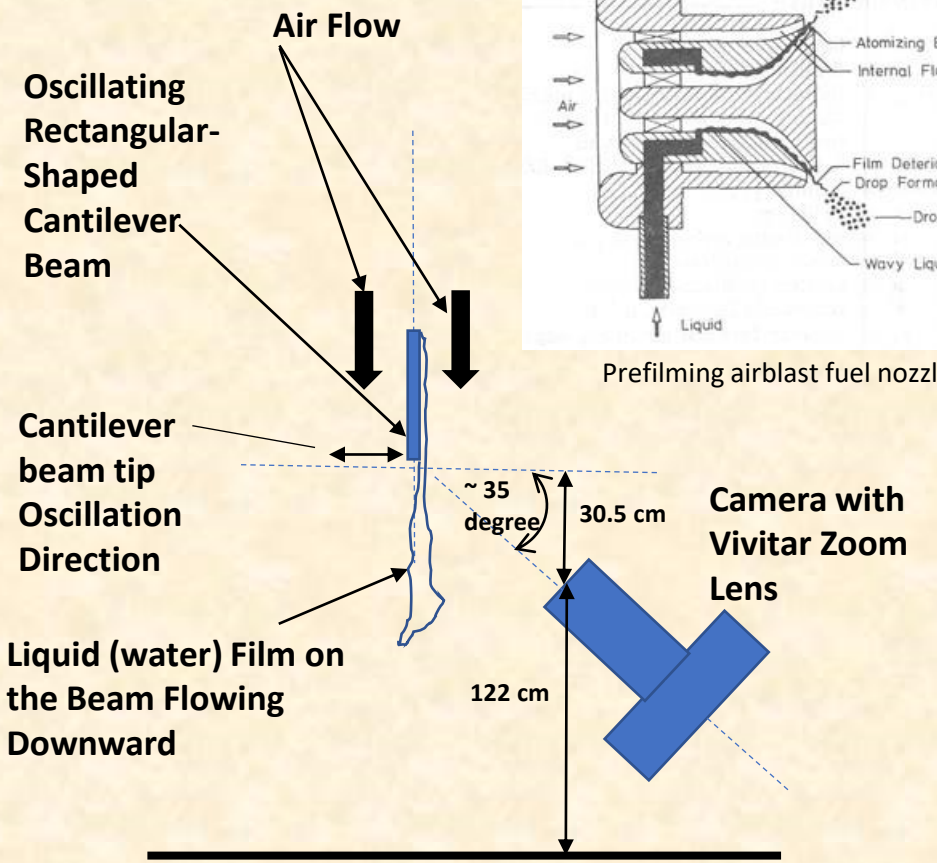
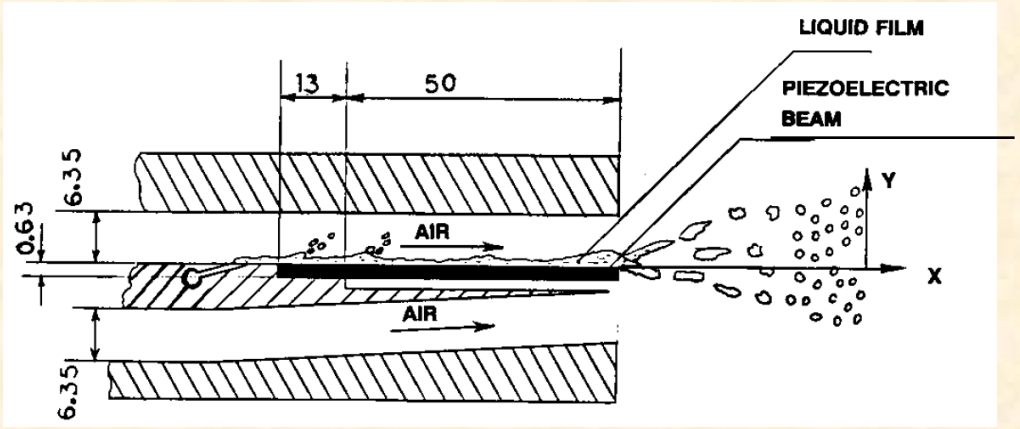
Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



Prefilming airblast fuel nozzle

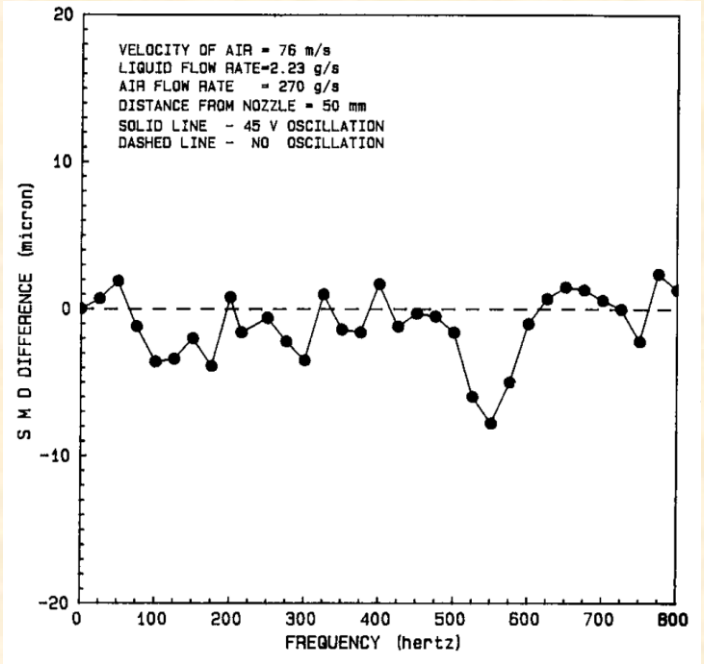


Cantilever Rectangular-Shaped Piezoelectric Beam

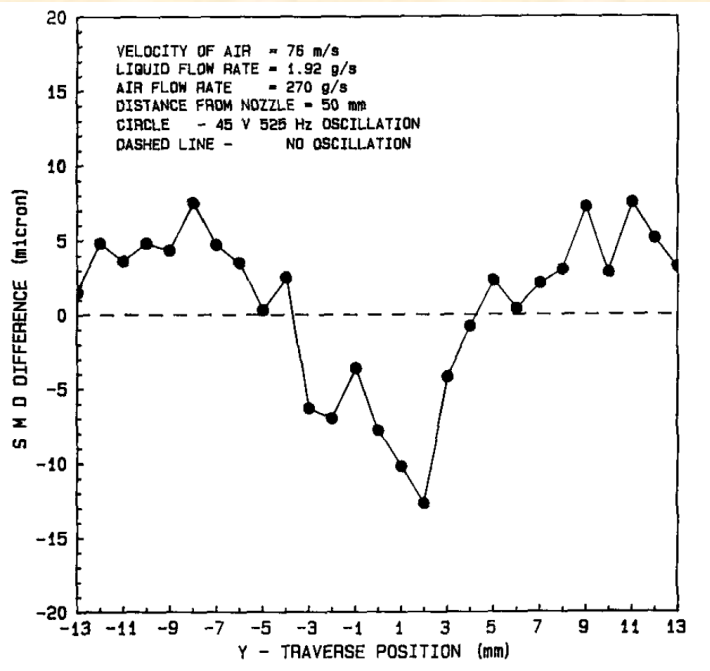
Schematic diagram of a two-dimensional model of the prefilming atomizer with piezoelectric oscillating beam. All dimensions are in millimeter.

Liquid Sheet is on the cantilever rectangular-shaped piezoelectric beam and flows downward in this page. Gravity direction is downward. Camera to subject distance is 81.3 cm. Flash light to subject distance is 30.5 cm.

Zoom lens: Vivitar Series 1, Model 28530352, Macro Focusing Zoom Lens, 70-210 mm 1:2.8 – 4.0 f/No.



Difference between SMD values for with and without beam oscillations as a function of beam oscillation frequency.



Difference between SMD values for with and without beam oscillations as a function of Y-traverse position at a distance of 50 mm from the nozzle.

B. Chehroudi, PhD

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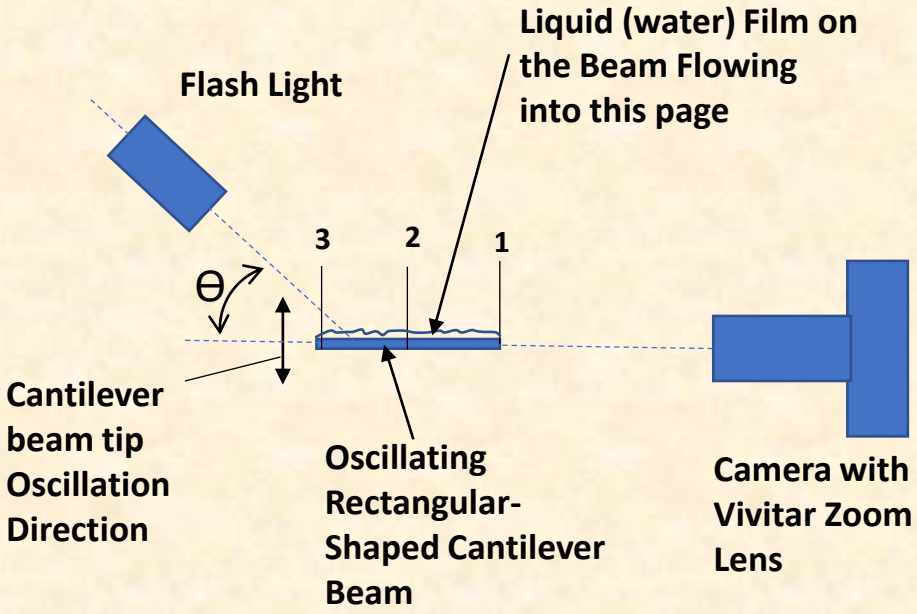
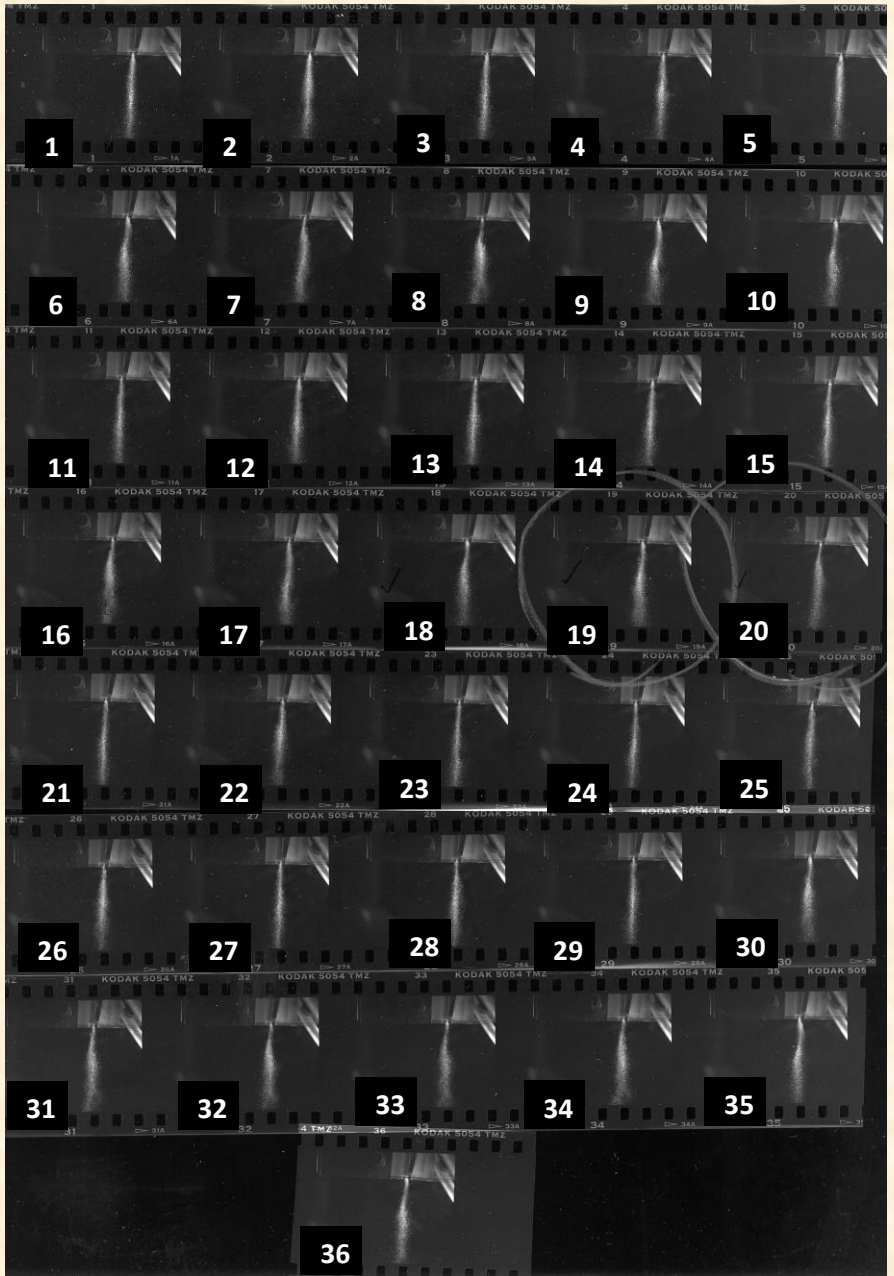


Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _ F/# 2.8		
Frame #	Oscillation	Focused Location
1	Off	1
2	Off	1
3	Off	1
4	Off	1
5	Off	1
6	On (537 Hz)	1
7	On (537 Hz)	1
8	On (537 Hz)	1
9	On (537 Hz)	1
10	On (537 Hz)	1
11	Off	2
12	Off	2
13	Off	2
14	Off	3
15	Off	3
16	On (537 Hz)	3
17	On (537 Hz)	3
18	On (537 Hz)	2
19	On (537 Hz)	2
20	On (537 Hz)	2
21	On (400 Hz)	2
22	On (400 Hz)	2
23	On (400 Hz)	2
24	On (400 Hz)	2
25	On (400 Hz)	2
26	Off	2
27	Off	2
28	Off	2
29	Off	2
30	On (537 Hz)	2
31	On (537 Hz)	2
32	On (537 Hz)	2
33	On (537 Hz)	2
34	On (537 Hz)	1
35	On (537 Hz)	1
36	On (537 Hz)	1+A1:C40



In this schematic diagram, the liquid Sheet is on the cantilever rectangular-shaped piezoelectric beam (its size is exaggerated) and flows perpendicular into this page. Gravity direction is also into the page. Camera to subject distance is 99.06 cm. The Θ angle is about 45degrees. Flash light to subject distance is 20.32 cm.

Zoom lens: Vivitar Series 1, Model 28530352, Macro Focusing Zoom Lens, 70-210 mm 1:2.8 – 4.0 f/No.

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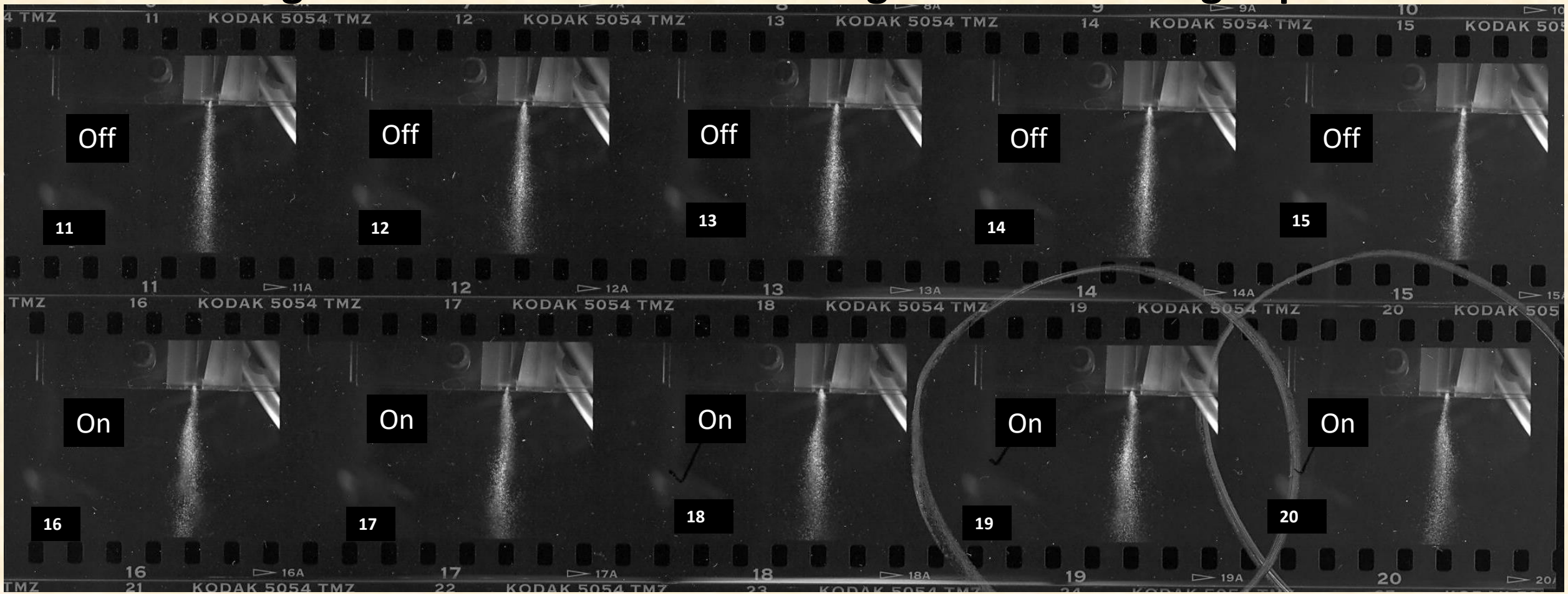
Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



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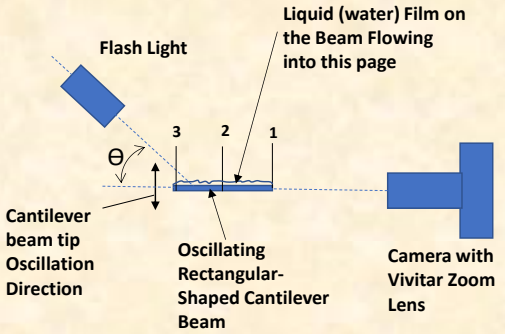

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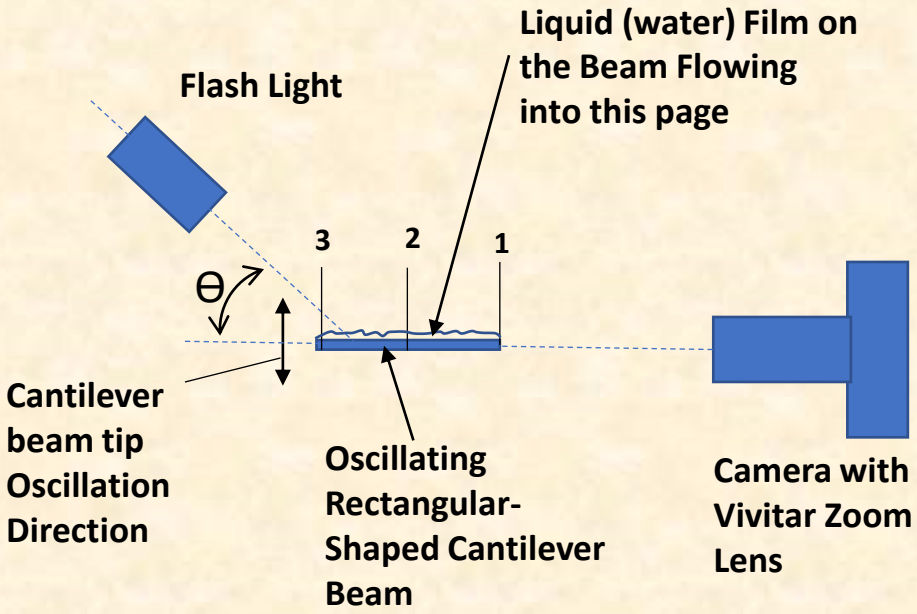
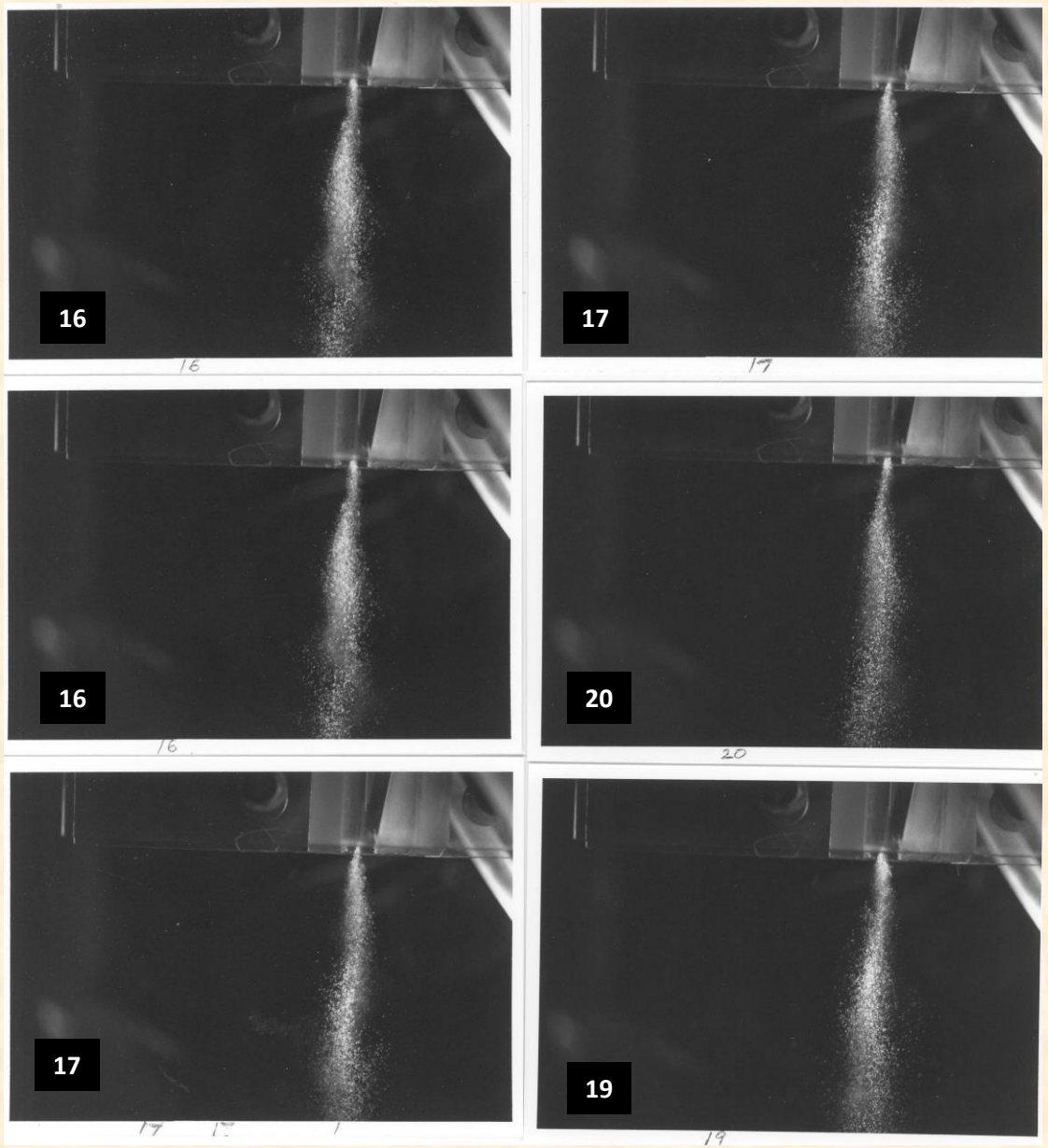
Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _ F/# 2.8		
Frame #	Oscillation	Focused Location
1	Off	1
2	Off	1
3	Off	1
4	Off	1
5	Off	1
6	On (537 Hz)	1
7	On (537 Hz)	1
8	On (537 Hz)	1
9	On (537 Hz)	1
10	On (537 Hz)	1
11	Off	2
12	Off	2
13	Off	2
14	Off	3
15	Off	3
16	On (537 Hz)	3
17	On (537 Hz)	3
18	On (537 Hz)	2
19	On (537 Hz)	2
20	On (537 Hz)	2
21	On (400 Hz)	2
22	On (400 Hz)	2
23	On (400 Hz)	2
24	On (400 Hz)	2
25	On (400 Hz)	2
26	Off	2
27	Off	2
28	Off	2
29	Off	2
30	On (537 Hz)	2
31	On (537 Hz)	2
32	On (537 Hz)	2
33	On (537 Hz)	2
34	On (537 Hz)	1
35	On (537 Hz)	1
36	On (537 Hz)	1+A1:C40



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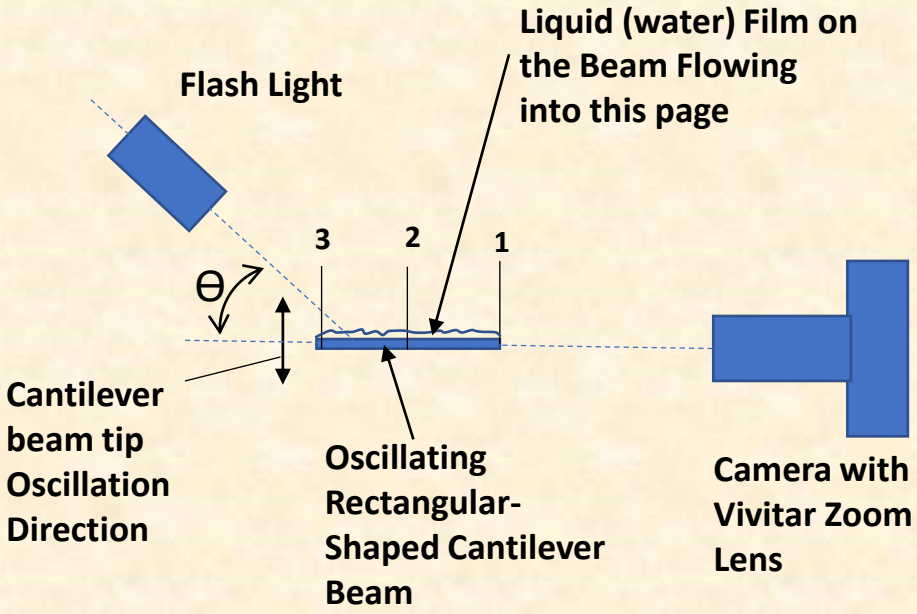
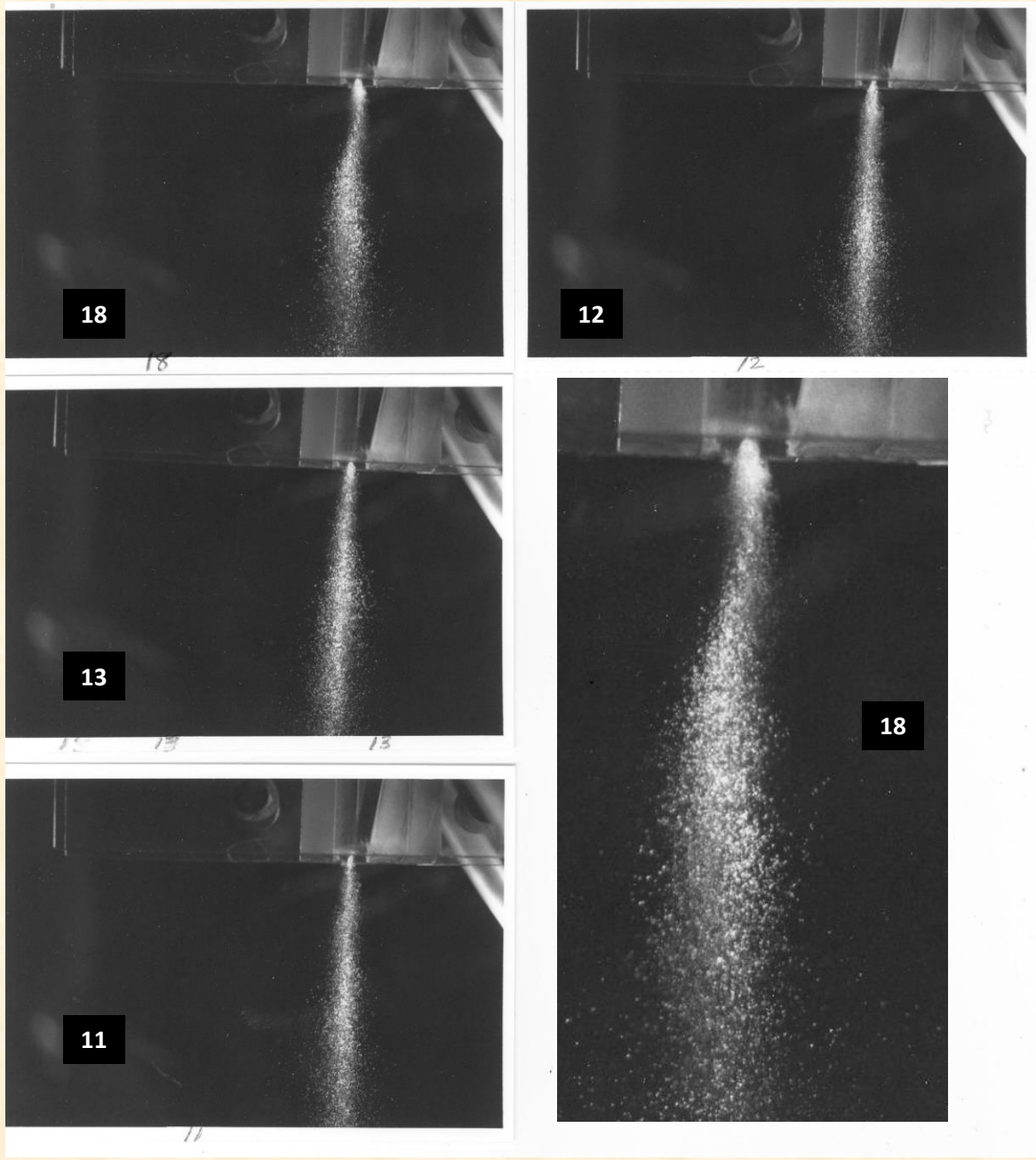
Zoom lens: Vivitar Series 1, Model 28530352, Macro Focusing Zoom Lens, 70-210 mm 1:2.8 – 4.0 f/No.

B. Chehroudi, PhD

Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _ F/# 2.8		
Frame #	Oscillation	Focused Location
1	Off	1
2	Off	1
3	Off	1
4	Off	1
5	Off	1
6	On (537 Hz)	1
7	On (537 Hz)	1
8	On (537 Hz)	1
9	On (537 Hz)	1
10	On (537 Hz)	1
11	Off	2
12	Off	2
13	Off	2
14	Off	3
15	Off	3
16	On (537 Hz)	3
17	On (537 Hz)	3
18	On (537 Hz)	2
19	On (537 Hz)	2
20	On (537 Hz)	2
21	On (400 Hz)	2
22	On (400 Hz)	2
23	On (400 Hz)	2
24	On (400 Hz)	2
25	On (400 Hz)	2
26	Off	2
27	Off	2
28	Off	2
29	Off	2
30	On (537 Hz)	2
31	On (537 Hz)	2
32	On (537 Hz)	2
33	On (537 Hz)	2
34	On (537 Hz)	1
35	On (537 Hz)	1
36	On (537 Hz)	1+A1:C40



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Zoom lens: Vivitar Series 1, Model 28530352, Macro Focusing Zoom Lens, 70-210 mm 1:2.8 – 4.0 f/No.

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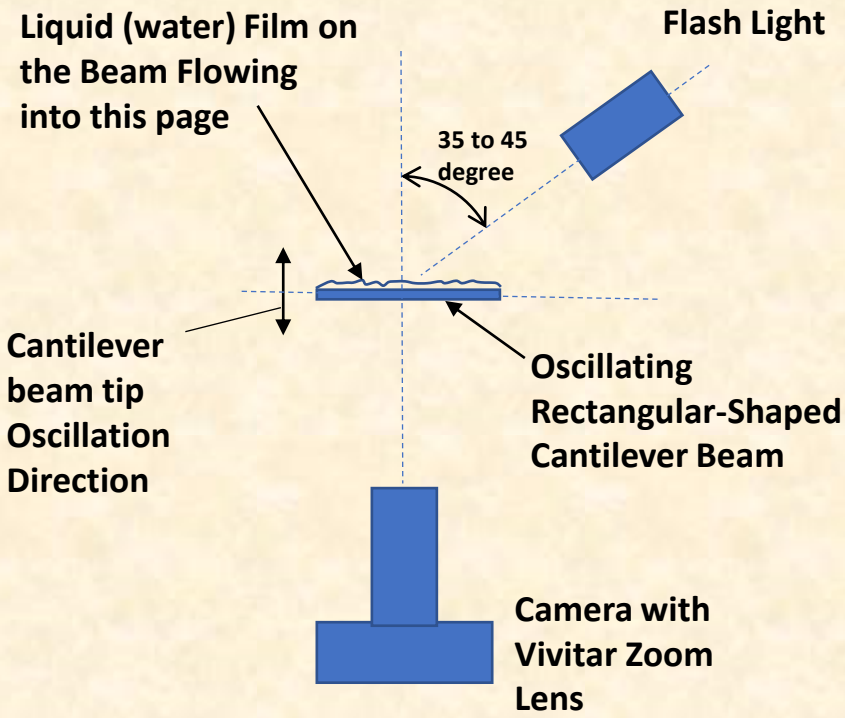

In this schematic diagram, the liquid Sheet is on the cantilever rectangular-shaped piezoelectric beam and flows perpendicular into this page. Gravity direction is also into the page. Camera to subject distance is 68.6 cm. Flash light to subject distance is 30.5 cm.

Zoom lens: Vivitar Series 1, Model 28530352, Macro Focusing Zoom Lens, 70-210 mm 1:2.8 – 4.0 f/No.

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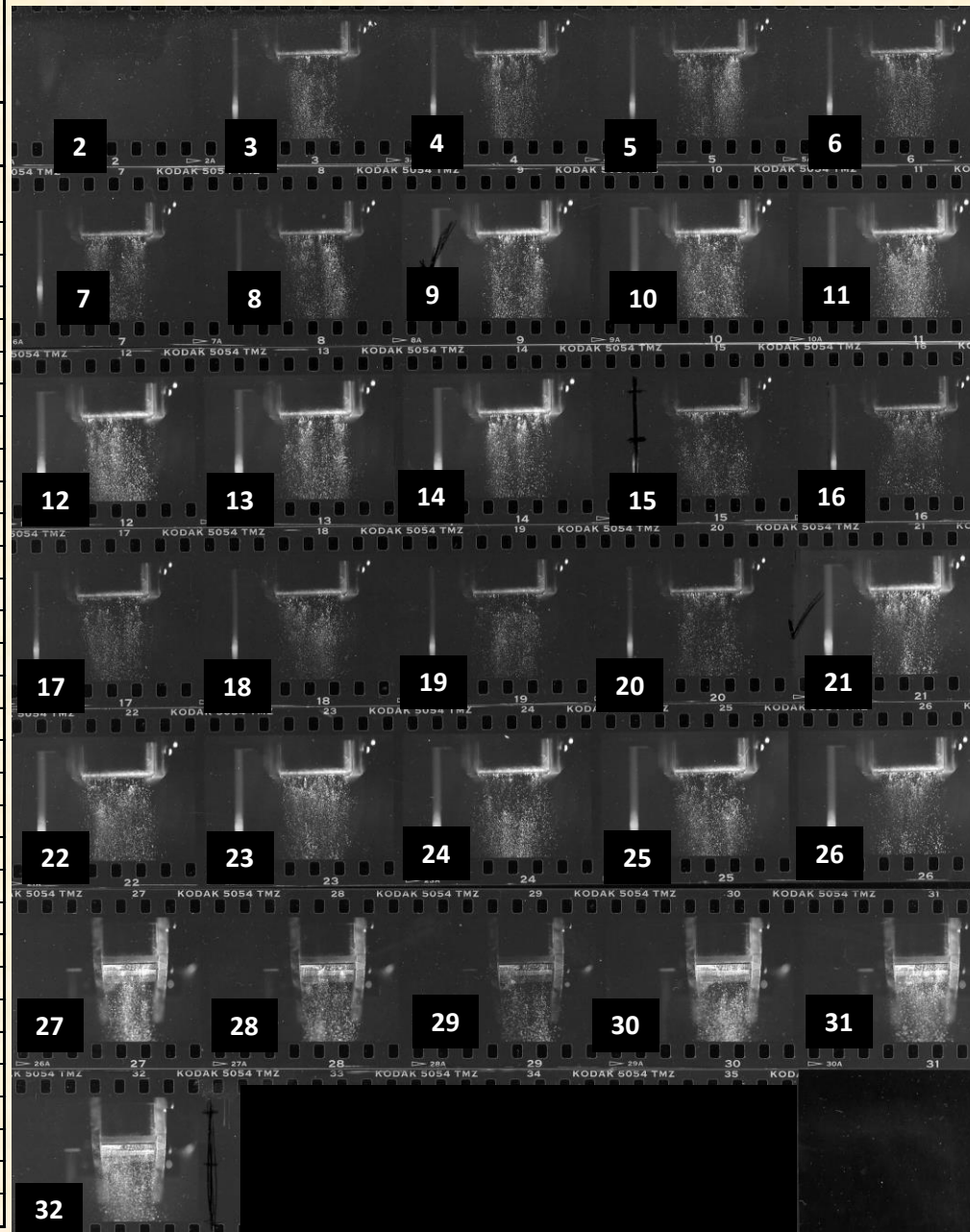
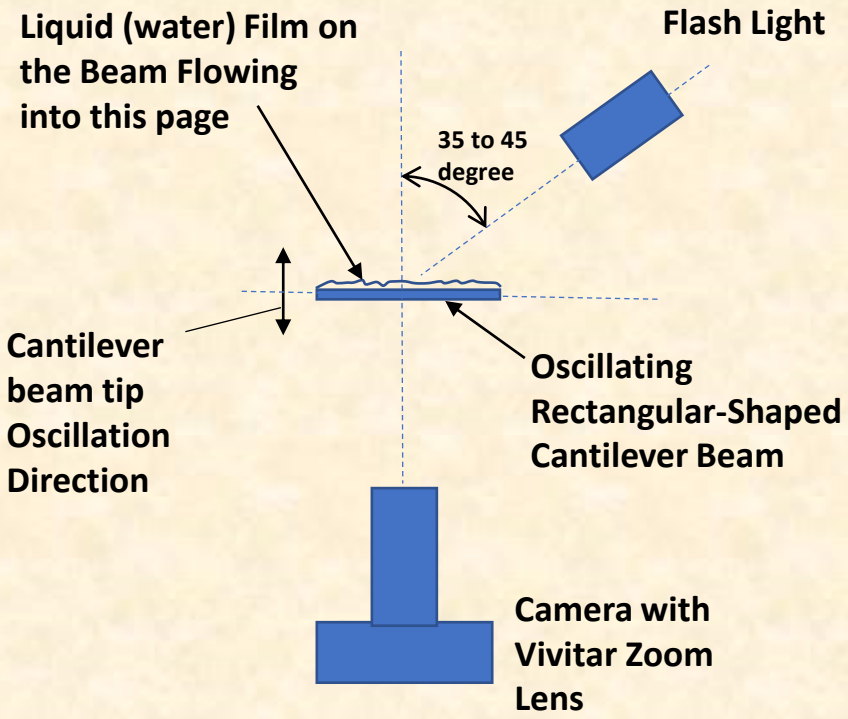
Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _Camera Shutter is Open			
Frame #	Oscillation	F/#	Camera View Direction
1		8	Perpendicular to Liquid Film
2		1	"
3	Off	1	"
4	Off	1	"
5	Off	1	"
6	Off	1	"
7	Off	1	"
8	Off	1	"
9	Off	5.6	"
10	Off	1	"
11	Off	2	"
12	Off	2	"
13	Off	2	"
14	Off	8	"
15	On (537 Hz)	8	"
16	On (537 Hz)	8	"
17	On (537 Hz)	8	"
18	On (537 Hz)	8	"
19	On (537 Hz)	8	"
20	On (537 Hz)	8	"
21	On (537 Hz)	5.6	"
22	On (537 Hz)	5.6	"
23	On (537 Hz)	5.6	"
24	On (537 Hz)	5.6	"
25	On (537 Hz)	5.6	"
26	On (537 Hz)	5.6	"
27	Off	2.8	Looking Upward
28	Off	4	"
29	Off	5.6	"
30	On (537 Hz)	2.8	"
31	On (537 Hz)	4	"
32	On (537 Hz)	5.8	"



Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



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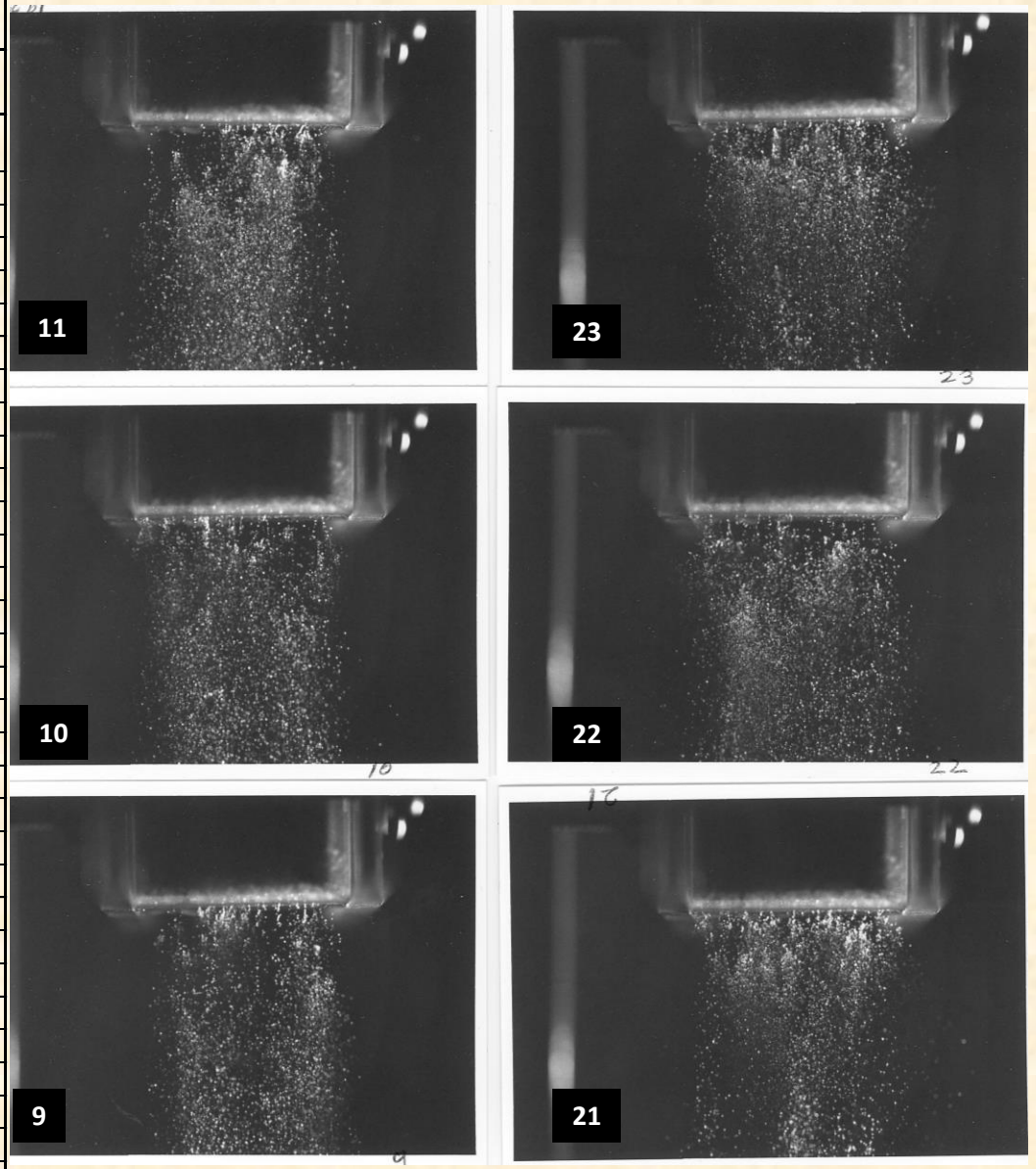
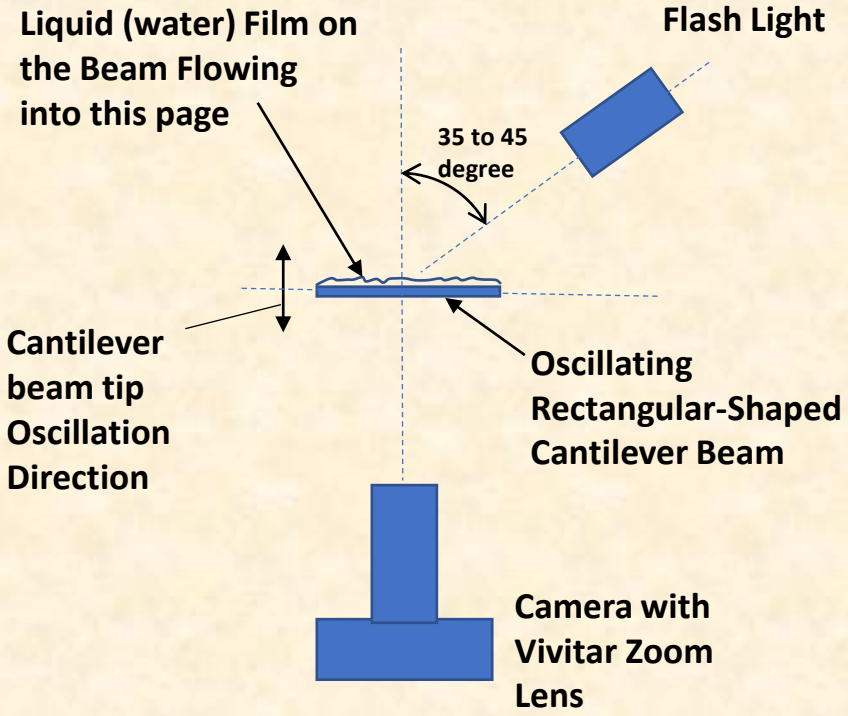
Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _Camera Shutter is Open			
Frame #	Oscillation	F/#	Camera View Direction
1		8	Perpendicular to Liquid Film
2		1	"
3	Off	1	"
4	Off	1	"
5	Off	1	"
6	Off	1	"
7	Off	1	"
8	Off	1	"
9	Off	5.6	"
10	Off	1	"
11	Off	2	"
12	Off	2	"
13	Off	2	"
14	Off	8	"
15	On (537 Hz)	8	"
16	On (537 Hz)	8	"
17	On (537 Hz)	8	"
18	On (537 Hz)	8	"
19	On (537 Hz)	8	"
20	On (537 Hz)	8	"
21	On (537 Hz)	5.6	"
22	On (537 Hz)	5.6	"
23	On (537 Hz)	5.6	"
24	On (537 Hz)	5.6	"
25	On (537 Hz)	5.6	"
26	On (537 Hz)	5.6	"
27	Off	2.8	Looking Upward
28	Off	4	"
29	Off	5.6	"
30	On (537 Hz)	2.8	"
31	On (537 Hz)	4	"
32	On (537 Hz)	5.8	"



Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



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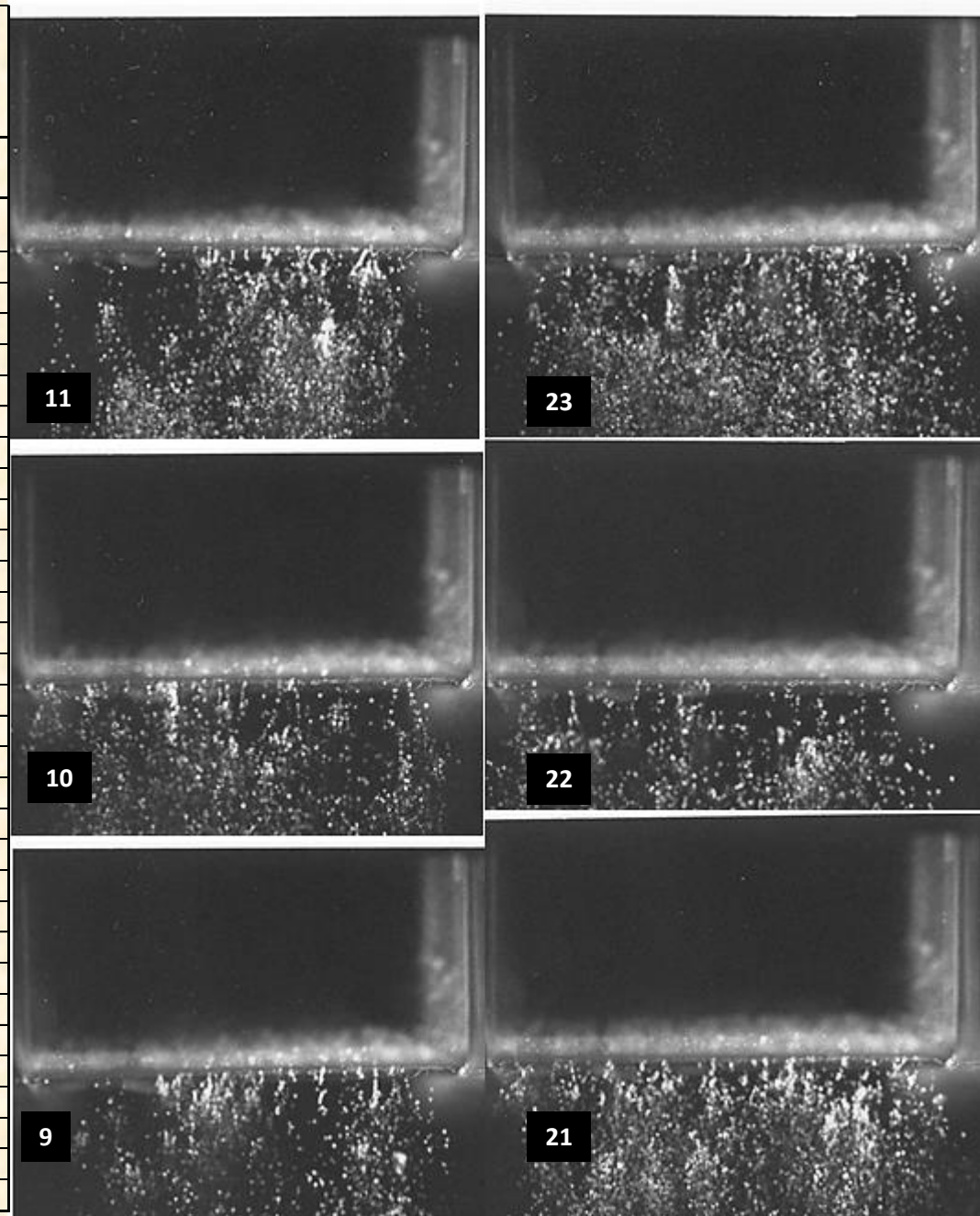
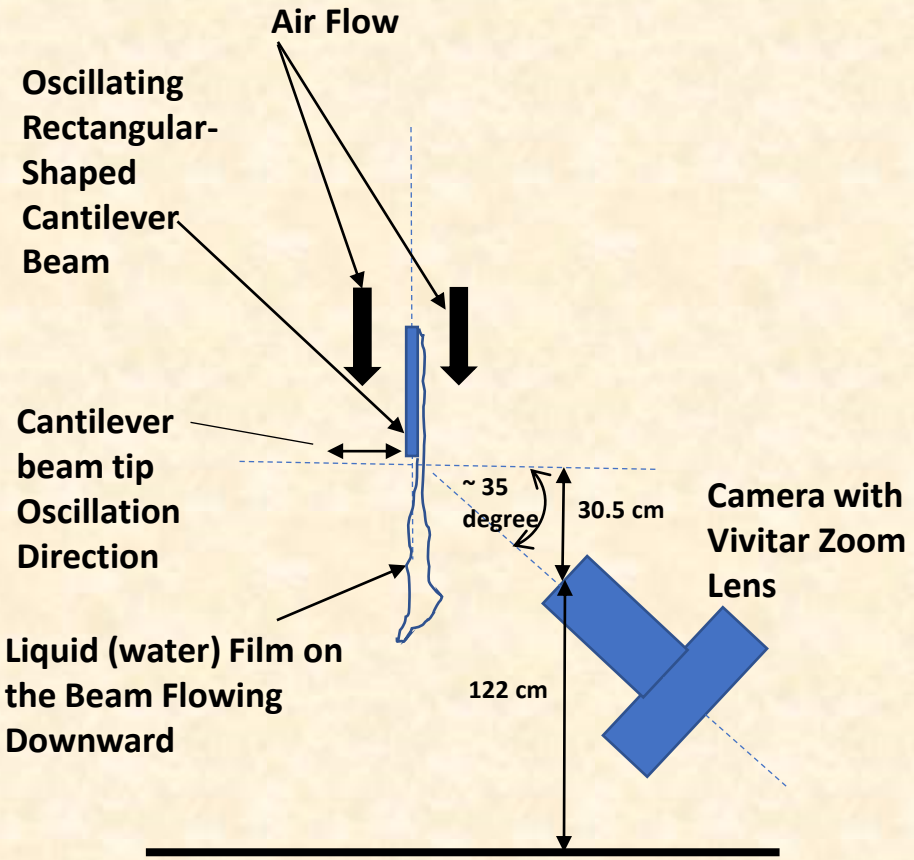
B. Chehroudi, PhD

Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _Camera Shutter is Open			
Frame #	Oscillation	F/#	Camera View Direction
1		8	Perpendicular to Liquid Film
2		1	"
3	Off	1	"
4	Off	1	"
5	Off	1	"
6	Off	1	"
7	Off	1	"
8	Off	1	"
9	Off	5.6	"
10	Off	1	"
11	Off	2	"
12	Off	2	"
13	Off	2	"
14	Off	8	"
15	On (537 Hz)	8	"
16	On (537 Hz)	8	"
17	On (537 Hz)	8	"
18	On (537 Hz)	8	"
19	On (537 Hz)	8	"
20	On (537 Hz)	8	"
21	On (537 Hz)	5.6	"
22	On (537 Hz)	5.6	"
23	On (537 Hz)	5.6	"
24	On (537 Hz)	5.6	"
25	On (537 Hz)	5.6	"
26	On (537 Hz)	5.6	"
27	Off	2.8	Looking Upward
28	Off	4	"
29	Off	5.6	"
30	On (537 Hz)	2.8	"
31	On (537 Hz)	4	"
32	On (537 Hz)	5.8	"



Prefilming Gas Turbine Fuel Nozzle Design with Oscillating Liquid Sheet



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Zoom lens: Vivitar Series 1, Model 28530352, Macro Focusing Zoom Lens, 70-210 mm 1:2.8 – 4.0 f/No.

B. Chehroudi, PhD

Oscillation and Camera Settings for the Pictures Taken _ ASA 3200 _Camera Shutter is Open			
Frame #	Oscillation	F/#	Camera View Direction
1		8	Perpendicular to Liquid Film
2		1	"
3	Off	1	"
4	Off	1	"
5	Off	1	"
6	Off	1	"
7	Off	1	"
8	Off	1	"
9	Off	5.6	"
10	Off	1	"
11	Off	2	"
12	Off	2	"
13	Off	2	"
14	Off	8	"
15	On (537 Hz)	8	"
16	On (537 Hz)	8	"
17	On (537 Hz)	8	"
18	On (537 Hz)	8	"
19	On (537 Hz)	8	"
20	On (537 Hz)	8	"
21	On (537 Hz)	5.6	"
22	On (537 Hz)	5.6	"
23	On (537 Hz)	5.6	"
24	On (537 Hz)	5.6	"
25	On (537 Hz)	5.6	"
26	On (537 Hz)	5.6	"
27	Off	2.8	Looking Upward
28	Off	4	"
29	Off	5.6	"
30	On (537 Hz)	2.8	"
31	On (537 Hz)	4	"
32	On (537 Hz)	5.8	"