Slight leakage indication	No leakers
20	21 Possible leakage	No leakers
21	No leakers	No leakers
22	No leakers	No leakers
23	No leakers	No leakers
24	No leakers	22 Possible leakage
25	No leakers	No leakers
26	No leakers	No leakers
27	No leakers	No leakers
28	No leakers	No leakers
29	No leakers	No leakers
30	No leakers	No leakers
31	No leakers	No leakers
32	No leakers	No leakers
33	No leakers	No leakers
34	No leakers	No leakers

Secondary Pressure 75 psig

See Figure 4

TABLE II

January 13 and 14, 1960

Leak Location Probe Test

Tube Lips Ground Row	Tube	Leakage	Location
2	9*	No leakage	------
3	21	0 ml in 32 min.	------
6	26	No leakage	------
8	26	46 ml. in 10 min.	0 to 6" from tube inlet

* Tube was blown twice with air after reducing secondary pressure to zero. With secondary pressure at 75 psig, still no leakage detected.

TABLE III

Tube Inside Diameter (inches) by Boregage Test

Row	19	13	12	2	12	3	6	8	4
Tube	15*	4*	13*	9*	29*	21*	26*	26*	20
Distance From Tube Sheet (in)									
1	.6325		.6370		.6355	.6340	.6425	.6304	
2	.6326	.6367	.6364	.6413	.6340	.6373	.6420	.6295	
3	.6321	.6370	.6351	.6356	.6299	.6351	.6390	.6296	
3 1/2		.6344							
4	.6282		.6349	.6352	.6313	.6378	.6395	.6319	
4 1/2		.6295							
4 3/4		.6270							
5	.6284	.6268	.6351	.6361	.6321	.6394	.6373	.6317	.6311
5 1/4		.6290							
6	.6290	.6282	.6355	.6361	.6330	.6392	.6538	.6315	.6311
6 1/4							.6535	.6318	
6 1/2							.6498	.6317	
6 3/4							.6468	.6318	
7	.6282	.6285	.6357	.6365	.6332	.6395	.6454	.6319	.6311
7 1/4				.6365			.6420	.6318	
7 1/2		.6285		.6365			.6392	.6314	
7 3/4	.6284			.6320			.6432	.6286	
8	.6284	.6325	.6344	.6395	.6334	.6378	.6454	.6315	.6311
8 1/4	.6284	.6270		.6395	.6326	.6365	.6446	.6316	.6312
8 1/2	.6284	.6265	.6352	.6295	.6336	.6365	.6450	.6307	.6312
8 3/4	.6272	.6261	.6325	.6261	.6318	.6240	.6330	.6305	.6308
8 7/8	.6146		.6315			.6190		.6115	.6256
9		.6147	.6175	.6181	.6163		.6158		.6195
9 1/8		.6127	.6124						
9 1/4				.6187					.6182
9 1/2				.6185					
11 13/16									

* Leaking tubes per air pressurization test

(1) All measurements taken at tube inlet

TABLE III (cont'd)

Tube Inside Diameter (inches) by Boregage Test

Row	6	10	14	16	19	22	23	23	25	28
Tube	21	23	26	26	30	19	14	12	9	7
Distance From Tube Sheet (in)										
1										
2										
3										
3 1/2										
4										
4 1/2										
4 3/4										
5	.6312	.6311	.6310	.6309	.6310	.6310	.6309	.6311	.6312	).6320
5 1/2										
5 3/4										
6	.6310	.6311	.6311	.6310	.6310	.6311	.6310	.6313	.6311	).6320
6 1/4										
6 1/2										
6 3/4										
7	.6310	.6311	.6311	.6310	.6311	.6312	.6311	.6312	.6312	).6320
7 1/4										
7 1/2										
7 3/4										
8	.6311	.6311	.6311	.6310	.6311	.6311	.6309	.6310	.6312	.6311
8 1/4	.6311	.6311	.6311	.6310	.6311	.6311	.6309	.6311	.6312	.6310
8 1/2	.6311	.6310	.6311	.6310	.6311	.6309	.6310	.6311	.6311	.6310
8 3/4	.6257	.6311	.6310	.6310	.6311	.6309	.6311	.6313	.6311	.6309
8 7/8	.6217			.6209	.6275		.6311	.6285	.6311	
9	.6195	.6209	.6310	.6182	.6205	.6195	.6174	.6265	.6275	.6235
9 1/8			.6225							
9 1/4	.6187	.6203		.6180	.6180	.6178	.6168	.6197	.6203	.6233
11 13/16	.	.6205	.6204	.6180	.6177	.6177	.6166	.6194	.6205	.6197

See Figure 5

TABLE IV

Tubes Tested by Ultrasonic Method*

Row	Tube	Amplitude (%)	Distance From the Tube Sheet (inches)	Screen Location
34	9	78	8 3/4	5.5
		100	8 3/4	7.5
34	10	100	8 7/8	5.5
34	11	No indication		
34	1	10	7 1/2	5.5
34	2	55	8 7/8	5.5
		75	8 7/8	7.5
33	1	10	8 3/4	5.5
33	2	65	8 3/4	5.5
		75	8 3/4	7.5
33	3	25	4 1/2	5.5
33	4	15	8 3/4	5.5
		55	8 3/4	7.5
33	12	7	8 3/4	5.5
		25	8 3/4	7.5
33	13	20	8 3/4	5.5
		10	7 3/4	6.5
33	14	10	8 3/4	5.5
33	15	15	8 3/4	5.5
		22	8 3/4	6.5
		10	8 3/4	7.5
		20	7 3/4	6.5
33	16	7	8 3/4	5.5
		20	8 3/4	8.0
33	17	Probe would not enter the tube		
32	1	30	8 3/4	1D
32	2	25	9.0	1D
32	3	50	8 7/8	1D
		80	8 7/8	7.8
32	4	35	8 7/8	1D
		90	8 7/8	7.8

* All testing was done at the inlet side of the tubes

TABLE IV (cont'd)

Tubes Tested by Ultrasonic Method

Row	Tube	Amplitude (%)	Distance from the Tube Sheet (inches)	Screen Location
32	5	20	9.0	1.D.
		45	9.0	7.8
32	6	20	8 7/8	1.D.
		80	8 7/8	7.8
32	8	Probe would not enter the tube		
32	9	Probe would not enter the tube		
32	13	10	8 7/8	1.D.
		15	8 7/8	7.8
32	14	10	8 7/8	1D
		15	8 7/8	7.8
32	15	10	8 7/8	1.D.
		--	8 7/8	7.8
32	16	20	9.0	1.D.
		--	9.0	7.8
31	15	15	9.0	1.D.
		14	9.0	7.8
31	14	Back dam won't enter tube		
31	13	Back dam won't enter tube		
31	12	20	8 7/8	1.D.
		30	8 7/8	7.8
31	11	25	8 7/8	1.D.
		30	8 7/8	7.8
31	10	Back dam won't enter tube		
31	9	Probe won't enter tube		
31	8	Probe won't enter tube		
31	7	Front dam won't enter tube		
31	6	55	8 7/8	1D
		90	8 7/8	7.8
31	5	45	8 7/8	1D
		40	8 7/8	7.8
31	4	35	8 7/8	1D
		45	8 7/8	7.8
31	3	15	8 7/8	1D
		20	8 7/8	7.8

TABLE IV (cont'd)

<u>Tubes Tested By Ultrasonic Method</u>

Row	Tube	Amplitude (F)	Distance from the Tube Sheet (inches)	Screen Location
31	2	90	8 7/8	1D
		100	8 7/8	7.8
		15	8 3/4	0.D
31	1	15	8 7/8	1.D
		50	8 7/8	7.8
30	3	30	8 7/8	1D
		40	8 7/8	7.8
		10	8 7/8	0.D.
30	1	15	8 7/8	1D
		40	8 7/8	7.8
30	2	100	8 7/8	1D
		100	8 7/8	7.8
30	3	45	8 7/8	1D
		60	8 7/8	7.8
		10	8 7/8	0.D
30	4	40	8 7/8	1D
		90	8 7/8	7.8
		12	8 7/8	OD
30	5	50	8 7/8	1D
		80	8 7/8	7.8
30	6	70	8 7/8	1D
		100	8 7/8	7.8
		15	8 7/8	1D
		12	8 7/8	0.D.
30	7		8 7/8	1D
			8 7/8	7.8
		12	8 7/8	OD
30	8	Probe would not enter the tube		
30	9	Probe would not enter the tube		
30	10	30	8 7/8	1D
		50	8 7/8	7.8
		10	8 7/8	OD
30	11	Front dam would not enter the tube		
30	12	Rear dam would not enter the tube		

TABLE IV (cont'd)

Tubes Tested by Ultrasonic Method

Row	Tube	Amplitude	Distance from the Tube Sheet (inches)	Screen Location
30	13	30	8 7/8	1D
		50	8 7/8	7.8
		15	7 3/4	O.D.
30	14	Rear dam would not enter the tube		
30	15	30	8 7/8	1D
		60	8 7/8	7.8
30	16	30	8 7/8	OD
		60	8 7/8	OD
		40	8 7/8	OD
		45	8 3/4	OD
30	17	25	8 7/8	1D
		30	8 7/8	7.8
30	18	28	8 7/8	1D
		--	8 7/8	7.8
29	7	50	8 7/8	1D
		90	8 7/8	7.8
29	9	90	8 7/8	
		100	8 7/8	
29	11	15	8 7/8	
		25	8 7/8	
29	13	Probe would not enter the tube		
29	14	60	8 7/8	1D
		90	8 7/8	
		12	8 7/8	OD
		18	8 7/8	OD
29	15	20		
		40		
29	17	Probe would not enter the tube		
29	18	25	8 7/8	
		40	8 7/8	
27	8	20	8 7/8	
		35	8 7/8	
27	10	Probe would not enter the tube		
27	13	25	8 7/8	1D
27		60	8 7/8	7.8

TABLE IV (cont'd)

Tubes Tested by Ultrasonic Method

Row	Tube	Amplitude	Distance from the Tube Sheet (inches)	Screen Location
27	15	40	8 7/8	ID
		60	8 7/8	7.8
		18	8 7/8	OD
27	17	20	8 7/8	ID
		60	8 7/8	7.8
		10 - 15	7 1/2	
21	13	25	8 7/8	ID
		--	8 7/8	7.8
		12	8 7/8	OD
19	15	30	8 7/8	ID
		--	8 7/8	7.8
14	9	15	8 7/8	ID
		--	8 7/8	7.8
2	9	No indication		
6	26	35	10	OD
		10	5 1/2	ID
8	26	No indication		
12	13	10	7 3/4	OD
		10	7 3/4	ID
		10	9	ID
13	4	25	8 7/8	ID
		20	4	ID
13	4*	60	9	ID
		15	4	ID
11	13	25	8 3/4	ID
		20	7 3/4	OD
12	14	20	8 3/4	ID
		15	7 3/4	---
11	14	Probe would not enter the tube		
11	13*	20	8 3/4	ID
11	13*	5	7 3/4	ID
12	13*	10	10	ID
		15	7 3/4	OD

* Recheck data

TABLE IV (cont'd)

Tubes Tested by Ultrasonic Method

Row	Tube	Amplitude	Distance from the Tube Sheet (inches)	Screen Location
12	14*	5	8 3/4	ID
13	4*	50	8 3/4	ID
		5	7 5/8	OD
		10	4	ID
12	13*	15	8 1/4	ID
		2	7 1/2	ID
		10	7 1/2	OD

See Figure 17

* Recheck data

TABLE V

Film Badge Readings (Roentgen)*

Film Location 2" From Tube Sheet			5/16 Inch	1/6 Inch		No	20 Mil	Beta-Gamma
Row	Tube	Position	Plastic	Plastic		Shielding	Cadmium	Ratio
7	22	7 o'clock	3.63	3.94	4.05	4.58	4.05	7.6
26	3	2 o'clock	4.24	3.80	3.67	4.49	3.17	4.7
21	16	Midpoint	2.83	3.24	3.20	3.60	2.94	4.5

Film Location 6" From Tube Sheet			5/16 Inch	1/6 Inch		No	20 Mil	Beta-Gamma
Row	Tube	Position	Plastic	Plastic		Shielding	Cadmium	Ratio
7	22	7 o'clock	2.65	2.94	2.98	3.60	2.11	1.4
26	3	2 o'clock	2.58	3.88	3.42	3.17	2.54	4.1
21	16	Midpoint	2.03	2.50	2.08	2.01	1.75	6.7

* Exposure Time One Hour

Readings can be expressed as R/Hr.

Log of Events

February 3, 1958	It was determined that a leak of about 35 gallons per hour at 2000 psi differential pressure existed from the primary to the secondary side of the 1B heat exchanger. On the basis of air pressurization tests and probolog tests, four tubes were removed and a total of 17 tubes were plugged.
October 21 and 22 1959	Selected tubes of the 1B heat exchanger were subjected to probolog tests.
October 25, 1959 to November 14, 1959	All unplugged tubes were checked for leaks by pressurizing the secondary side with 75 psig air. Leakage was indicated in 9 tubes and leak rates were obtained.
January 13 and 14 1960	Of the 9 tubes indicating leakage the ends of 4 tubes were ground to permit the entry of a leak location detector probe. Measurable leakage was found in only one tube. Air pressure was applied on the primary side of the previous leaking tubes to reopen the cracks.
January 29, 1960 to February 12, 1960	Selected tubes were tested by the boregage method to determine inside diameters.
March 20-28, 1960	Selected tubes including the 9 leaking tubes were given a dye penetrant test.
March 24 and 25 1960	Selected tubes were tested by the ultrasonic method.

TABLE VI

1B Heat Exchanger Leak Rates

Date	Activity of Reactor Coolant (dpm/ml) ($x10^3$)	Secondary Boiler Water Activity dpm/ml	Hours at 100% Reactor Power	Leak Rate ml/min
3/25/59	7.60	0.61	148.0	0.30
4/29/59	4.60	0.18	245.0	0.15
5/20/59	3.90	0.32	379.0	0.31
8/28/59	6.80	0.15	168.0	0.08
9/ 2/59	3.40	0.22	51.3	0.28
9/ 4/59	7.40	0.16	99.7	0.08
9/24/59	2.70	0.24	195.0	0.41
Refueling				
5/15/60	2.50	1.30	79.0	2.00
5/12/60	2.10	1.30	119.0	2.30
5/17/60	2.20	0.93	33.0	2.20
5/20/60	1.90	1.19	105.0	2.40
5/24/60	2.30	1.74	40.0	3.60
6/10/60	2.30	1.26	453.0	2.10
6/28/60	14.90	15.90	71.2	4.30
7/ 8/60	14.70	9.74	356.0	2.50
8/ 8/60	21.30	17.40	100.0	3.10
9/ 9/60	16.50	16.50	506.0	3.70
10/7/60	2.73	1.15	277.4	1.60
11/15/60	2.36	1.01	215.5	1.60
12/27/60	1.24	0.44	465.4	1.30
1/27/61	1.75	0.45	1260.7	0.95
2/14/61	1.60	0.35	228.2	0.81
3/10/61	1.75	0.35	439.0	0.74
3/17/61	1.35	0.33	602.0	0.91

TEST RESULTS DLCS 3330101
1B HEAT EXCHANGER LEAK TEST
CORE I SEED 1

Results Prepared By Warren Duff

Results Reviewed By R. M. Johnson

Approved (Duquesne Light Company) George Santel Date 2-3-61

SECOND ISSUE

Approved By George A Santel Date 4-24-61