THE UNIVERSITY OF MICHIGAN

College of Engineering
Mechanical Engineering Department
Cavitation and Muliphase Flow Laboratory

Report No. UMICH 012449-19-I

CAVITATION DAMAGE

(In partial fulfillment of ME 490)

by

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Approved by

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INDRODUTION

The mean djective of this research is to investigate the cavitation damage from conventional vibratory means and the damage pattern.

DESCRIPTION

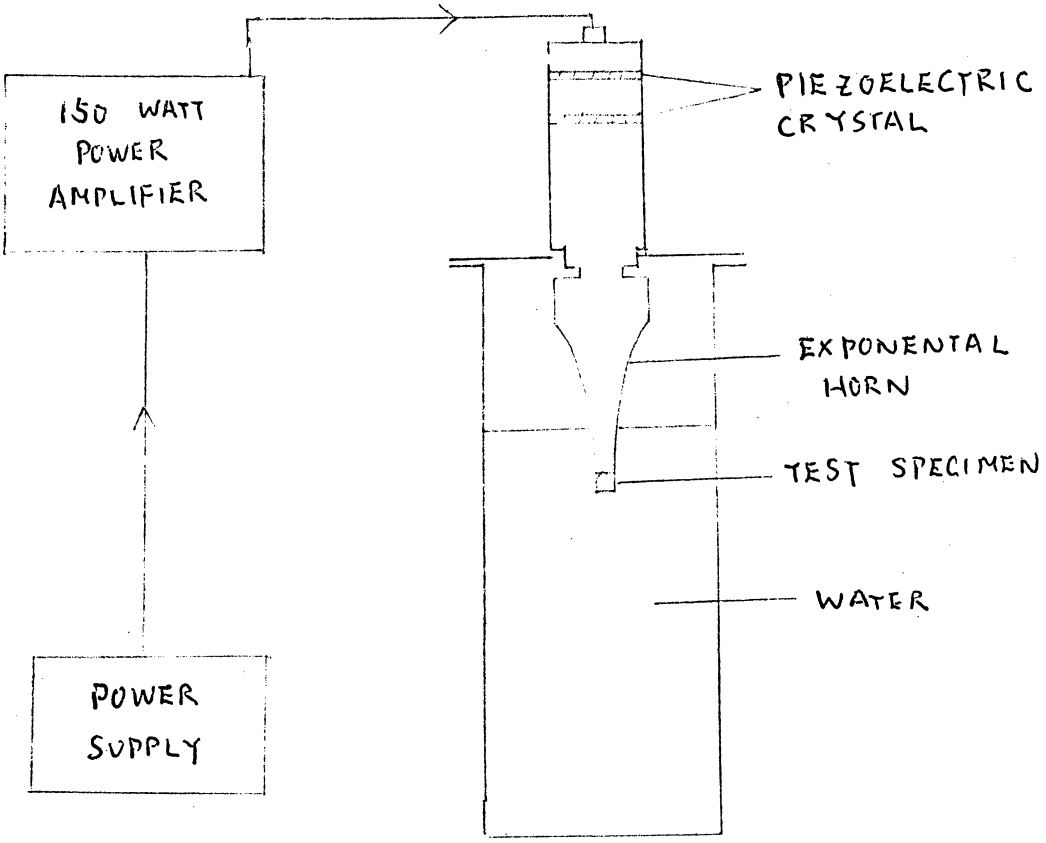
Cavitation damage data from conventional vibratory damage tests will be obtained in the usual way i.e. for a given fluid - material at given temperature and pressure, mass loss measurement will be made at selected interval, until the full damage curve has been developed.

Curves of weight loss vs time is plotted and from the maxium slope the MDPR max (Mean Depth of Penetration) will be calculated and ploted against amplitude. - The material employed was Aluminium and the fluid was water.

As for the pattern of cavitation damage, the material we employed are cadium plated specimen and plexiglass using the same apparatus set up

as the conventional vibratory damage test. The damage are photographed with ~~long~~ large scale magnification.

APARATUS



Power of ≈ 2.0 mils are sent to the horn. Their periodic motion generates a standing wave whose amplitude is increased as it traverses the exponential horn assembly, to which the test specimens are attached at the small end

RESULT

6 AL-1100 specimen are selected to demonstrate the cavitation damage from conventional vibratory means. The first 4 specimen are tested under normal condition. The weight loss were measured at selected interval until a general shape of weight loss vs time curve is developed. The rate of weight loss is pretty uniform at the beginning of the selected intervals finally the rate of weight loss decreased after a period of time. I believe it is the general behavior of the cavitation damage. Actually the ~~main~~ main object of developing such a curve is to find out the maxium slope of each individual curve. From it we can calculated for MDPR max by using the equation $MDPR_{max} = \frac{0.257 \times WLR\ max}{\text{Density of material}}$

For the 4 tested specimen, four different values of MDPR max are obtained, Using a log-log plot of MDPR max Vs Amplitude a straight line curve is obtained.

We then using the other 2 specimen and test it w in the same operating condition as above, instead a strong magnetic field of B ≅ 8000 GAUSE is applied during the cavitation damage took place.

To our great surprise, the shape of the curve did not change, even we can generated another curve which coincide with the without magnetic ~~one~~ field curve. Thus we can proof that ~~without~~ with or without magnetic field do not change the rate of cavitation damage

The results are shown in fig. 1 & 2.

As for the pattern of damage, we choose plexiglass and cadium-plated specimens and then run them under the same operation condition as the aluminum specimen. The only different is that only a very short operating time is allowed. Because we only want to obtain as little cavitation damage as possible. The result is shown in Fig 3, 4, 5 and 6.

CONCLUSION

The rate of cavitation damage we obtained are very successful. As for the damage pattern, due to machine cutting, lot of machine marks are left behind. Furthermore, there are lots of impurities embedded in the plexiglass specimen, thus we are ~~we~~ very difficult to distinguish whether it is cavitation damage or not. The end results were not a successful one. I think if we want a successful result, every specimen must be polished very well and inspected before we run it. During the operating time, ~~add~~ utmost care is needed to protect the specimens from scratching and in contact with other foreign material.

MATERIAL DAMAGE SHEET

rial F.L. - 1100

ber 5

RUNNING CONDITIONS

T. + S S	...mperature 75°F
ver ~ 8%	Pressure 1 ATM
rox. Date 3 - 4 - 75	Torque 80 - 90 IN-lb

rum

face Preparation

BASIS FOR CALCULATIONS

ity 2.71 gm / cm³	Area

Factor

ents $WLR_{max} = \frac{7.4 \text{ mg}}{5 \text{ min}} = 1.48 \text{ mg/min}$

$MDPR = \frac{0.257 \times 1.48}{2.71} = 0.140354 \text{ mils/min}$

DATA

terval MIN	Cumulative Time MIN	Wt. Loss mg	Cumulative Wt. Loss mg	MDP	Cumulative MDP
[illegible]	0	0	0		
[illegible]	5	8.25	8.25		
5	11	6.30	14.55		
5	15	3.65	18.20		
5	20	2.70	20.90		
5	25	1.70	22.60		
[illegible]	30	0.7	23.30		

MATERIAL DAMAGE SHEET

rial AL ÷ 110C

ber 4

RUNNING CONDITIONS

n Ti + SS	...mperature 75°F
pver ~16%	Pressure 1 ATM
rox. Date 4.4.-75	Torque 80 - 90 IN. lb

rum

face Preparation

BASIS FOR CALCULATIONS

nsity 2.71 gm / cm³	Area

Factor

mments $WLR_{max} = \frac{11}{5}$ mg/min = 2.2 mg/min

$MDPR = \frac{0.257 \times 2.2}{2.71} = 0.2086347$ mils/min

DATA

me Interval MIN	Cumulative Time MIN	Wt. Loss mg.	Cumulative Wt. Loss mg.	MDP	Cumulative MDP
C	0	C	C		
5	5	9.50	9.50		
5	10	12.65	22.15		
	15	4.75	26.90		
5	20	6.45	33.35		
5	25	4.25	37.60		
5	30	6.10	43.70		

MATERIAL DAMAGE SHEET

al AL - 1100

umber 6

RUNNING CONDITIONS

orn Ti + S.S	...mperature 75 °F
Power ~ 21%	Pressure 1 ATM
pprox. Date 3-5-75	Torque 80 - 90 IN-lb

erum

urface Preparation

BASIS FOR CALCULATIONS

ensity 2.71 gm/cm³	Area

DP Factor

omments

$$WLR_{max} = \frac{14}{5} = 2.8 \text{ mg/min}$$

$$MDPR = \frac{0.257 \times 2.8}{2.71} = 0.265535 \text{ mils/min}$$

DATA

Time Interval Min	Cumulative Time Min	Wt. Loss mg	Cumulative Wt. Loss mg	MDP	Cumulative MDP
0	0	0	0		
2.5	2.5	5.55	5.55		
2.5	5	8.15	13.70		
2.5	7.5	6.50	20.20		
2.5	10	8.50	28.70		
2.5	12.5	4.1	32.8		
2.5	15 0	5.4	38.20		
2.5	17.5	1.35	39.55		
2.5	20	2.90	42.45		

MATERIAL DAMAGE SHEET

erial Al 1100

umber 7

RUNNING CONDITIONS

orn Ti + S.S	...mperature 75 °F
Power ~38%	Pressure 1 ATM
pprox. Date	Torque 80-90 IN-16

rerum

urface Preparation

BASIS FOR CALCULATIONS

ensity 2.71 gm/cm³	Area

DP Factor

omments

$$WLR_{max} = \frac{18.75}{5} = 3.75$$

$$MDPR = \frac{0.257 \times 3.75}{2.71} = 0.3556273 \text{ mils/min.}$$

DATA

ime Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
2.5	2.5	8.05	8.05		
2.5	5	10.75	18.80		
2.5	7.5	9.50	28.30		
2.5	10	9.20	37.50		
2.5	12.5	8.95	46.45		
5	17.5	9.20	55.65		
5	22.5	9.65	65.30		

MATERIAL DAMAGE SHEET

Material	AL -1100
Number	10

RUNNING CONDITIONS

Horn	Ti + S.S.	Temperature	75 °F
% Power	35%	Pressure	1 ATM
Approx. Date	3-20-75	Torque	80-90 in lb
Prerun			

BASIS FOR CALCULATIONS

Density	2.71 gm / cm³	Area	
MDP Factor	0		

Comments: WLR_{max} $\frac{18.75}{5} = 3.75$

$$MDPR = \frac{0.257 \times 3.75}{2.71} = 0.355 \text{ mils/min}$$

WITH MAG. FIELD.

Time Interval MIN	Cumulative Time MIN	Weight Loss mg.	Cumulative Weight Loss mg	MDP	Cumulative M
0	0	0	0		
5	5	17.55	17.55		
2.5	7.5	11.15	28.70		
2.5	10	9.85	38.55		
2.5	12.5	8.75	47.30		
2.5	15	9.15	56.35		

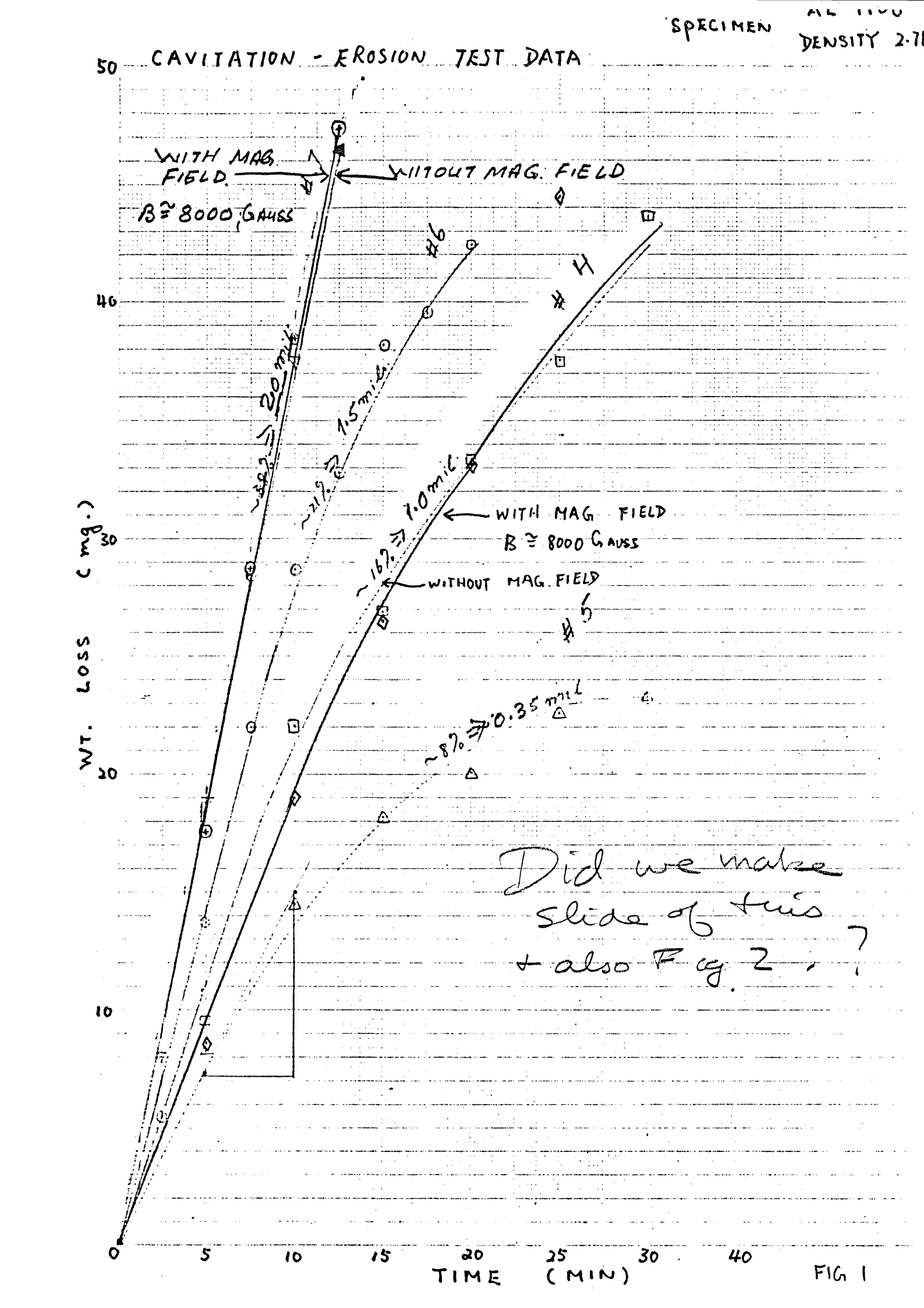

SPECIMEN
DENSITY 2.7
CAVITATION - EROSION TEST DATA
WITH MAG. FIELD
B ≅ 8000 GAUSS
WITHOUT MAG. FIELD
#6
#4
#5
2.0 mil
1.5 mil
1.0 mil
0.35 mil
~33%
~21%
~16%
~8%
WITH MAG FIELD
B ≅ 8000 GAUSS
WITHOUT MAG. FIELD
WT. LOSS (mg.)
TIME (MIN)
0
5
10
15
20
25
30
40
10
20
30
40
50
Did we make slide of this + also Fig 2 ?

FIG 1

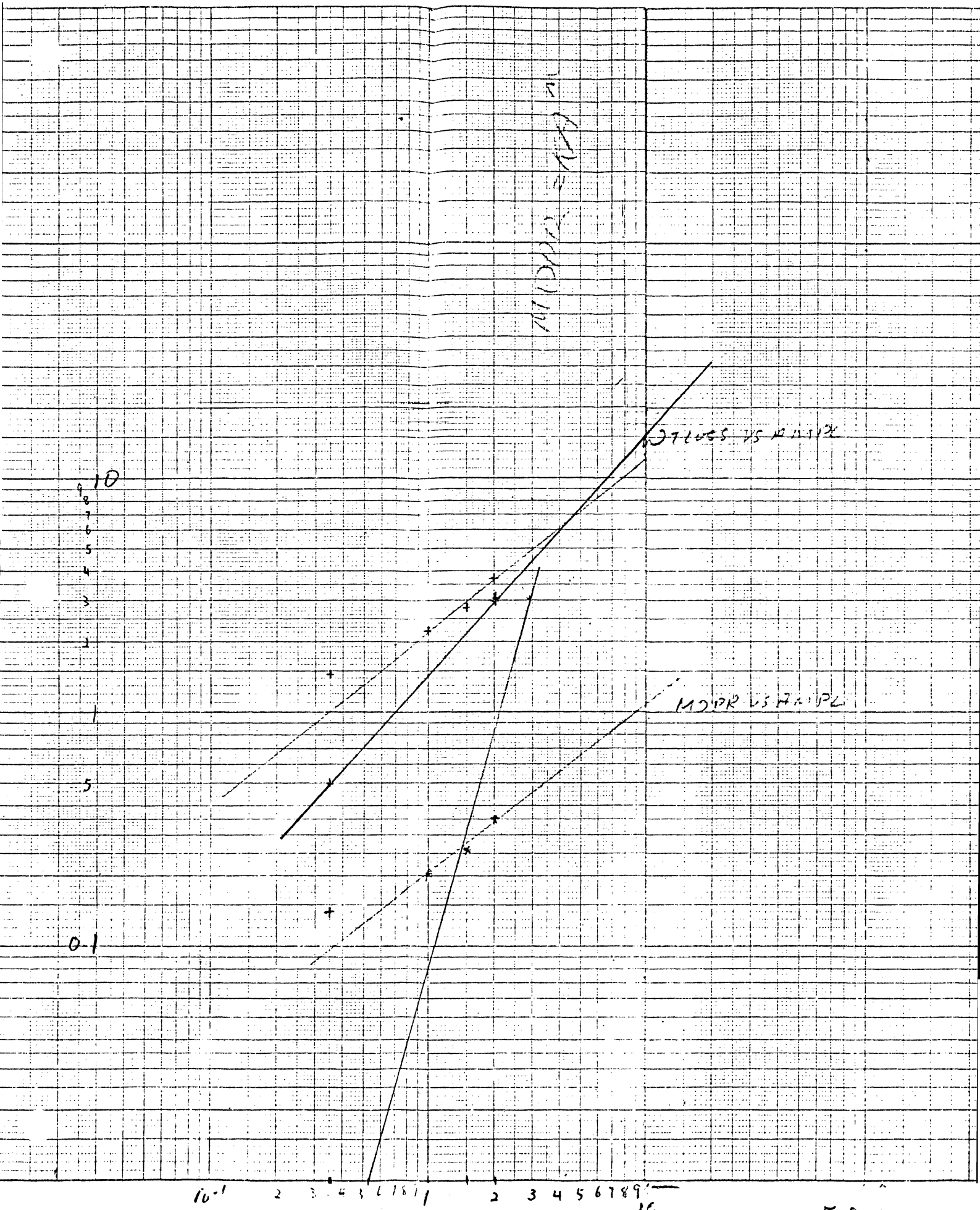
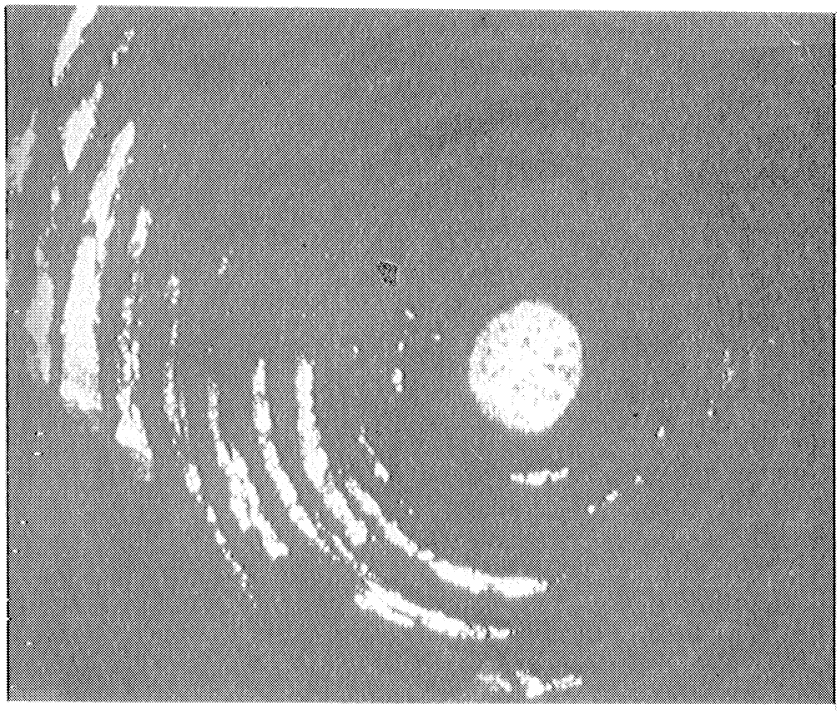
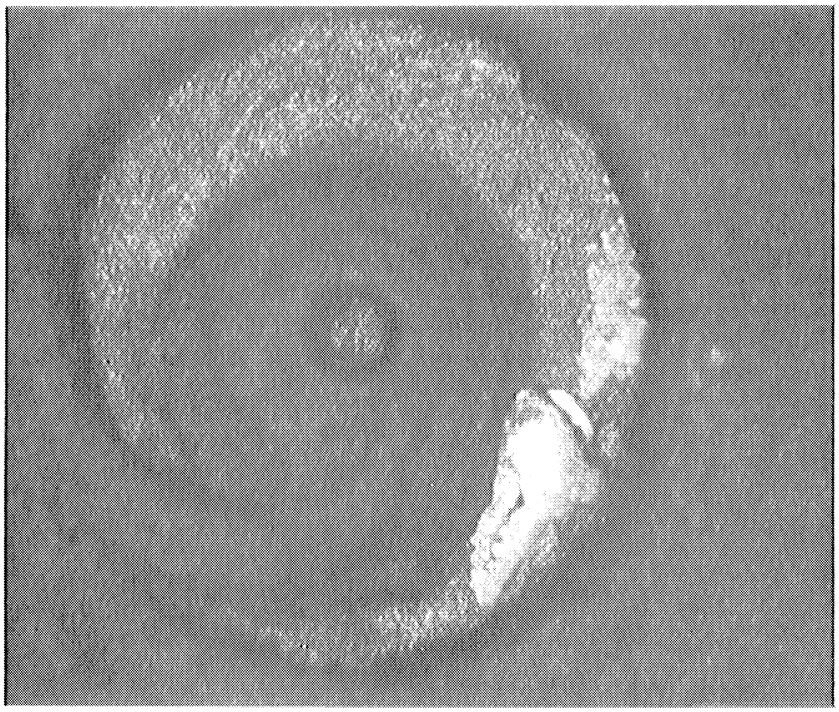


FIG 2

CAVITATION DAMAGE ON CADIMUM PLATED SPECIMEN :



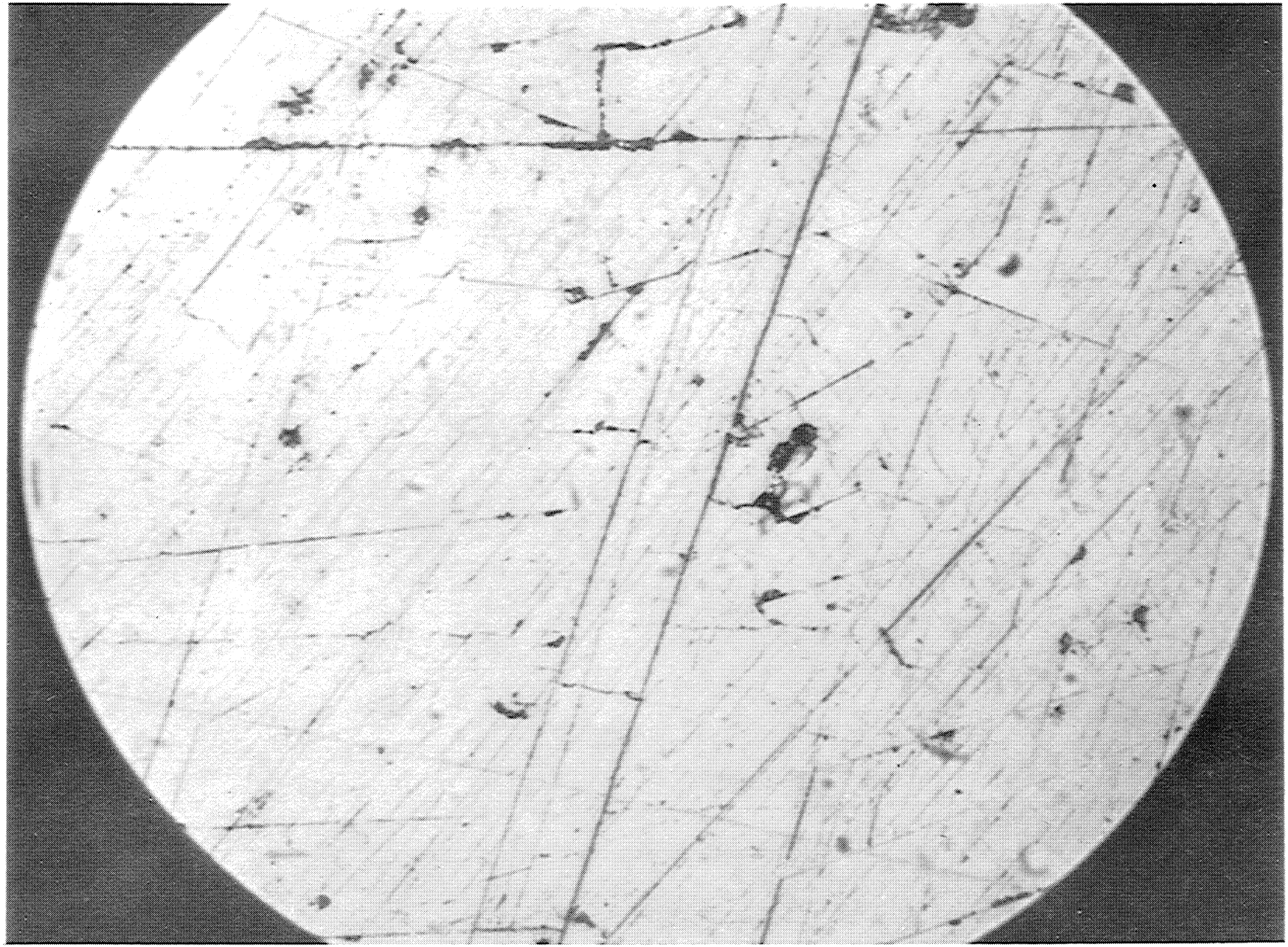
MAGNIFICATION : X 100
POWER ≈ 1·5 mls
TIME 10 MIN.



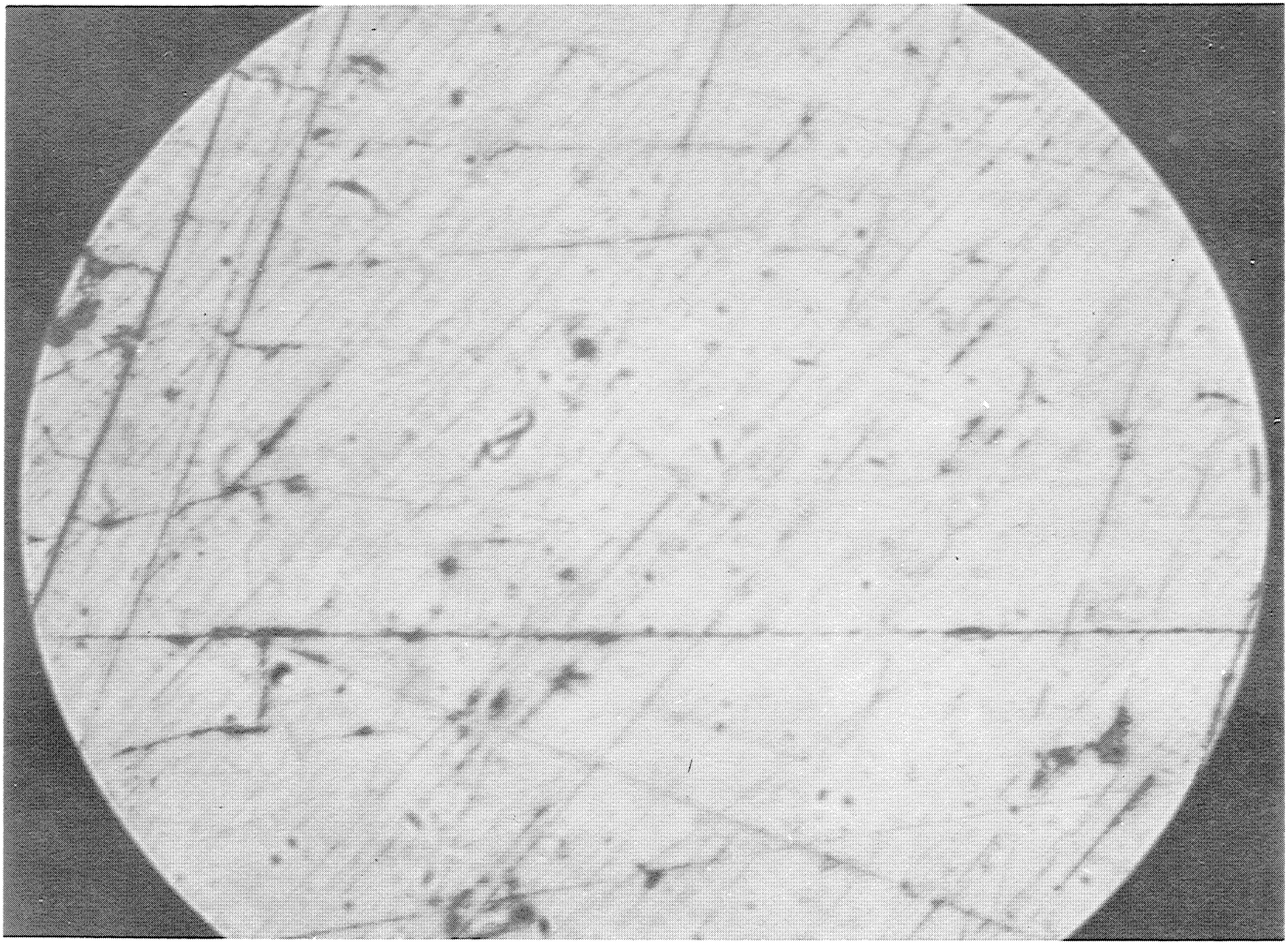
MAGNIFICATION X 100
POWER ≈ 1·5 mls.
TIME 10 MIN.

633

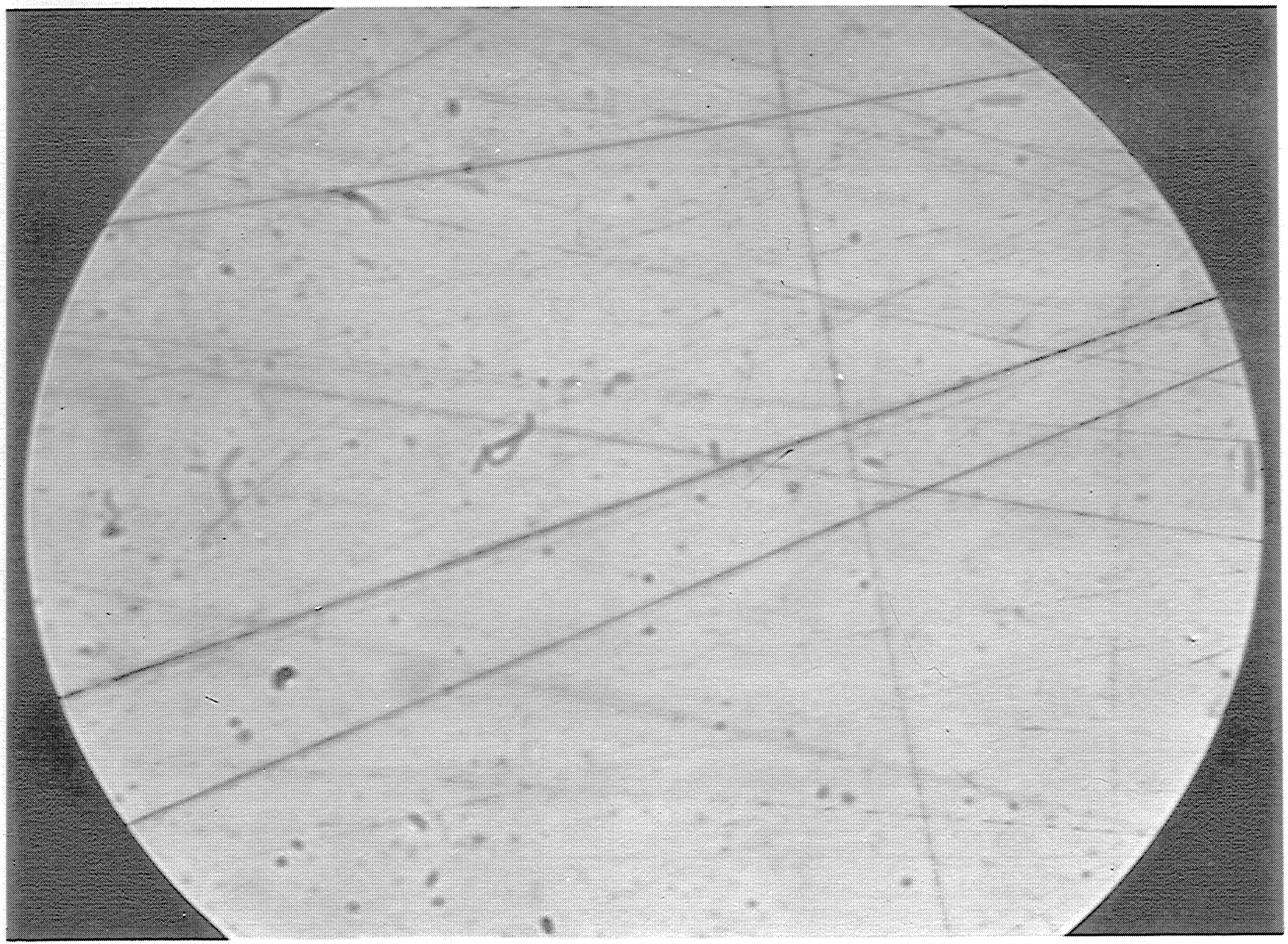
FIG 3



PLEXIGLASS POWER 1.5 MILS TIME 1 MIN FIG 4 634



.635" PLEXIGLASS POWER 1.5 MILS TIME 1 MIN FIG 5 C



636 PLEXIGLASS POWER 1.0 MILS TIME 1 MIN FIG 6 636