50-247

STEAM GENERATOR INSPECTION PROGRAM AND RESULTS

DTD March 1978

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ATTACHMENT A

Steam Generator Inspection Program and Results

March, 1978

Consolidated Edison Company of New York, Inc.

Indian Point Unit No. 2
Docket No. 50-247
Facility Operating License No. DPR-26

Docket # 50-247
Control # 7808170007
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INSPECTION PROGRAM DESCRIPTION

Following the Indian Point Unit No. 2 steam generator tube inspection in April, 1977, the Nuclear Regulatory Commission (NRC) issued Amendment No. 30 to Unit No. 2's Facility Operating License No. DPR-26. The Amendment issued on May 13, 1977, permitted twelve equivalent months of operation beyond this date. Equivalent operation was defined as operation with a primary coolant temperature greater than 350 F.

By letter from Mr. William J. Cahill, Jr. of Con Edison to Mr. Robert W. Reid of the NRC dated January 11, 1978, we submitted the details of the steam generator inspection program for the Unit's second refueling outage. This outage was begun on February 13, 1978. On February 24, we received a letter from Mr. A. Schwencer of the NRC commenting on our proposed program. These comments were discussed on February 24, and a revised inspection program was agreed upon. This program included the following:

1. Steam Generator Eddy Current Examination

   A sample group of tubes in the hot legs of Steam Generators 23 and 24 were eddy current inspected for dents and defects. The eddy current inspection for tube defects was performed nominally at 400 KHz at standard gain. The inspection to identify tube dents was performed nominally at 400 KHz and at a reduced gain.

A standard 700 mil eddy current probe was used to perform the eddy current testing. If any tube did not permit passage of this standard 700 mil probe, successively smaller probes were used until the size of the restriction was quantified. In all, five different size probes (700 mil, 675 mil, 640 mil, 610 mil, and 540 mil) were available to quantify the size of a restriction.

In addition, the tubes immediately adjacent to any tube that did not pass the 610 mil probe were also subjected to an eddy current inspection for dents.

Locations of the hot leg tubes in Steam Generators 23 and 24, which were eddy current inspected, are given in Tables 1&2 and Figures 1&2. In Steam Generator 23, 463 tubes, or about 14.6 percent of all the active tubes in that steam generator, were inspected. All of these tubes were inspected for defects and 444 of the tubes were inspected for dents. In Steam Generator 24, 473 tubes, or about 15.0 percent of all the active tubes, were examined. Of these tubes, all were inspected for dents and 283 tubes were inspected for defects.

The eddy current inspection included tubes in the hot legs of rows two and three of Steam Generators 23 and 24. The tubes that were inspected in these rows were selected from areas of higher stress concentrations near the flow slots all the way across the steam generator. Tubes in row one

TABLE 1

EDDY CURRENT INSPECTION
ON HOT LEG OF STEAM GENERATOR 23

ROW	COLUMN	NUMBER OF TUBES
2,3	2 through 35,58,59,60,63,64,65, 73,74,75 and 78 through 91	114
7	1 through 6, 88 through 92	11
8	1 through 6, 88 through 92	11
9 through 12	2 through 6, 88 through 91	36
13 through 15	3,4,5,6 and 88,89,90	21
16	4,5,6	3
21	7,10,13,16,19,22,25,28,31,34, 37,40,43	13
28,29	11 through 17, 76 through 82	28
30	12 through 17,19,22,25,28,31, 34,37,40,43 and 76 through 81	21
31,32,33	15,16,17,76,77,78	18
32,33	39 through 54	32
34	16,17,76,77	4
35	17,76	2
34 through 40	39,40,53 and 54	28
41	27 through 40, 53 through 66	28
42	29 through 64	36
43	32 through 61	30
44	35 through 58	24
45	39 through 54	16
3,6,9,12,15,18, 21,24,27	46,52, and 58	26
	TOTAL	502

TABLE 2

EDDY CURRENT INSPECTION
ON HOT LEG OF STEAM GENERATOR 24

ROW	COLUMN	NUMBER OF TUBES
2,3	2 through 35,58,59,60,63,64,65, 73,74,75,78,79,80,89,90 and 91	98
7	1 through 6, 88 through 92	11
8	1 through 6, 88 through 92	11
9 through 12	2 through 6, 88 through 91	36
13 through 15	3,4,5,6 and 88,89,90	21
16	4,5,6	3
21	7,10,13,16,19,22,25,28,31,34, 37,40,43	13
27	11,12,13	3
28,29	11 through 17, 76 through 82	28
30	12 through 17,19,22,25,28,31,34, 37,40,43 and 76 through 81	21
31,32	15,16,17,76,77,78	12
32,33	39 through 54	32
33	15,16,17,18,76,77,78	7
34	16,17,18,76,77	5
35	17,18,76	3
34 through 40	39,40,53, and 54	28
39	52	1
40	52	1
41	27 through 40, 52 through 66	29
42	29 through 64	36
43	32 through 61	30
44	35, 39 through 53, 57 and 58	18
45	39 through 54	16
3,6,9,12,15, 18,21,24,27	46,52, and 58	26
	TOTAL	489

NOTES: (1) Six locations in Steam Generator 24 have been previously plugged and were not eddy current tested. These six locations are Row 44, Columns 36, 37, 38, 54, 55, and 56.

(2) Row 1 tubes in all four steam generators were plugged during the construction phase when modifications were made to the water box divider plates of each steam generator. Tubes in Row 1, therefore, were not inspected.

FIGURE 1: Locations of Tubes that were Eddy Current Tested
(Hot Leg of Steam Generator 23)

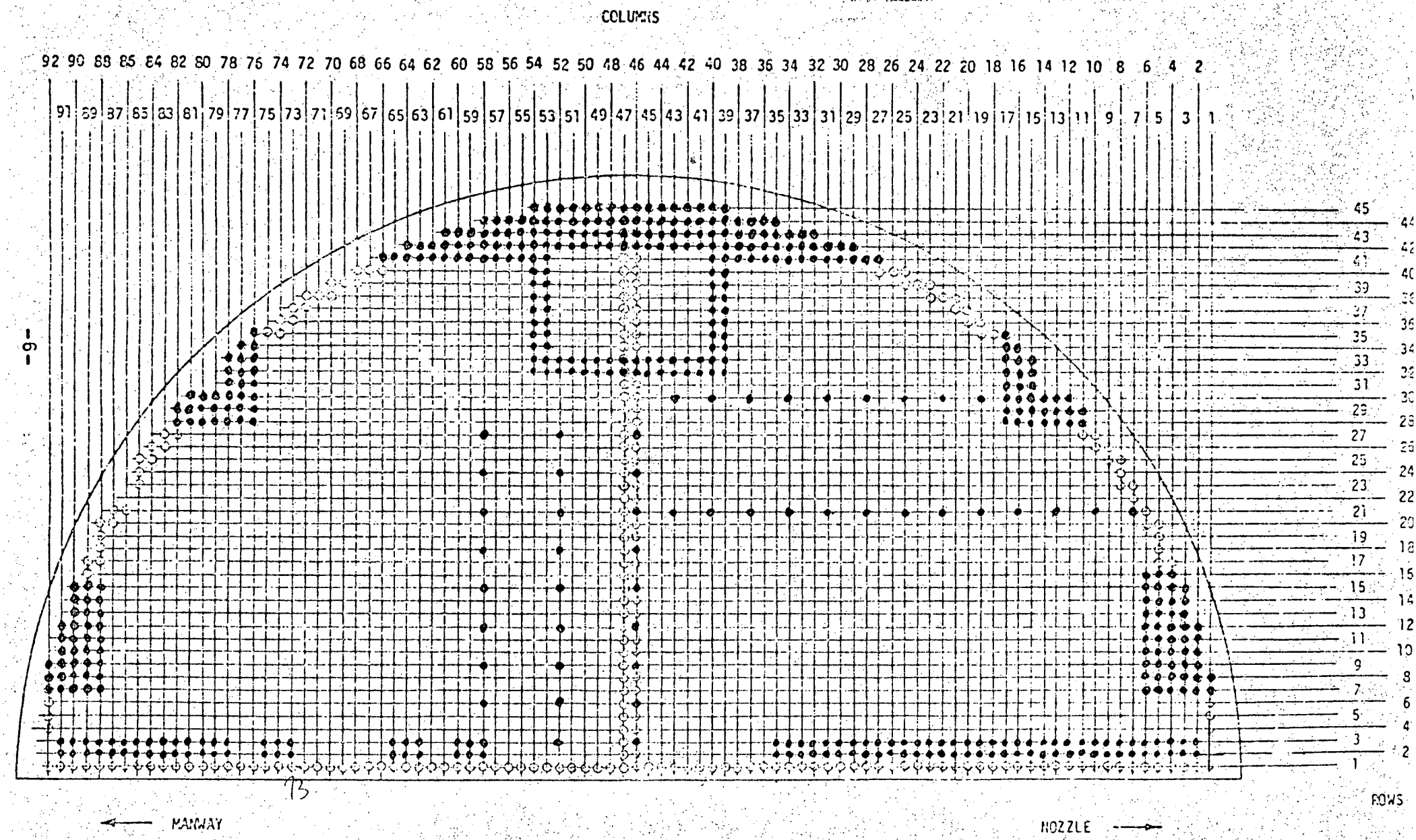
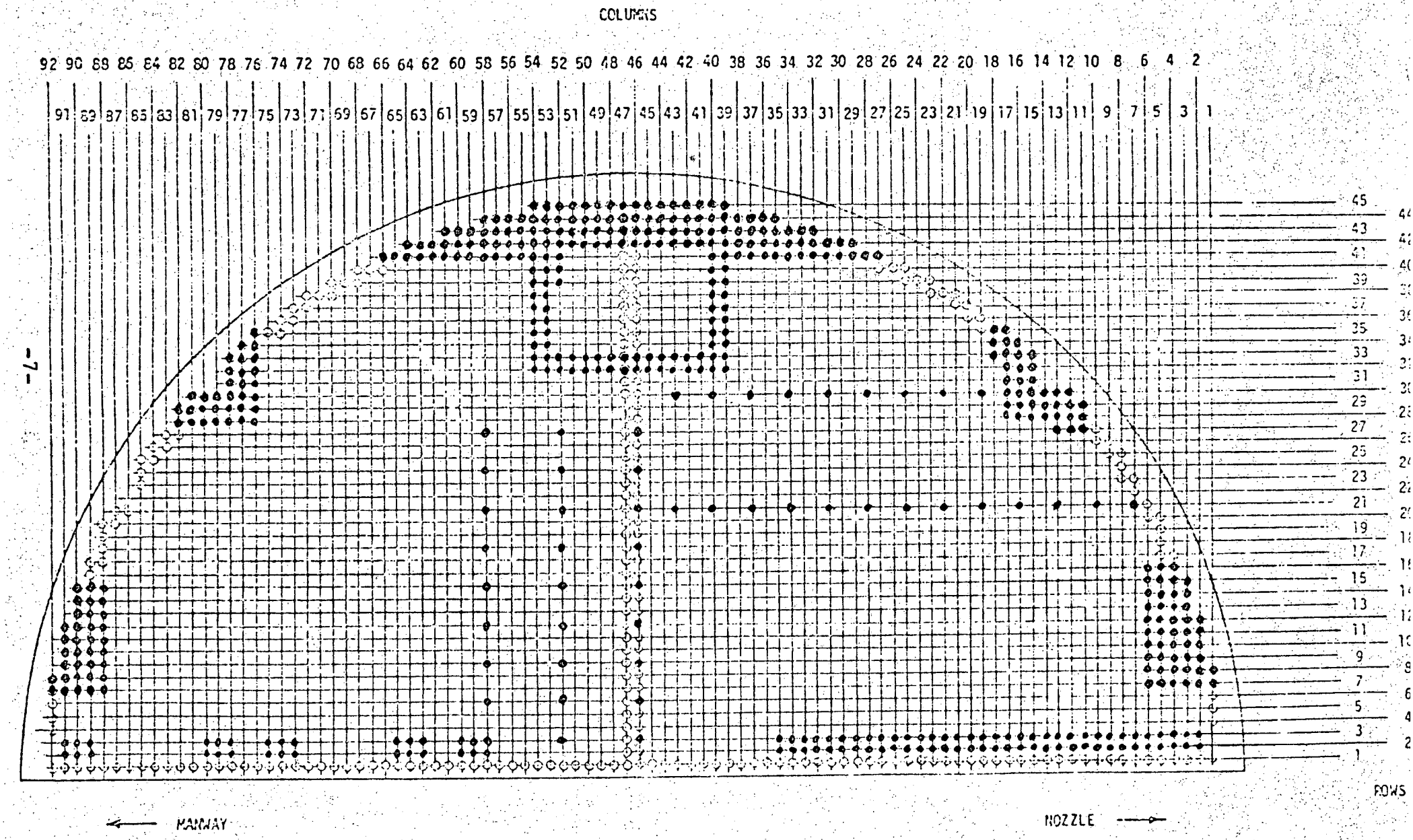


FIGURE 2: Locations of Tubes that were Eddy Current Tested
(Hot Leg of Steam Generator 24)



were not inspected because all the tubes in this row in all four steam generators were plugged during the unit's construction phase when modifications were made to the water box divider plates.

2. Flow Slot and Support Plate Inspection

Using the hand holes above the tube sheet for all four steam generators, a visual and photographic examination of the lower tube support plates was made. Where feasible, higher support plates were also photographed through the flow slot in the lower support plates.

Five inspection ports of nominal diameter of one inch were installed in Steam Generator 24. These inspection ports were provided at the levels of five of the six tube support plates in the steam generator and a visual examination of the tube support plates at these locations is planned. The ports were located in areas of the steam generator away from the tube lane so that the tube support plate ligaments in "hard spot" areas around the periphery of the plate could be viewed.

3. Top Support Plate Inspection of Steam Generator No. 22

The innermost (row number one) steam generator tube U-bends and the flow slots in the top support plates were visually inspected in Steam Generator No. 22. A borescope was utilized to make these observations through the one inch diameter (nominal) "hillside port" provided in the steam generator shell.

4. Wrapper to Tube Support Plate Annulus Examination

A photograph was taken through the hand hole above the tube sheet in Steam Generator 24 showing the wrapper to tube support plate annulus space.

5. Steam Generator Sludge Analysis

The sludge that was removed from the steam generator tube sheets during lancing operations was sampled and chemically analyzed.

RESULTS OF THE INSPECTION

(1) Eddy Current Examination Results

Average dent size in the tubes of Steam Generators 23 and 24 was not substantially different from that measured during the November, 1976 steam generator inspection. In Steam Generator 23, the average dent size was 2.5 mils and in Steam Generator 24 this average was 2 mils. The maximum dent indication that was measured with the standard 700 mil eddy current probe was 9 mils in both Steam Generators 23 and 24. With smaller probes (in tubes which did not permit passage of the standard 700 mil probe), a maximum dent indication of 17 mils was measured in Steam Generator 23 and one of 13 mils was measured in Steam Generator 24. Because of the resulting low probe fill factor, accuracy of these measurements made with smaller probes is questionable. The dent indications were similar to the last eddy current measurements taken in these two steam generators in November, 1976.

Of all the tubes tested, 47 tubes in Steam Generator 23, and 70 tubes in Steam Generator 24 did not permit passage of the standard 700 mil eddy current probe. Using successively smaller probes, the size of the restriction in these tubes was quantified. For these tubes, a minimum size of these "restrictions" was determined to be as follows:

Steam Generator 23:

Maximum Probe Size Passed by Tube	Number of "Restricted" Tubes Passing This Probe
675 mil	29
640 mil	15
610 mil	1
540 mil	1
<540 mil	1

Steam Generator 24:

Maximum Probe Size Passed by Tube	Number of "Restricted" Tubes Passing This Probe
675 mil	44
640 mil	17
610 mil	3
540 mil	3
<540 mil	3

Any tube tested during the inspection that did not permit passage of a 610 mil probe was plugged. In Steam Generator 23, two tubes were plugged and in Steam Generator 24, six tubes were plugged. The tubes that were plugged are identified in Table 3.

(2) Results of Top Support Plate Inspection of Steam Generator No. 22

Flow slots in this top support plate were measured and photographed during the November 1976 steam generator inspection program and during the April 1977 steam generator inspection program. As reported in the attachments to the November 18, 1976 letter from Mr. Carl L. Newman of Con Edison to Mr. Robert W. Reid of the NRC, and in the attachments to the May 6, 1977 letter from Mr. William J. Cahill, Jr. of Con Edison to Mr. Karl R. Goller of the NRC, the results of these inspections indicated no departure from straightness in the flow slots beyond the variations expected in a flame-cut edge.

The inspections of this top support plate performed during this March, 1978 inspection indicate that there has been no change in the flow slot width. The flow slots still show no discernible "hour-glassing". The photographs included in Attachment B to this letter demonstrate this lack of "hour-glassing", and the similarity in the present condition with that observed during the April, 1977 and November, 1976 inspections.

TABLE 3

Steam Generator Tubes Plugged Following
Eddy Current Inspection for Dents on Hot Legs of
Steam Generators 23 &24

Steam Generator	Tube Location	Minimum Probe Size Passed by Tube	Support Plate Number (1)
23	R45C54	less than 540	2
23	R8C90	540	2
24	R28C12	less than 540	3
24	R35C17	less than 540	3
24	R45C39	less than 540	2
24	R28C11	540	2
24	R34C17	540	2
24	R40C53	540	2

NOTE:

(1) "Support Plate Number" is the number of the support plate where the tube "restriction" was detected.

(3) Lower Support Plate Inspection Results

Inspections of the first (bottom) tube support plate flow slots for Steam Generators 21 and 22 were performed during the first refueling outage at Indian Point Unit No. 2 in 1976, and during the steam generator inspection program of April, 1977. Inspection of the first tube support plates and flow slots for Steam Generators 23 and 24 was performed during the November, 1976 inspection program. The results of these examinations indicated that some flow slot "hour-glassing" existed, averaging about 1/8 inch. This represents only about 5% of the flow slot width.

Re-examination of these first support plates in the steam generators during this March, 1978 inspection indicated that the flow slots remain essentially unchanged.

Photographs showing typical first tube support plate flow slots are included as Attachment C to this report.

(4) Intermediate Support Plate Inspection Results

Flow slots in the upper support plates in Steam Generators 23 and 24 were examined for the first time during this March, 1978 inspection. The upper support plate flow slots in Steam Generators 21 and 22 were examined before, during the April, 1977 steam generator inspection. Some apparent "hour-glassing" was observed in the upper support plate flow slots examined during the April, 1977 inspection. Although the photographs taken in April, 1977 contained significant distortion due to distance, camera angle, and shadows created by the lighting, measurements taken from the photographs indicated the maximum "hour-glassing" did not exceed 3/4 inch total slot width reduction.

The photographs taken of the upper support plate flow slots during this March, 1978 inspection indicated that some "hour-glassing" is apparent in these flow slots in all four steam generators. All four steam generators show generally the same amount of this "hour-glassing". For the support plates that were examined in April, 1977 and again in March, 1978, the "hour-glassing" appears to be essentially unchanged. Averaged "hour-glassing" for the flow slots examined in Steam Generators 21 and 22 during both the April, 1977 and the March, 1978 inspections are given in Table 4.

The photographs did reveal two cracks in the third flow slot from the manway side in the second tube support plate in Steam Generator No. 24. The cracks are in the ligaments between the flow slot and first row tube holes near the center of the flow slot. There is no indication as to when these cracks were formed, as this is the first time these areas were examined since the steam generators were fabricated.

Photographs showing typical upper tube support plate flow slots are included as Attachment C to this report. Enlargement photographs of the observed cracks in the one flow slot in Steam Generator No. 24 are included as Attachment D to this report.

(5) Wrapper to Tube Support Plate Annulus Examination

A photograph of the wrapper to tube support plate annulus space was taken in Steam Generator 24 during this March 1978 inspection.

TABLE 4

Average Flow Slot Measurements

	April, 1977 Inspection	March, 1978 Inspection
Steam Generator 21	0.24 inches	0.30 inches
Steam Generator 22	0.30 inches	0.37 inches

The tube support plate appeared to be in contact with the steam generator wrapper. It is possible, however, that the steam generator was constructed with the plate and wrapper in contact at this location since this was the first inspection of this space conducted at Indian Point Unit No. 2.

The photograph showing the wrapper and the tube support plate annulus area is included as Attachment E to this report.

(6) Steam Generator Sludge Analysis

Analyses of four samples of the sludge removed from the steam generators during lancing operations were performed. The results of these analyses are included as Attachment F to this report.

CONCLUSIONS

In conclusion, there is no evidence of severe steam generator degradation as found at other facilities. The inspection demonstrated that the Indian Point Unit No. 2 steam generators are acceptable for continued service.

Based on the results of this inspection program, we are scheduling our next steam generator inspection during the next refueling outage which is planned for the Fall of 1979. In any case, the steam generators will be inspected within sixteen equivalent months of operation following the Unit's return to operation after this ongoing refueling outage. For the purpose of this plan, equivalent operation is defined as operation with the primary coolant temperature greater than 350°F.

Con Edison is also evaluating the feasibility of chemically cleaning the secondary side of the steam generators at Indian Point Unit No. 2. This effort could take place as early as August, 1978 and would be accompanied by extensive steam generator inspection efforts at that time.

ATTACHMENT B

Photographs of Upper Tube Support Plate Flow Slots

Steam Generator No. 22

Consolidated Edison Company of New York, Inc.

Indian Point Unit No. 2
Docket No. 50-247
Facility Operating License No. DPR-26
March, 1978

NUMBER 22 STEAM GENERATOR

TOP TUBE SUPPORT PLATE

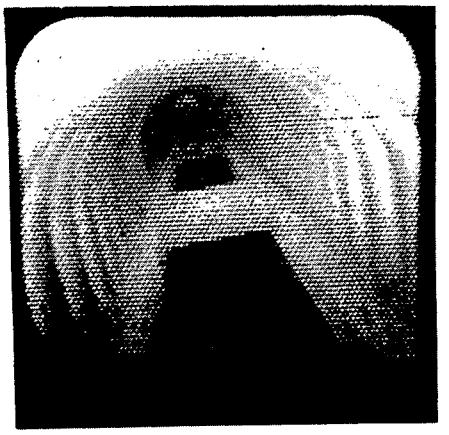


Figure 1

No. 1 and 2 Flow Slots

(view from above)

April, 1977

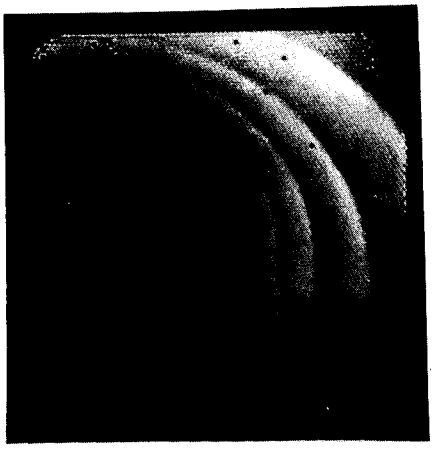


Figure 2

No. 1 and 2 Flow Slots

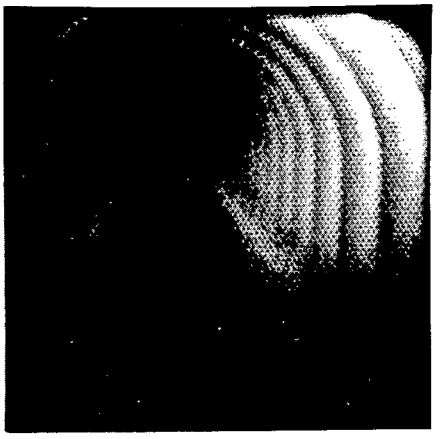
(view from above)

March, 1978

Figure 3

No. 2 Flow Slot

(view from above)



April, 1977

Figure 4

No. 2 Flow Slot

(view from above)

March, 1978

Figure 5

No. 2 Flow Slot

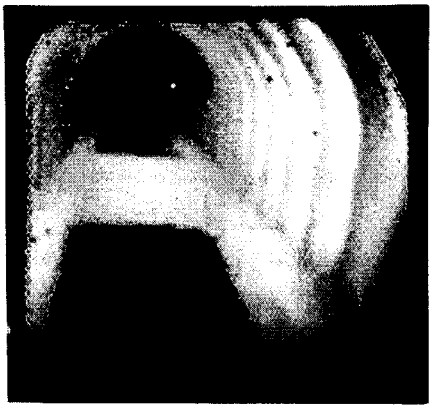
(view from below)

April, 1977

Figure 6

No. 2 and 3 Flow Slots

(view from above)



March, 1978

Figure 7

No. 3 Flow Slot

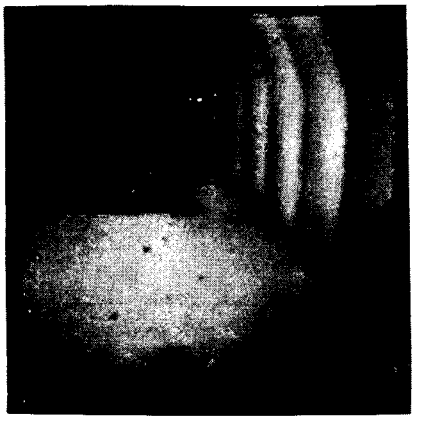
(view from above)

April, 1977

Figure 8

No. 3 Flow Slot

(view from above)



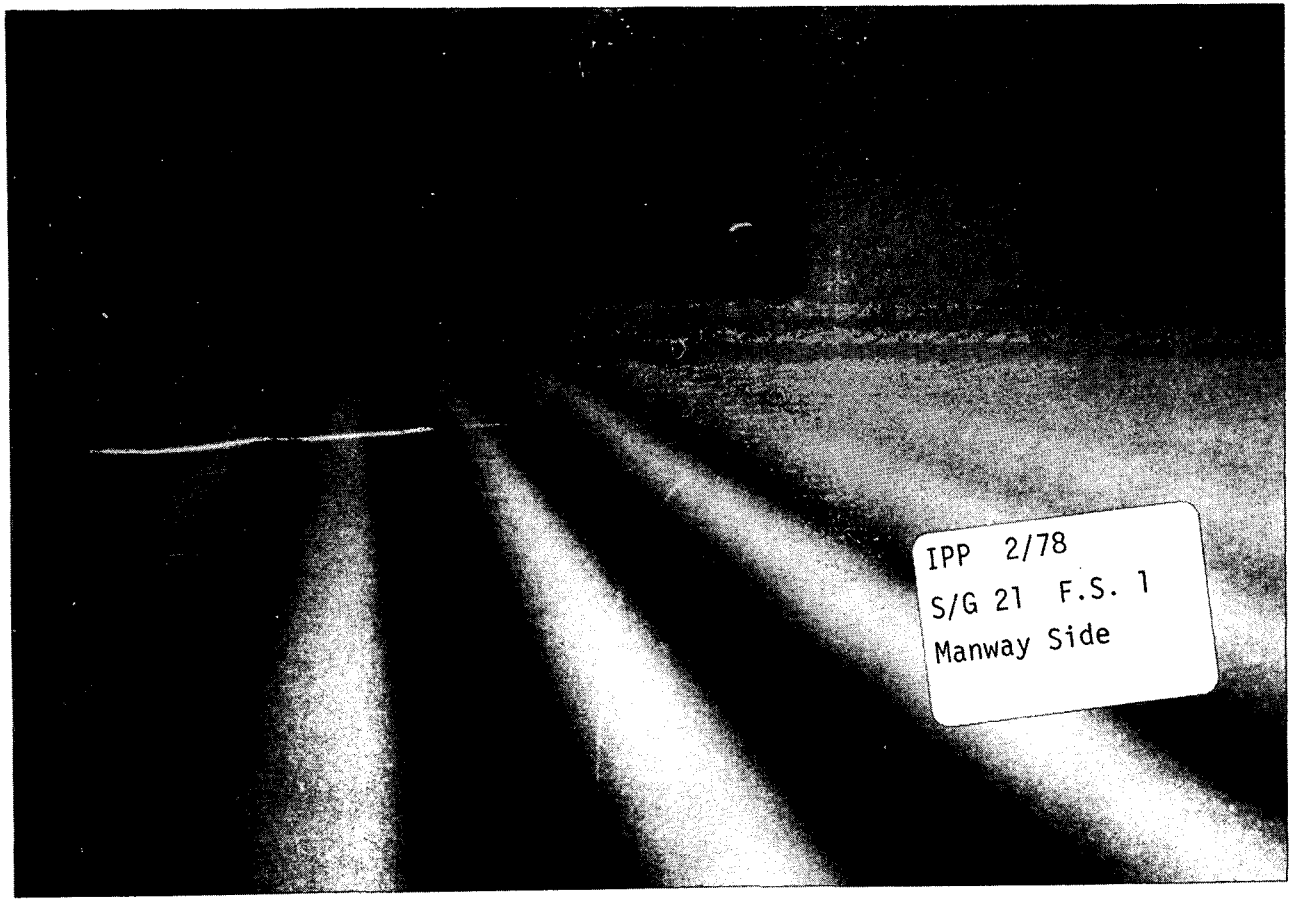
March, 1978

ATTACHMENT C

Photographs of Tube Support Plate Flow Slots

Consolidated Edison Company of New York, Inc.

Indian Point Unit No. 2
Docket No. 50-247
Facility Operating License No. DPR-26
March, 1978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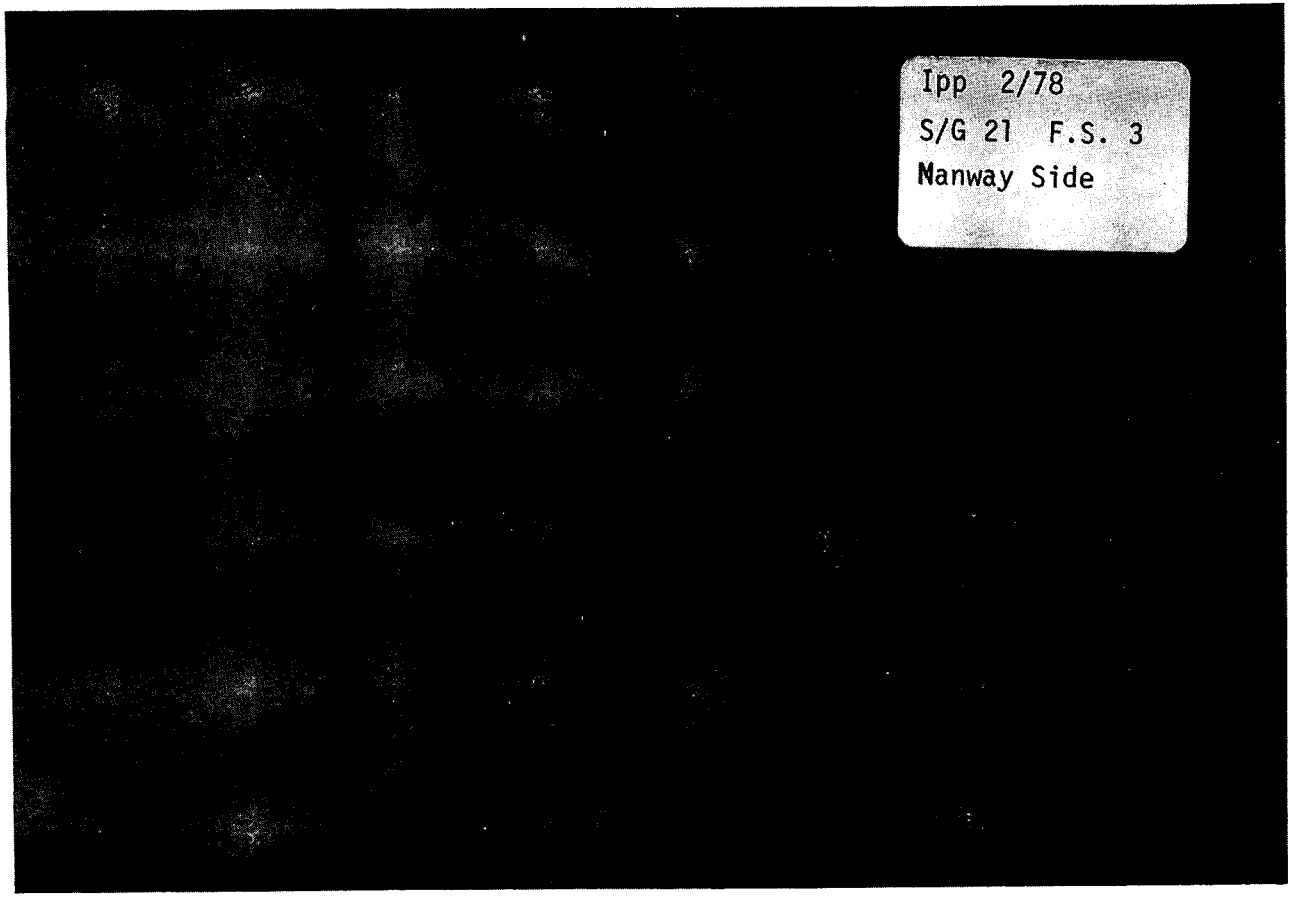
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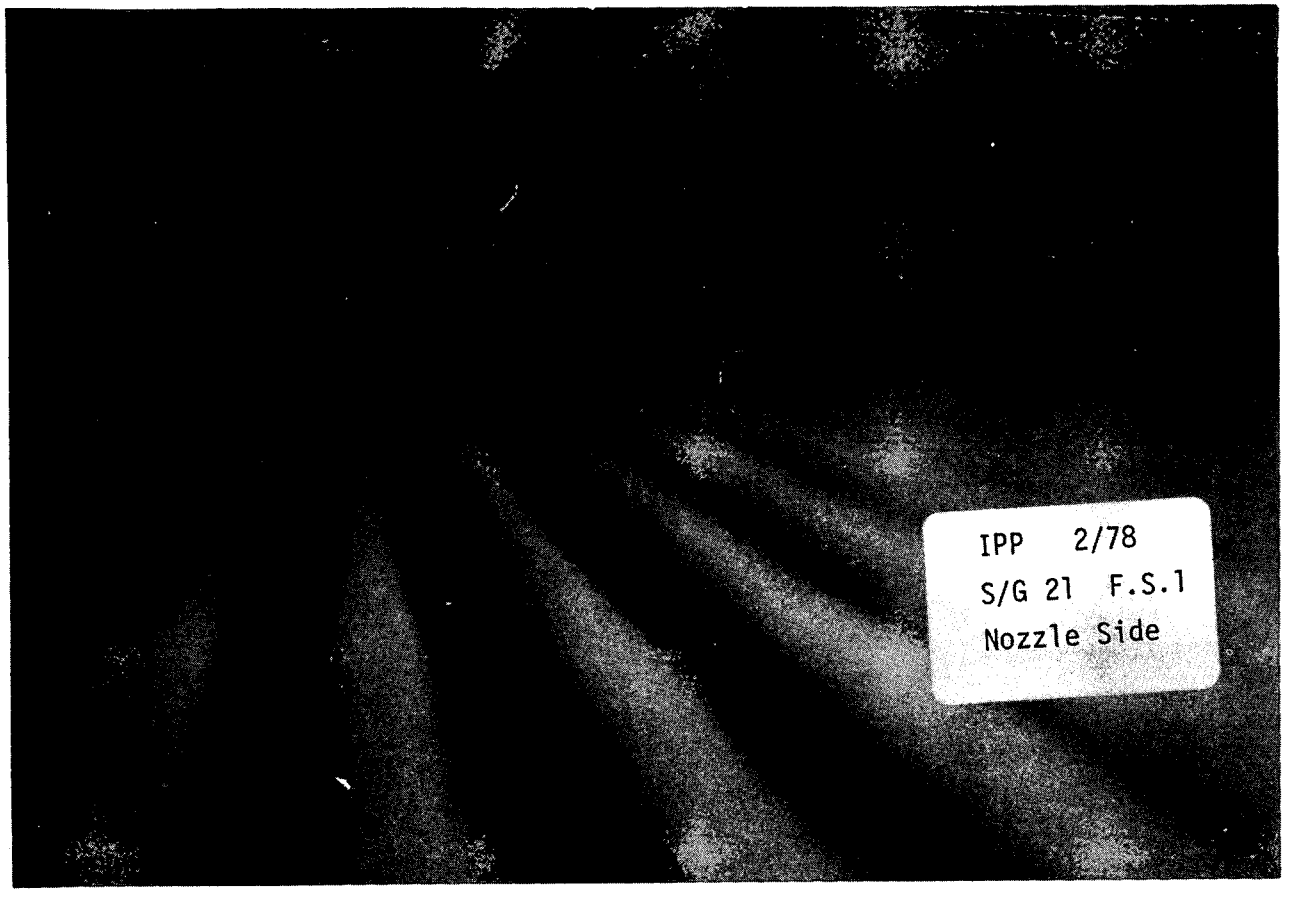
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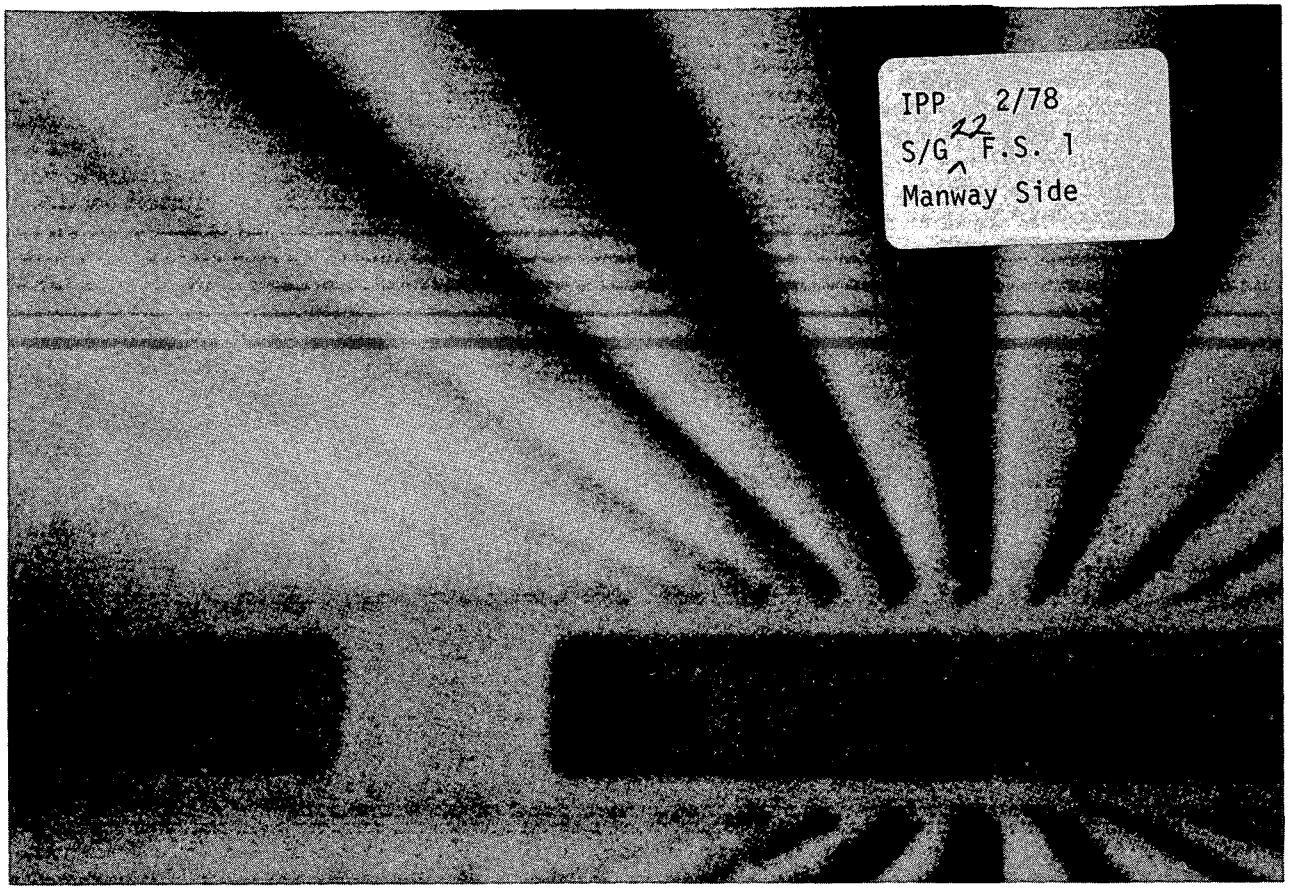
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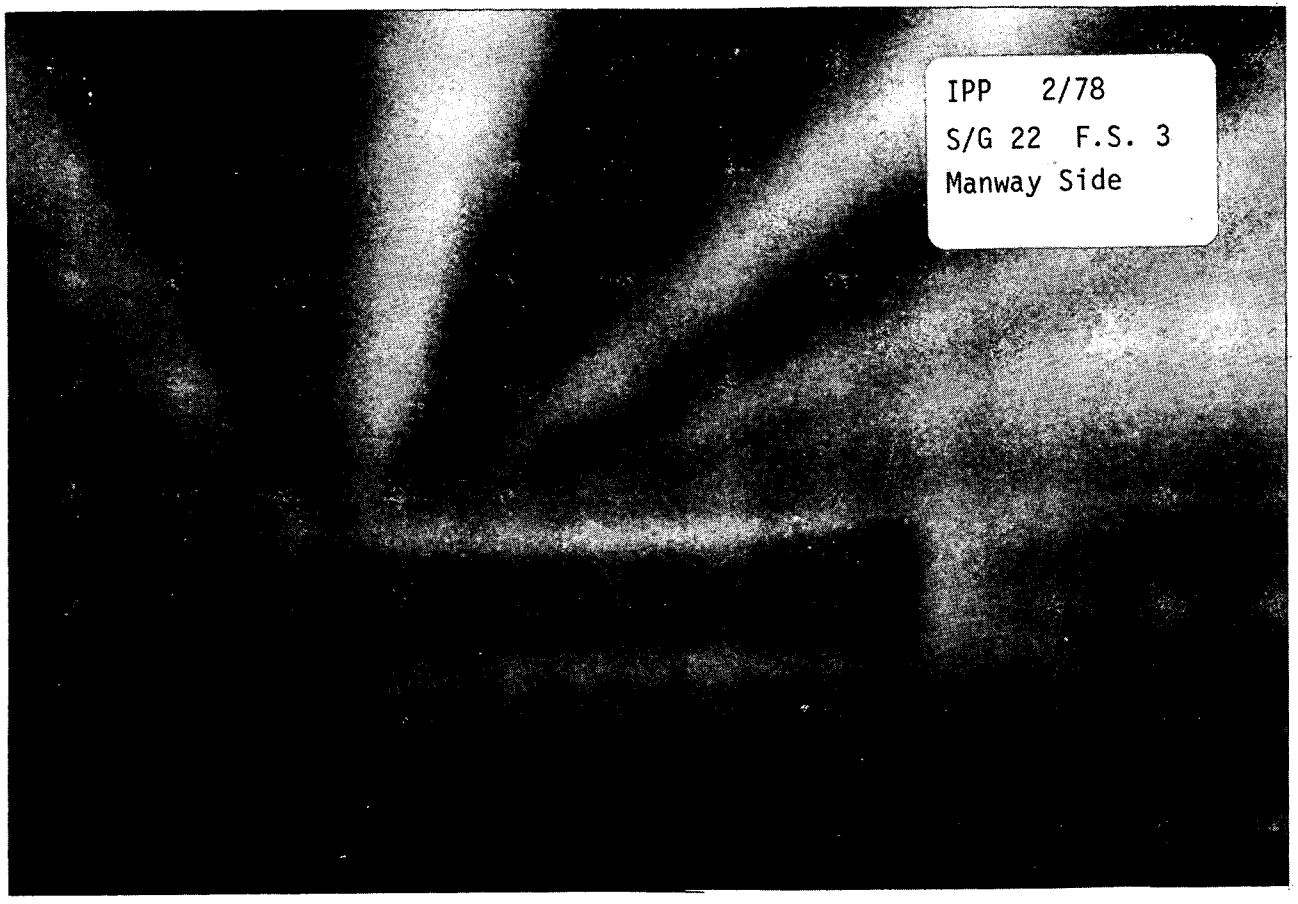
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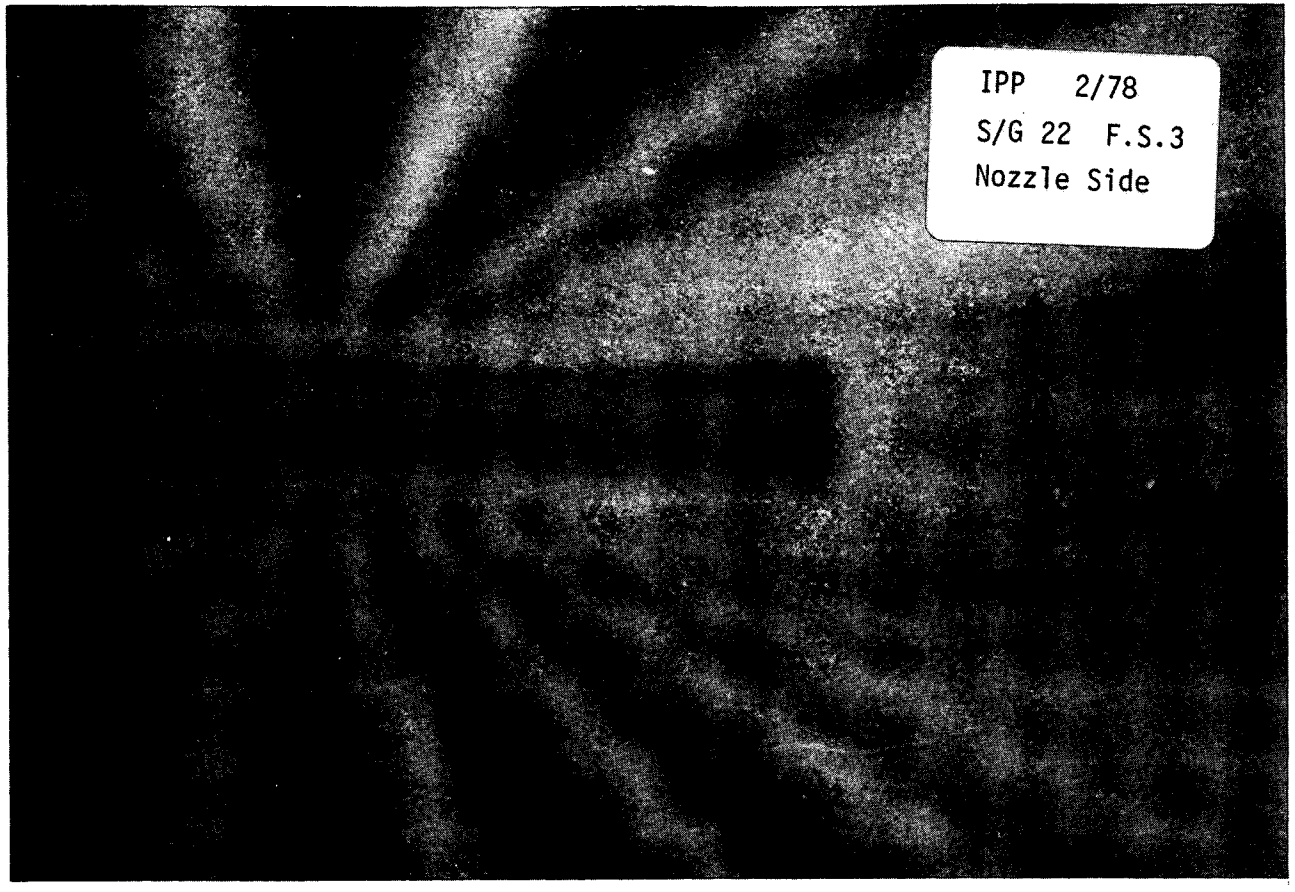
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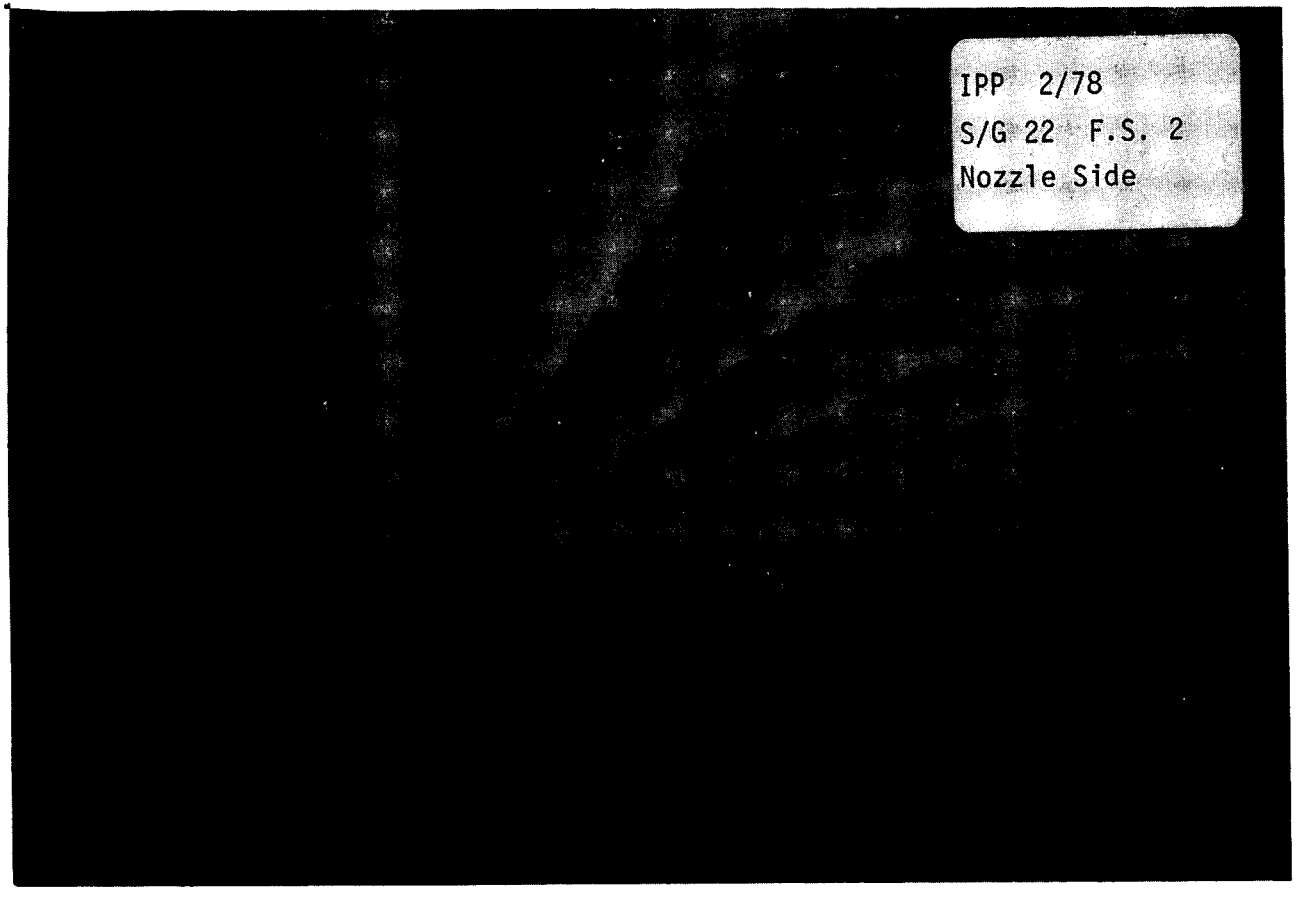
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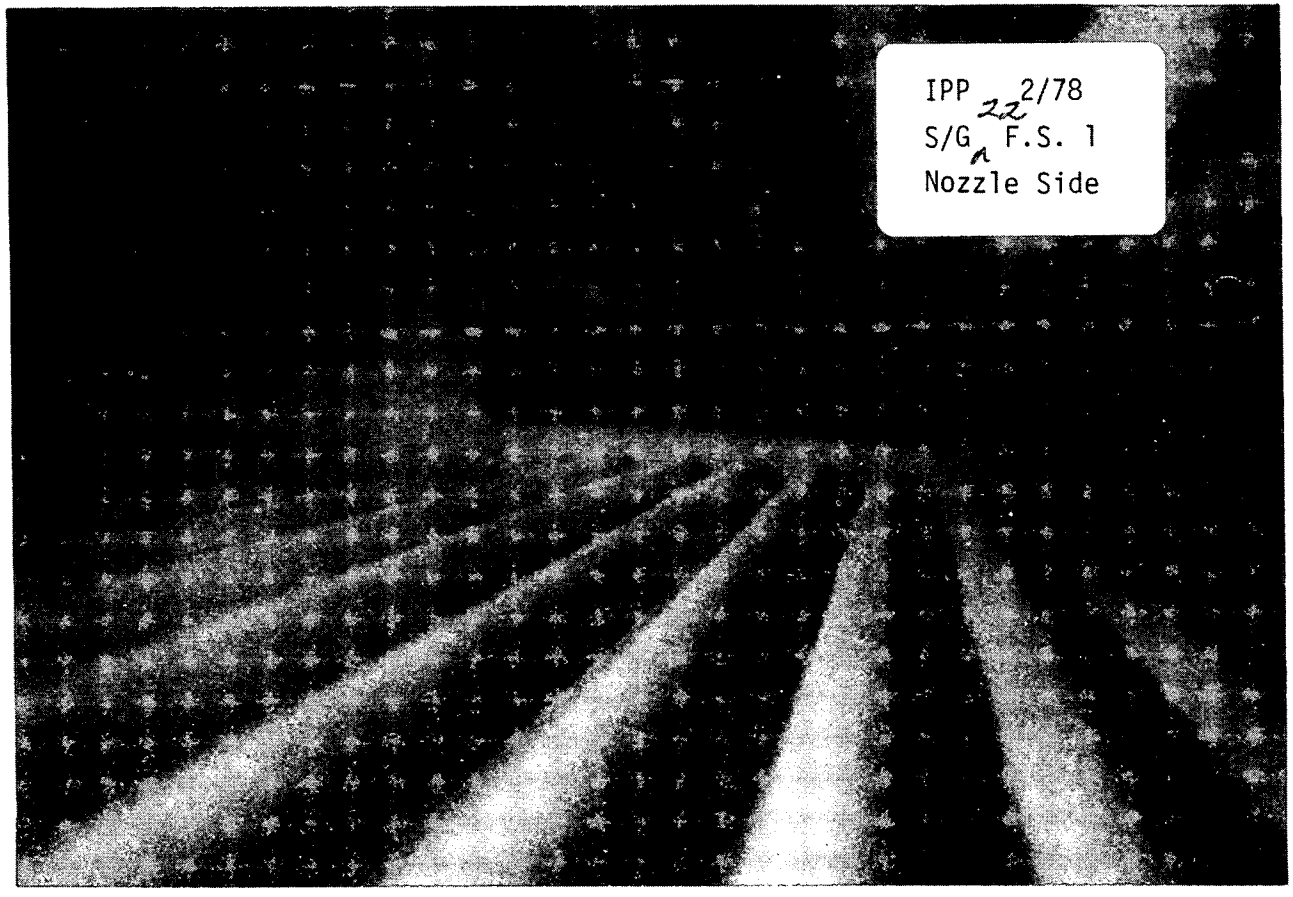
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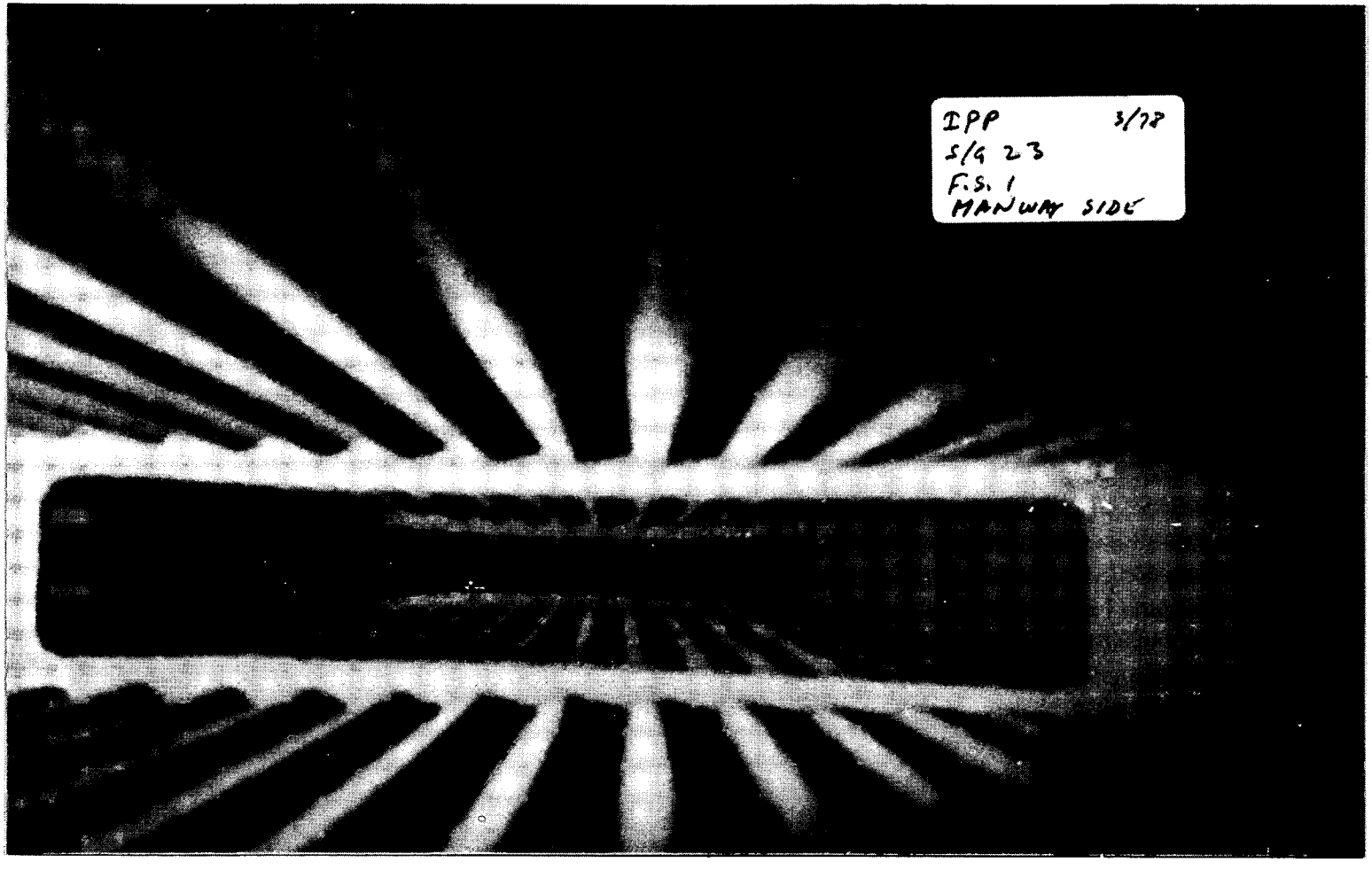
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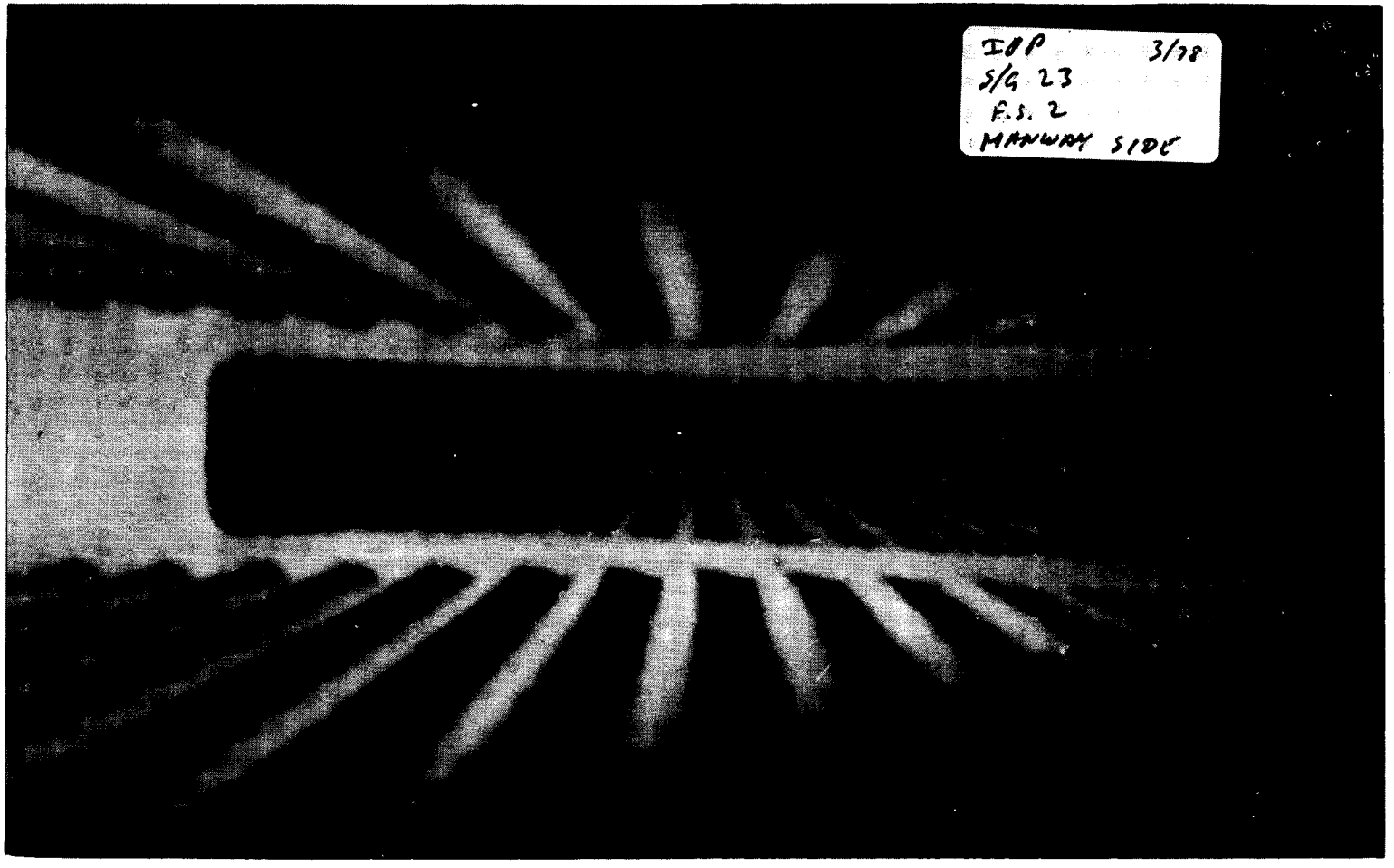
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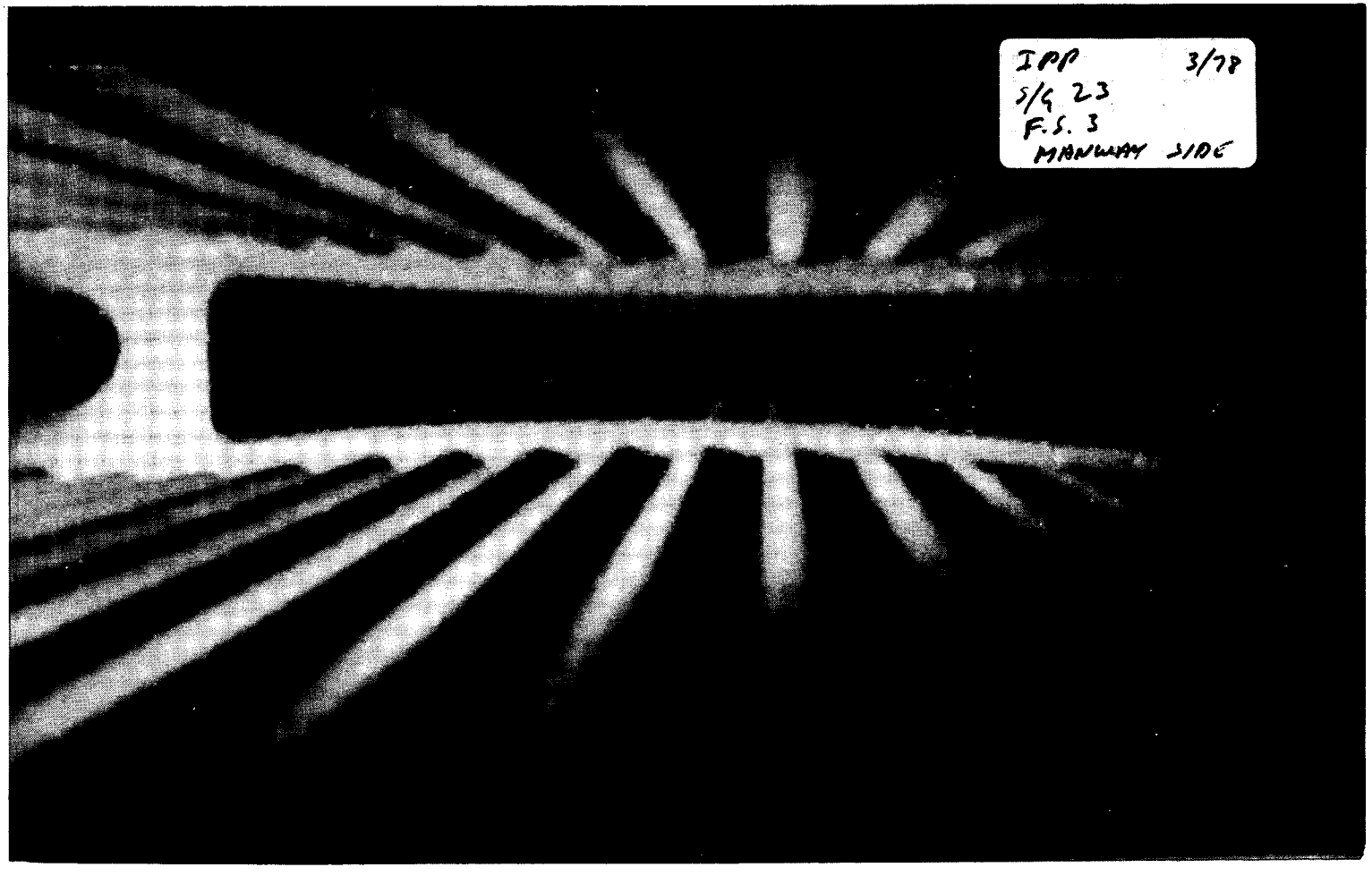
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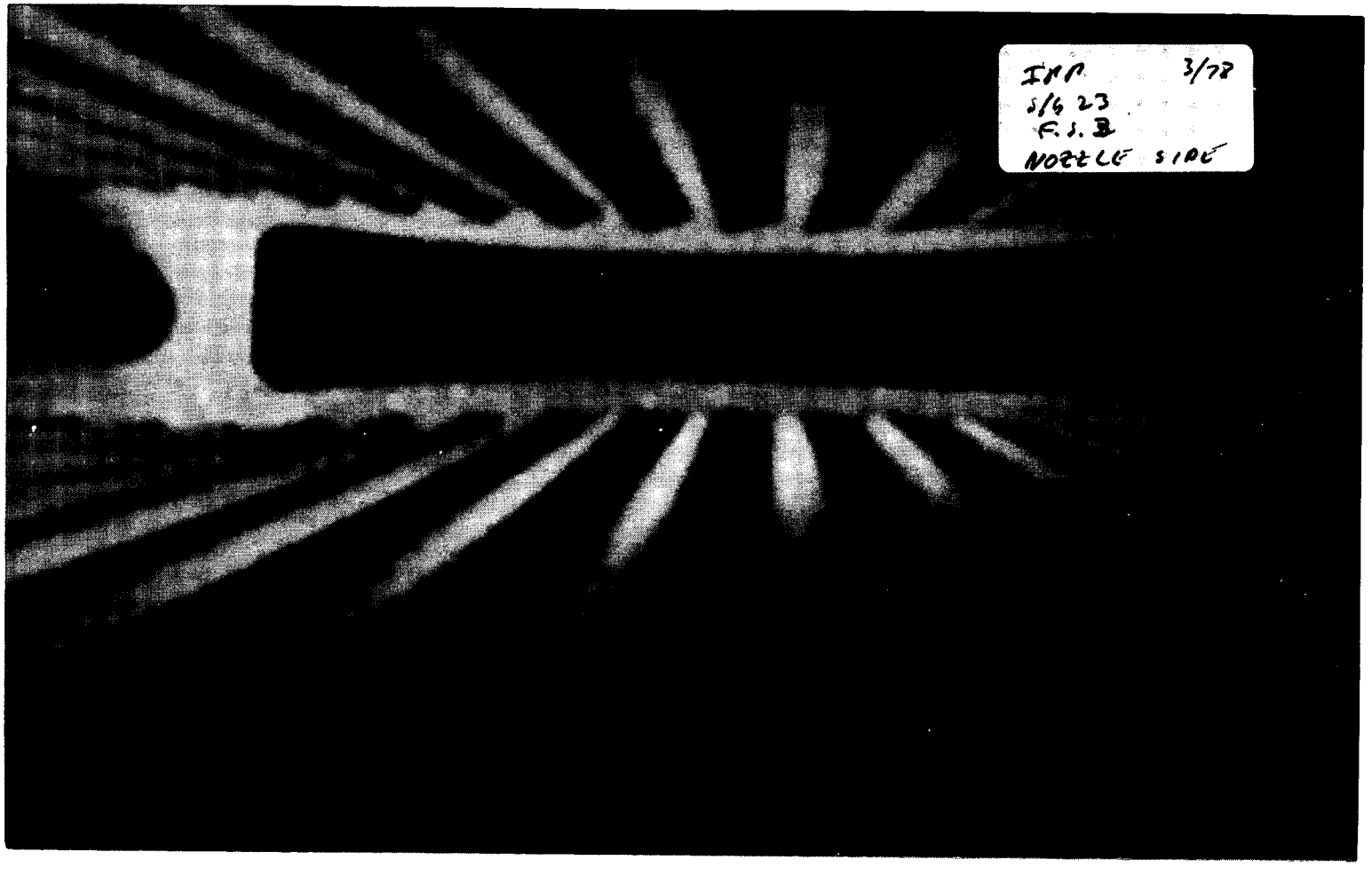
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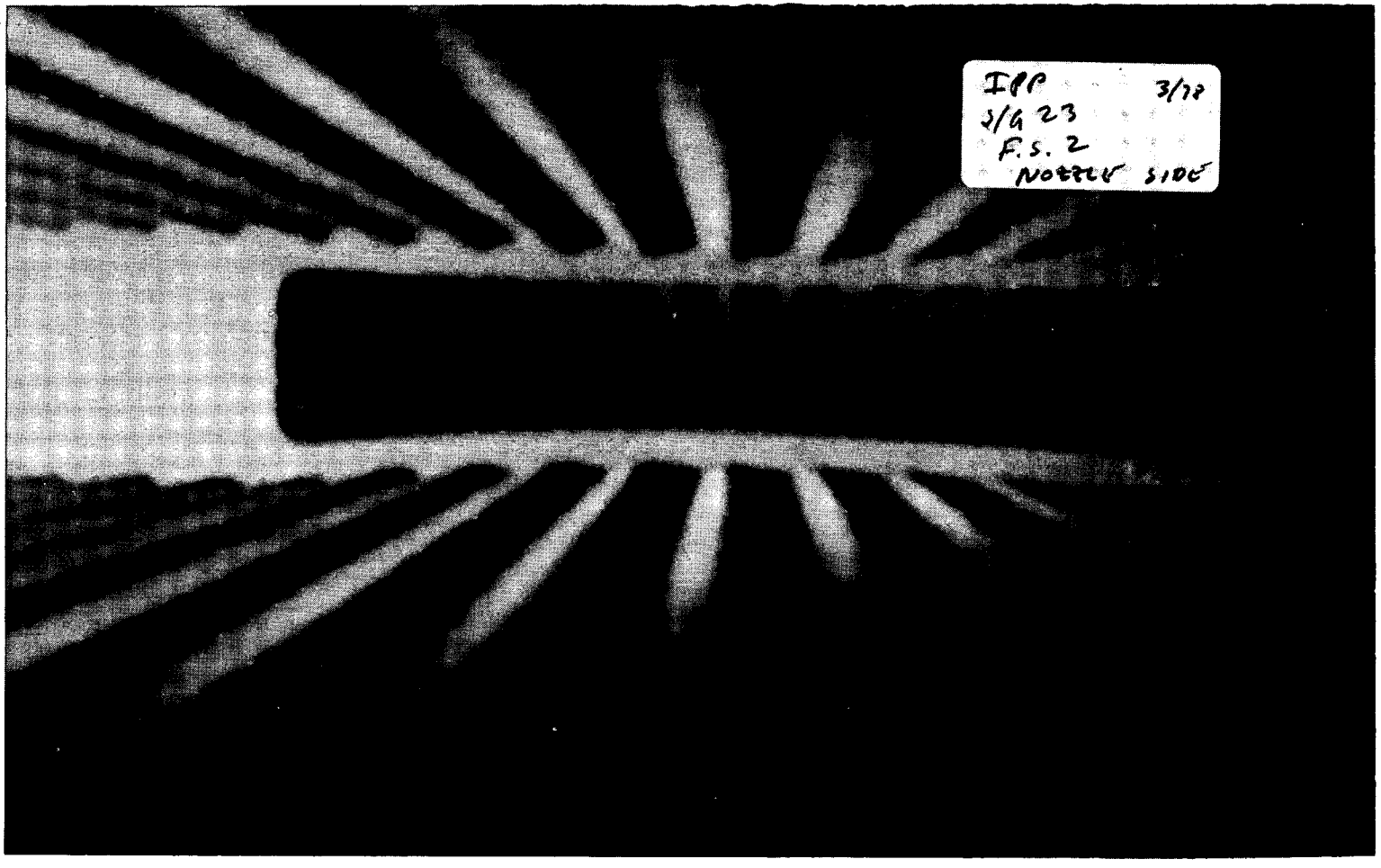
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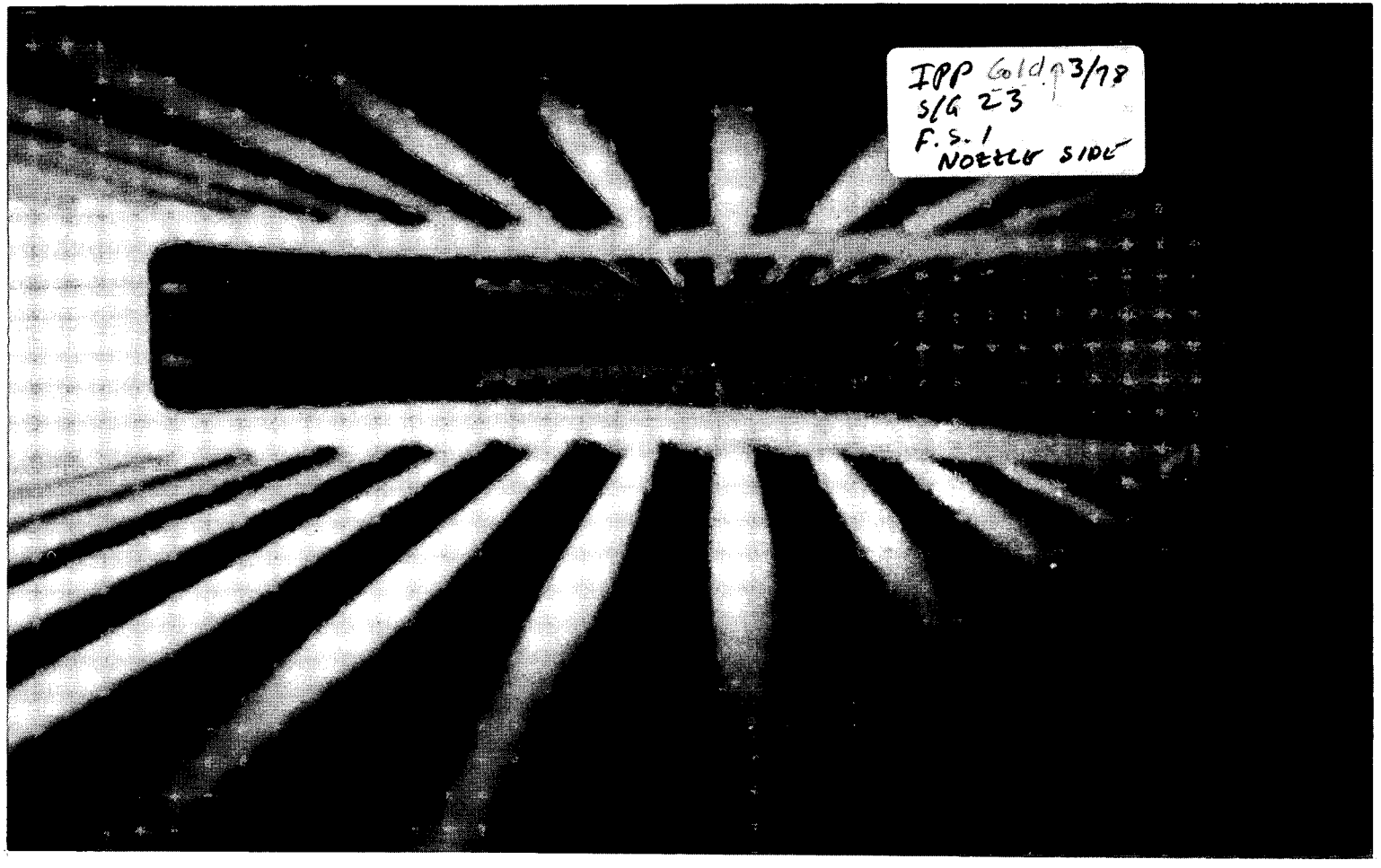
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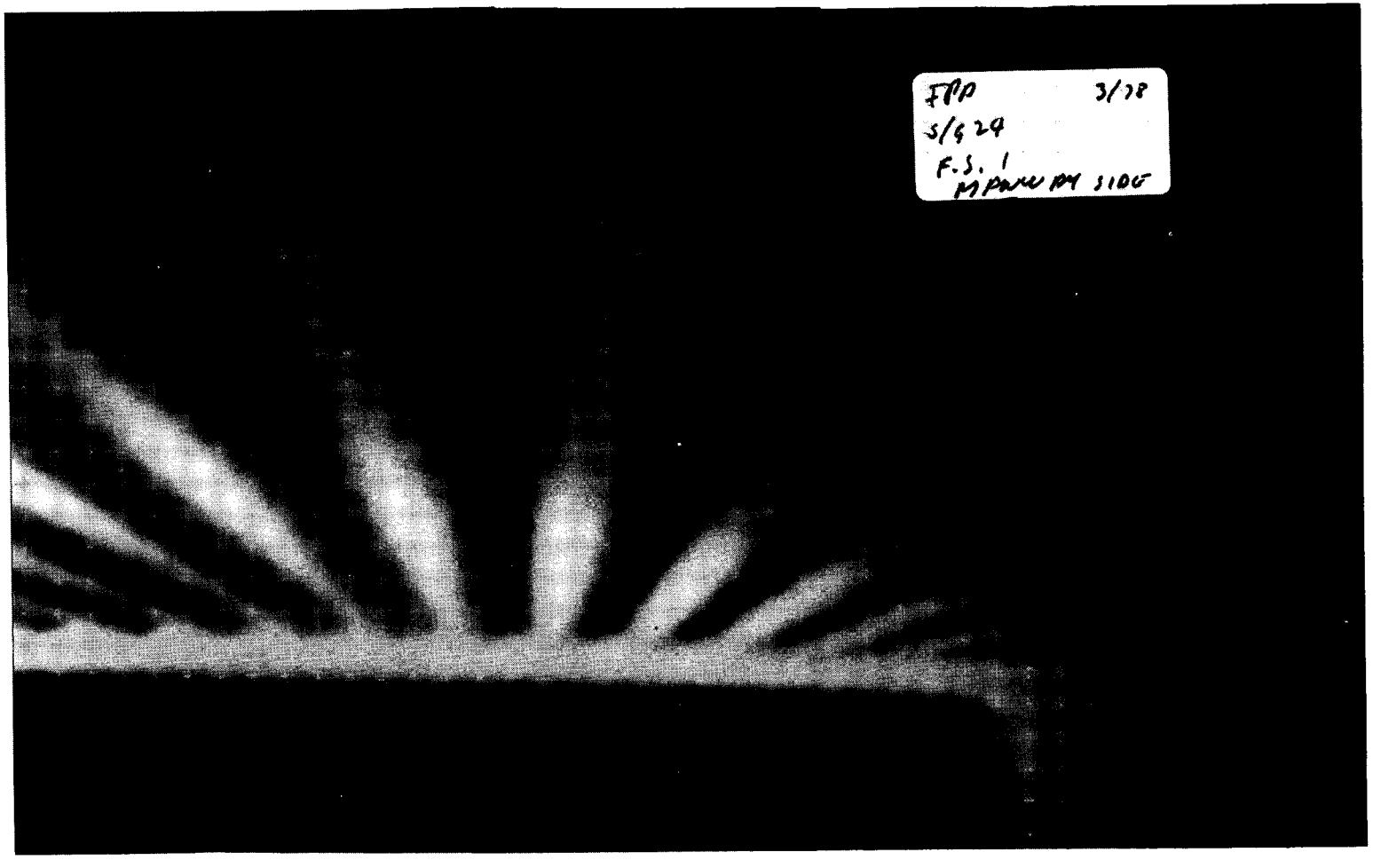
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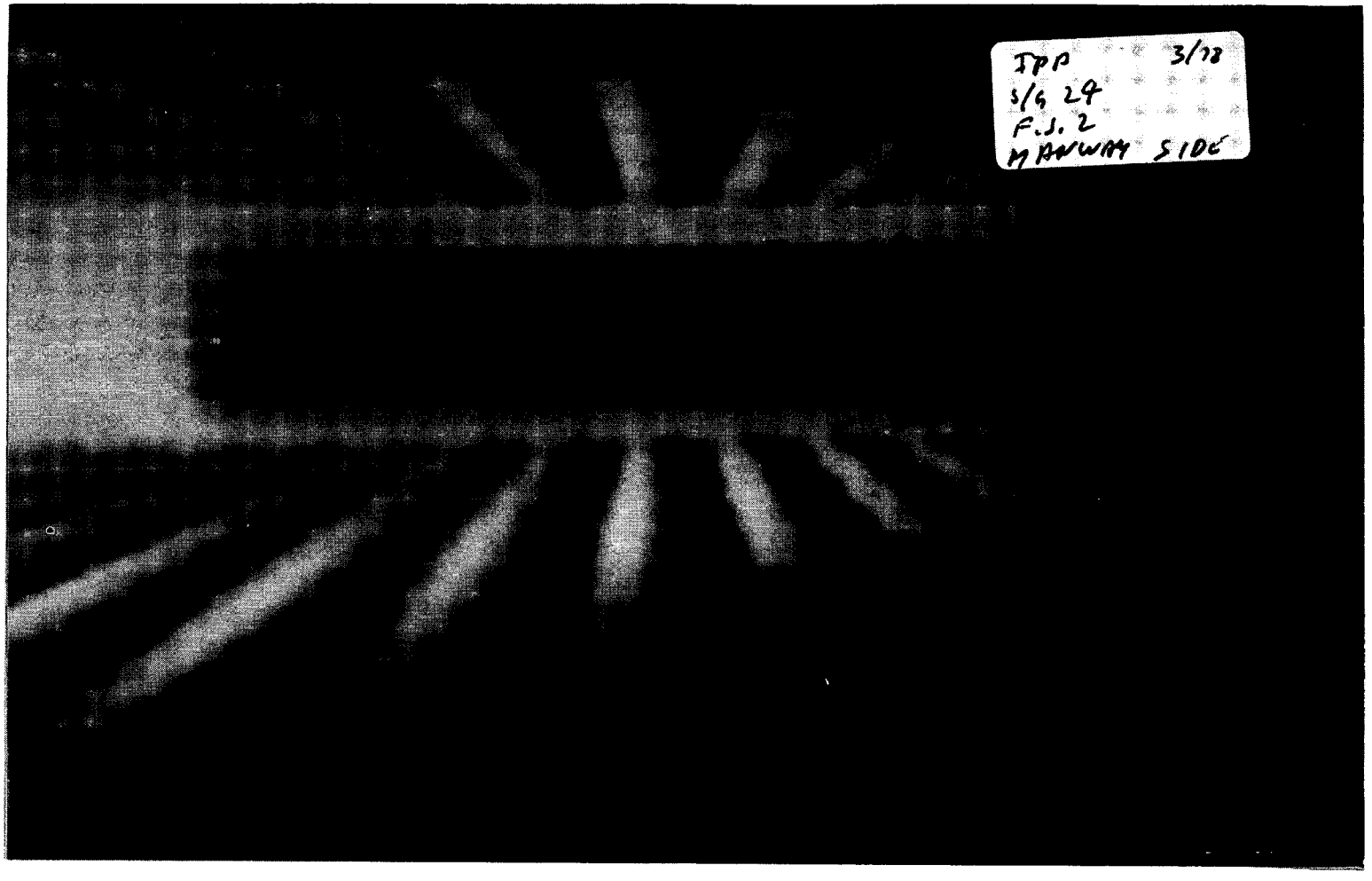
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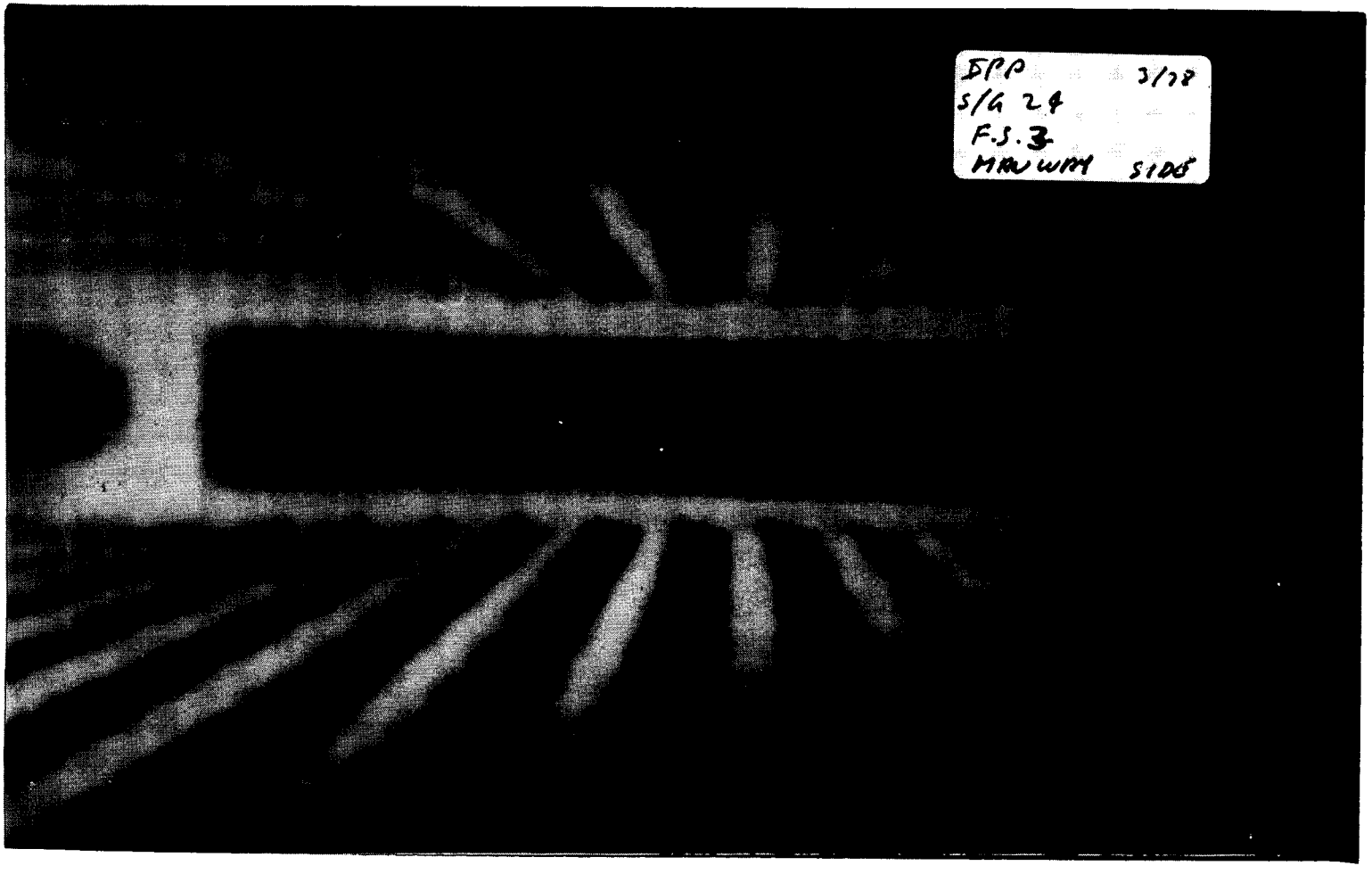
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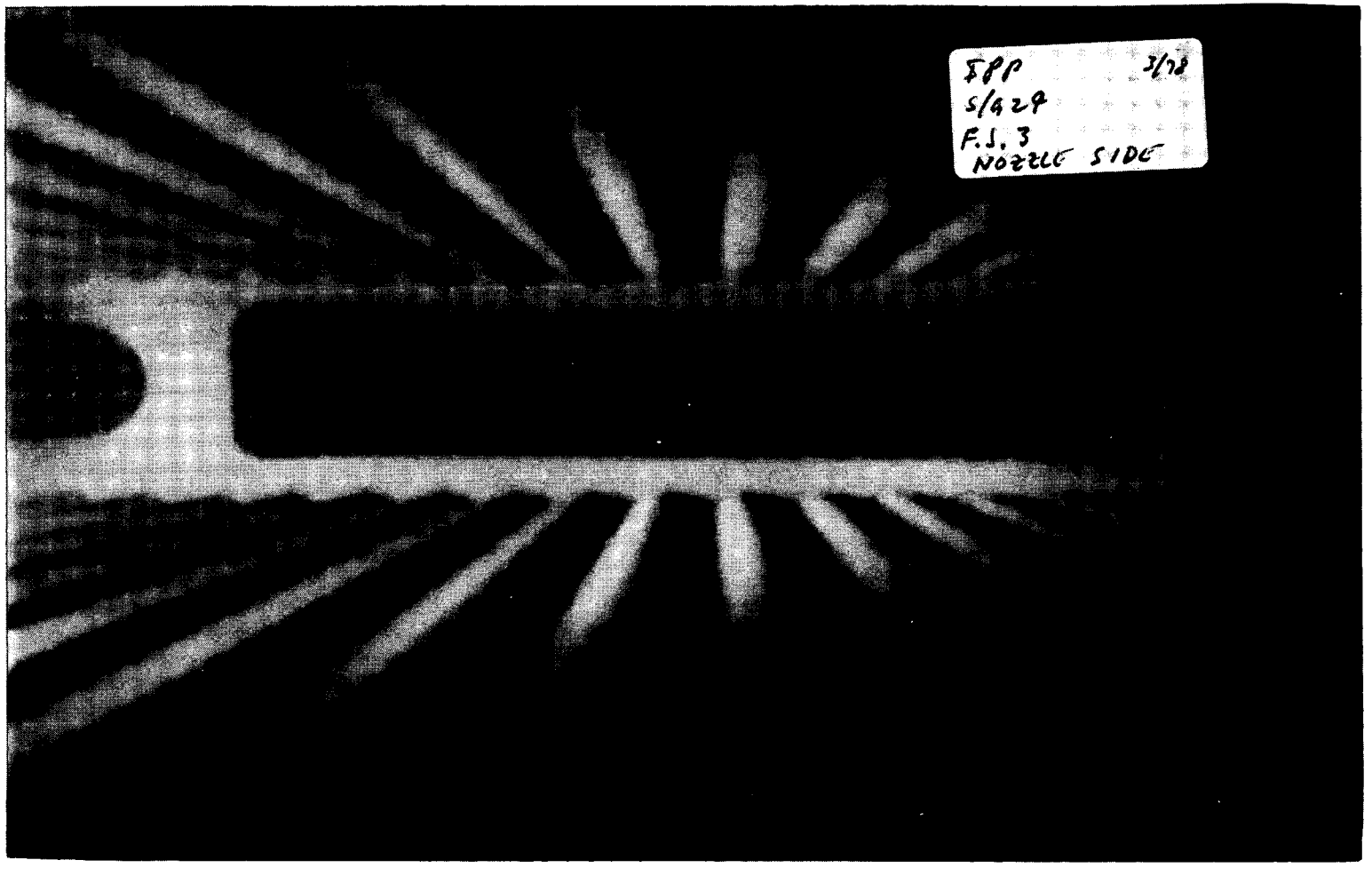
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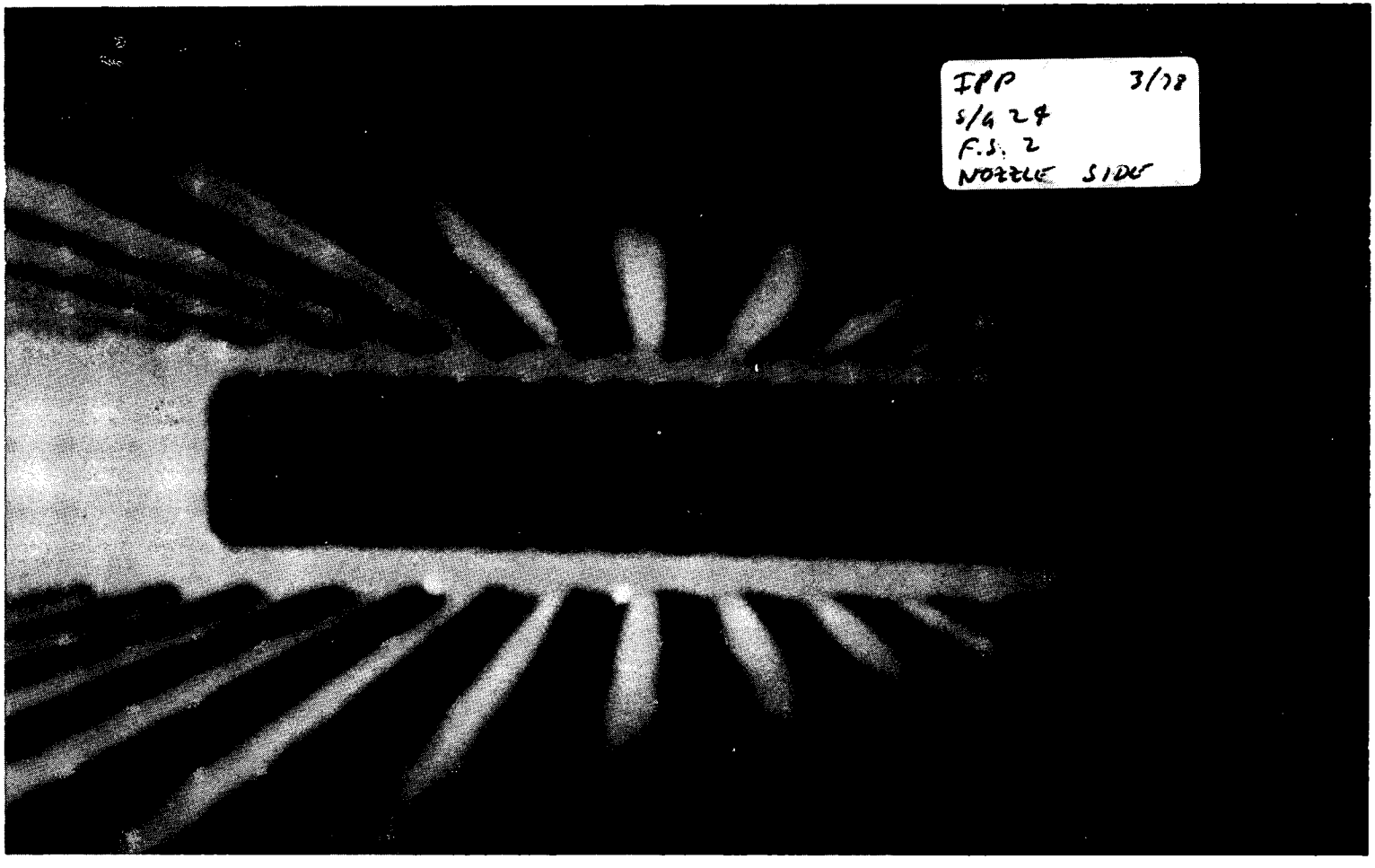
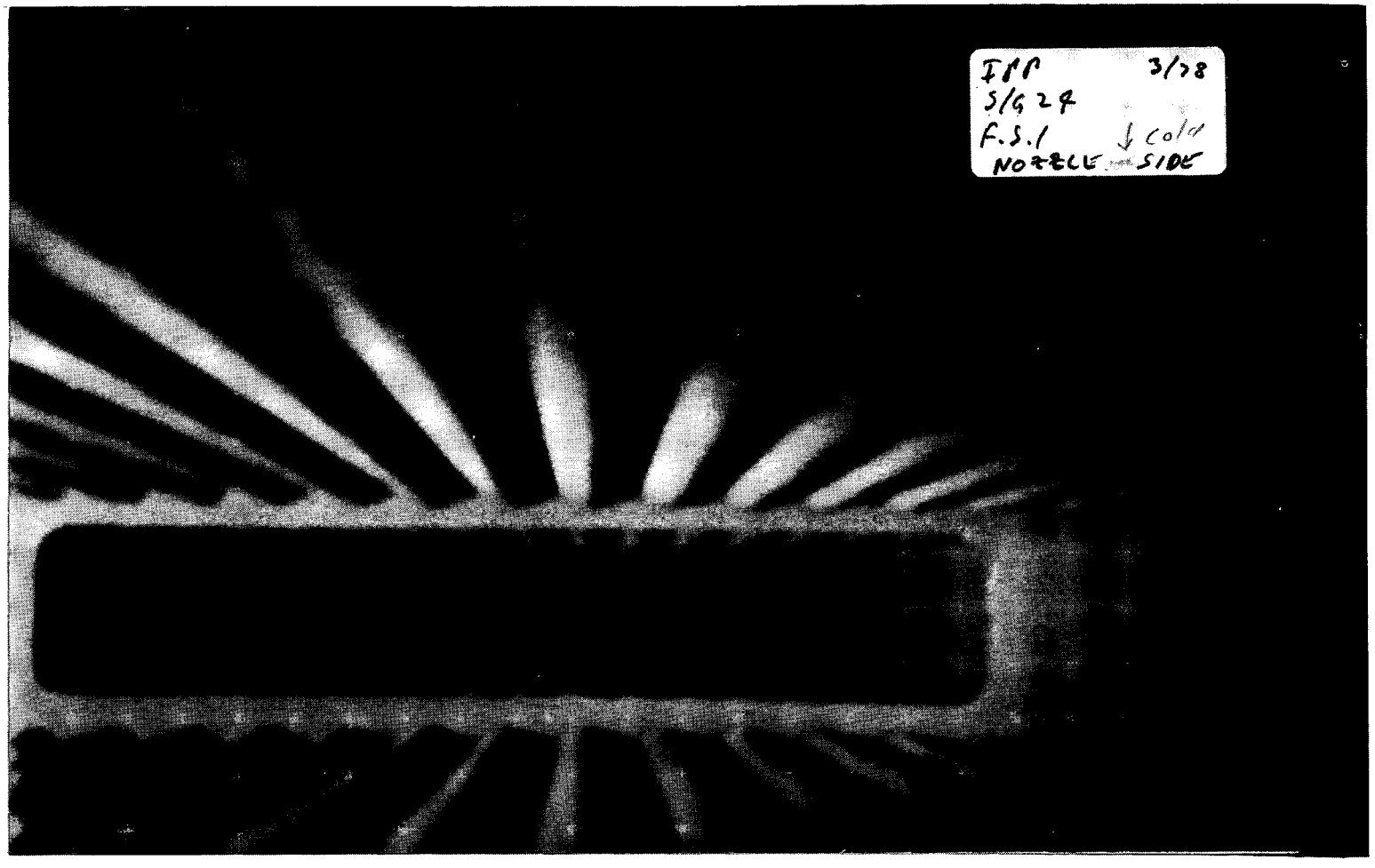
F.J. 3
NOZZLE SIDE


IPP 3/78
S/G 24
F.S. 2
NOZZLE SIDE


IPP 3/78
S/G 24
F.S.1 ↓ cold
NOZZLE SIDE

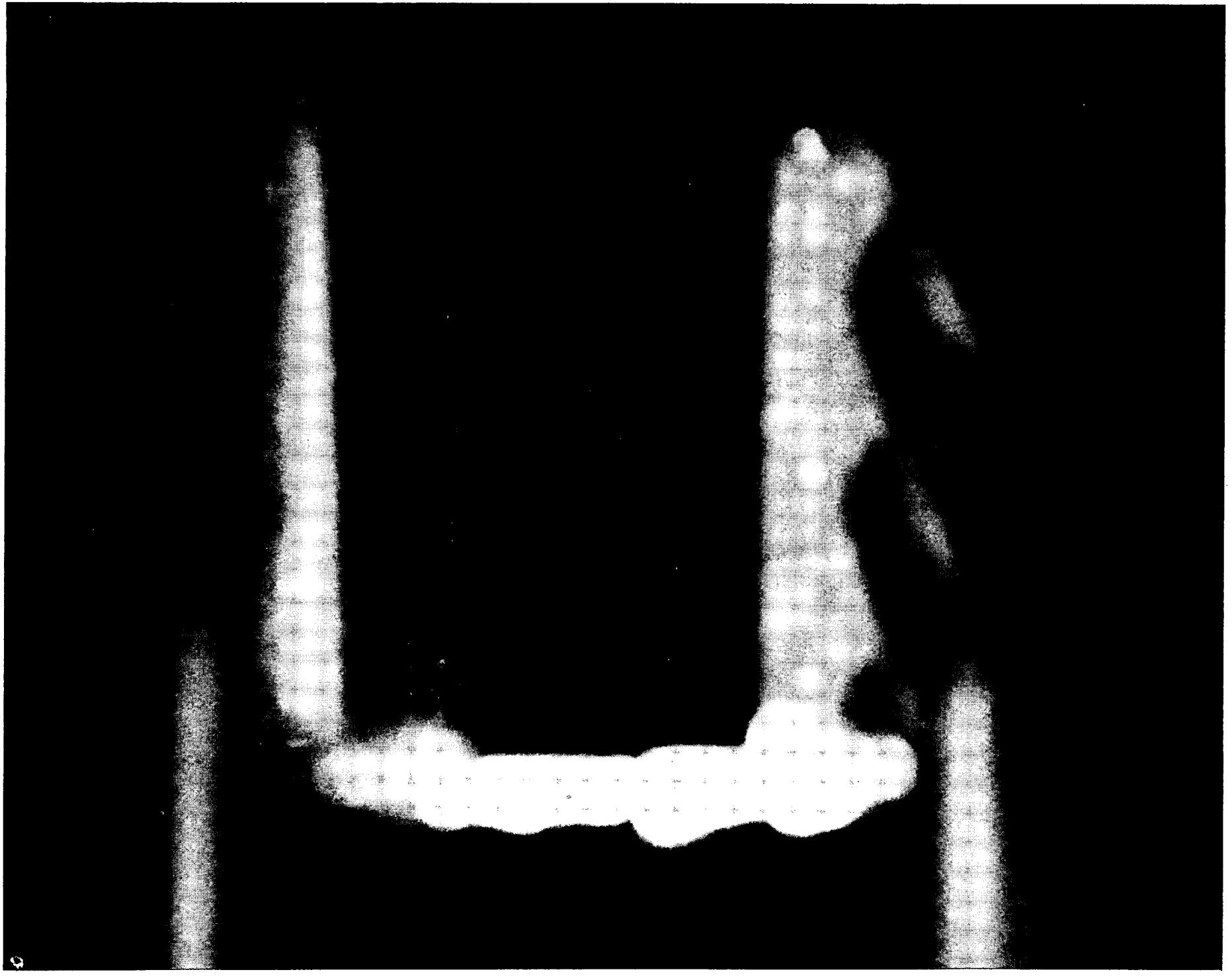
ATTACHMENT D

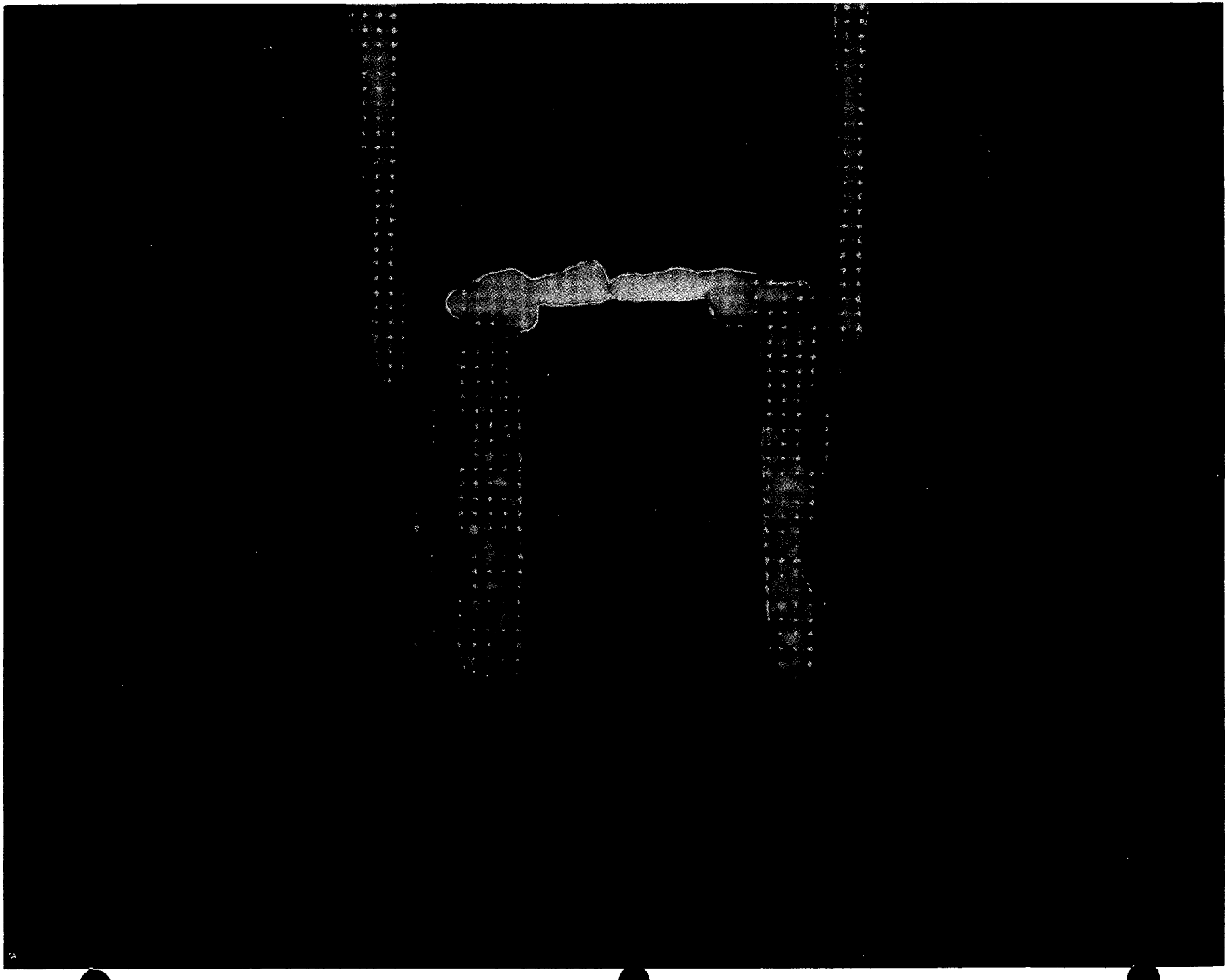
Enlargement Photographs of Tube Support Plate Flow Slot

Steam Generator No. 24

Consolidated Edison Company of New York, Inc.

Indian Point Unit No. 2
Docket No. 50-247
Facility Operating License No. DPR-26
March, 1978





ATTACHMENT E

Photograph of Wrapper and Tube Support Plate Annulus

Consolidated Edison Company of New York, Inc.

Indian Point Unit No. 2
Docket No. 50-247
Facility Operating License No. DPR-26
March, 1978

ATTACHMENT F

Steam Generator Sludge Analysis

Consolidated Edison Company of New York, Inc.

Indian Point Unit No. 2
Docket No. 50-247
Facility Operating License No. DPR-26
March, 1978

SLUDGE SAMPLE FROM INDIAN POINT

UNIT NO. 2 STEAM GENERATORS

SAMPLE NO. 1

Petrographic Analysis

Fe_3O_4	65 - 70%
Fe_2O_3	Trace
Cu as metal	20 - 30%
Cu as CuO	1 - 5%
SiO_2 (Amorphous)	Trace
SiO_2 (Quartz)	Trace
$Ca_3(PO_4)_2$	Trace

Quantitative Analysis

Fe as Fe_3O_4	68.8%
Cu as Cu	23.6%
Zn as Zn	2.0%
Al as Al	0.19%
Ni as Ni	1.24%
B as BO_3	1.9%

Spectrographic Analysis

Fe	$\gg$10%
Cu	>10%
Zn	>1%
Al	0.1 - 1%
Ni	0.1 - 1%
Si	$\approx$ 0.1%
Cr	<0.1%
Sn	<0.1%
Pb	<0.1%
Mn	0.1 - 1%
Mg	<0.1%
B	<0.1%
Ca	<0.1%
Mo	<0.1%
Ti	<0.1%
Ag	<0.1%

Quantitative Anions

Sulfates	Not detected
Chlorides	0.03% Cl
Phosphate (H_2O sol)	0.002% PO_4
Phosphate (H_2O Insol)	3.4% PO_4

COMMENT: All results are on a dry weight basis. Total weight of the dried sample is 10.7520 gm.

SLUDGE SAMPLE FROM INDIAN POINT

UNIT NO. 2 STEAM GENERATORS

SAMPLE NO. 2

Petrographic Analysis

Fe_3O_4	55-65%
Fe_2O_3	1-5%
Cu (metal)	20-30%
Cu as CuO	1-5%
SiO_2 (Amorphous)	Trace
SiO_2 (Quartz)	Trace
$Ca_3 (PO_4)2$	Trace

Quantitative Analysis

Fe as Fe_3O_4	57.5%
Cu as Cu	21.0%
Zn as Zn	2.2%
Ni as Ni	1.4%
B as BO_3	3.9%
Na as Na	0.9%

Spectrographic Analysis

Fe	$\gg$ 10%
Cu	$>$ 10%
Zn	$\approx$ 1%
Al	$\approx$ 0.1%
Ni	$\approx$ 1%
Si	0.1%-1%
Cr	$\approx$ 1.0%
Sn	$<$ 0.1%
Pb	$\approx$ 0.1%
Mn	$\approx$ 0.1%
Mg	$<$ 0.1%
B	$<$ 0.1%
Ca	$<$ 0.1%
Mo	
Ti	$<$ 0.1%
Ag	$<$ 0.1%
Na	$<$ 0.1%

Quantitative Anions

Sulfates	Not detected
Chlorides	0.09% Cl
Phosphates (H_2O sol)	0.007% Po_4
Phosphates (H_2O Insol)	1.0% Po_4

COMMENT: All results are on a dry weight basis.

SLUDGE SAMPLE FROM INDIAN POINT

UNIT NO. 2 STEAM GENERATORS

SAMPLE NO. 3

Petrographic Analysis

Fe_3O_4	35 - 45%
Fe_2O_3	Trace
Cu (metal)	45 - 55%
Cu as CuO	1 - 10%
SiO_2 (Amorphous)	Trace
SiO_2 (Quartz)	Trace
$Ca_3 (PO_4)_2$	Trace

Quantitative Analysis

Fe as Fe_3O_4	38.1%
Cu as Cu	49.5%
Zn as Zn	2.3%
Al as Al	0.2%
Ni as Ni	2.3%
B as BO_3	2.0%

Spectrographic Analysis

Fe	> 10%
Cu	>> 10%
Zn	> 1%
Al	< 0.1%
Ni	0.1 - 1%
Si	< 0.1%
Cr	< 0.1%
Sn	< 0.1%
Pb	< 0.1%
Mn	< 0.1%
Mg	< 0.1%
B	< 0.1%
Ca	< 0.1%
Mo	< 0.1%
Ti	< 0.1%
Ag	< 0.1%

Quantitative Anions

Sulfates	Not detected
Chlorides	0.02% Cl
Phosphates (H_2O sol)	0.0004% PO_4
Phosphates (H_2O Insol)	1.8% PO_4

COMMENT: All results are on a dry weight basis. Total weight of the dried sample is 9.7600 gm.

SLUDGE SAMPLE FROM INDIAN POINT

UNIT NO. 2 STEAM GENERATORS

SAMPLE NO. 4

Petrographic Analysis

Fe_3O_4	75 - 85%
Fe_2O_3	Trace
Cu as metal	10 - 20%
Cu as CuO	Trace
SiO_2 (Amorphous)	Trace
SiO_2 (Quartz)	Trace
$Ca_3(PO_4)_2$	Trace

Quantitative Analysis

Fe as Fe_3O_4	80.6%
Cu as Cu	12.2%
Zn as Zn	1.6%
Al as Al	0.17%
Ni as Ni	0.73%
B as BO_3	2.1%

Spectrographic Analysis:

Fe	$\gg$ 10%
Cu	1 - 10%
Zn	$>$ 1%
Al	0.1 - 1%
Ni	0.1 - 1%
Si	$\approx$ 0.1%
Cr	$<$ 0.1%
Sn	$<$ 0.1%
Pb	$<$ 0.1%
Mn	0.1 - 1%
Mg	$<$ 0.1%
B	$<$ 0.1%
Ca	$<$ 0.1%
Mo	$<$ 0.1%
Ti	$<$ 0.1%
Ag	$<$ 0.1%

Quantitative Anions

Sulfates	Not detected
Chlorides	0.04% Cl
Phosphate (H_2O sol)	0.008% PO_4
Phosphate (H_2O Insol)	2.7% PO_4

COMMENT: All results are on a dry weight basis. Total weight of the dried sample is 1.0457 gm.