Chapter III

RESULTS AND DISCUSSIONS

3.1 Experimental results

In the operation of the nitrogen gas laser, as particular spark gap spacing between one of the adjacent plates and the mutual plate of the capacitor in the Blumlein switching circuit must be chosen. Adjustment is required to produce the desired repetitive rate of the electric discharge under the certain pressure of flowing nitrogen gas in the laser chamber.

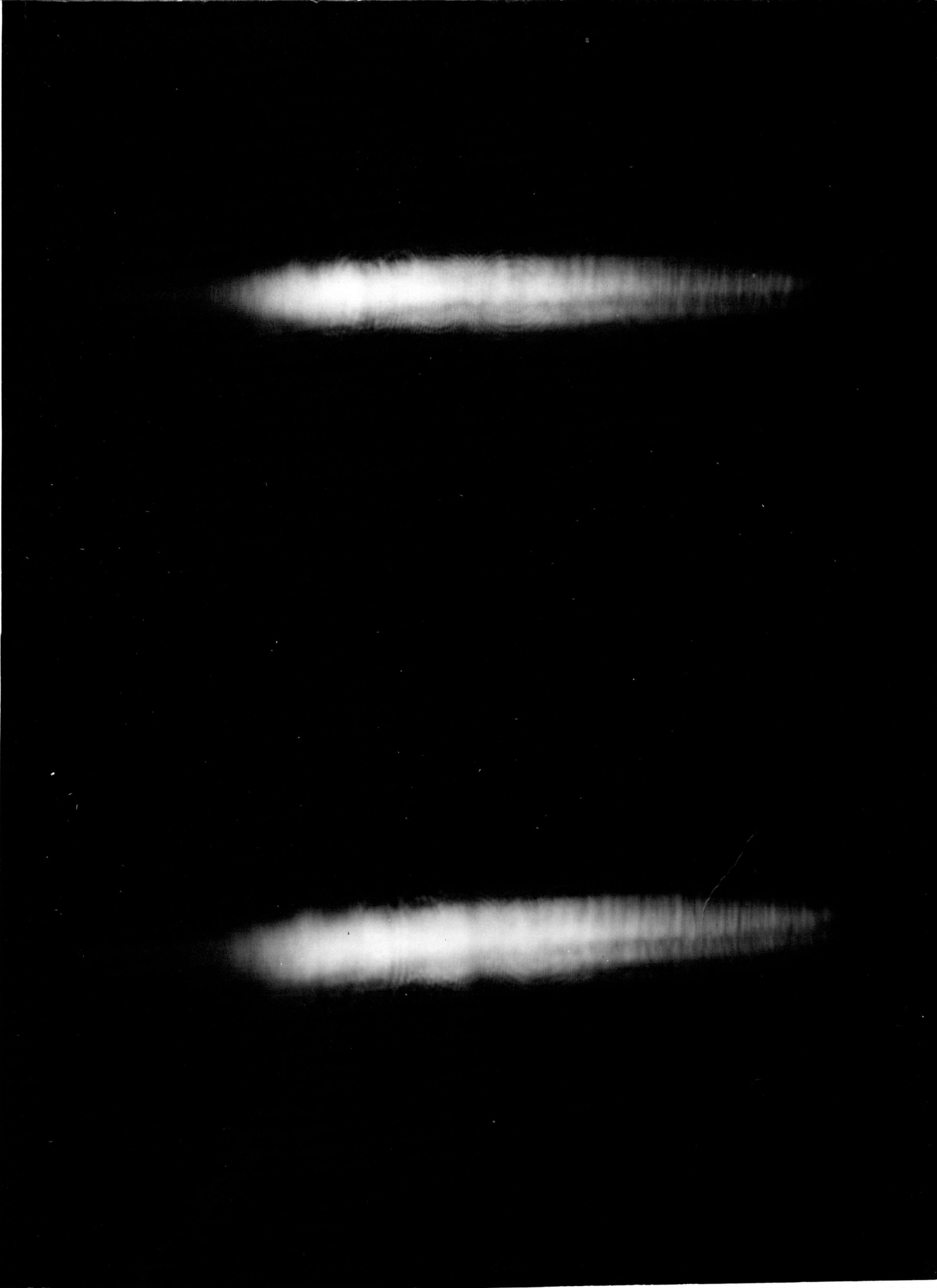
The output pulses of the laser are emitted from both ends of the column of excited nitrogen gas A plane mirror placed at one end will more than double the power output. The output of the laser is in the range of ultraviolet light. To detect the output pulses, fluorescent materials are used to convert the radiation into the optical region. In the experiment, Anthracene is used as a fluorescent material. It is coated on the screen to detect the output pulses of the ultraviolet laser. The cross-sectional view of the laser beam is shown in figure 20 a and b. The laser output pulses are emitted at the rate of 120 pulses per minute with the applied voltage of 25 kilovolts.

Table 1 shows series of pressures which laser lasing action occured.

Flowing nitrogen gas pressure (torr)	laser lasing action
30	Undetectable
40	....
50	Detectable
60	
70	....
80	
90	
100	Detectable with the strongest
110	intensity on fluorescent screen
120	....
130	
140	Detectable
150	
160	
170	
180	....
190	Undetectable

Table 1 Series of pressures for laser lasing in nitrogen with applied voltage of 25 kilovolts.

Figure 20a and b show the single shot photographs of the cross-sectional view of the laser beam recorded on the photographic film Ilford HP4. Scale 1:4



3.1.1 Wavelength measurement

The laser lasing in nitrogen gas results in highly monochromatic light. The output is in the range of ultraviolet light. The wavelength is determined via diffraction grating method, see figure 21

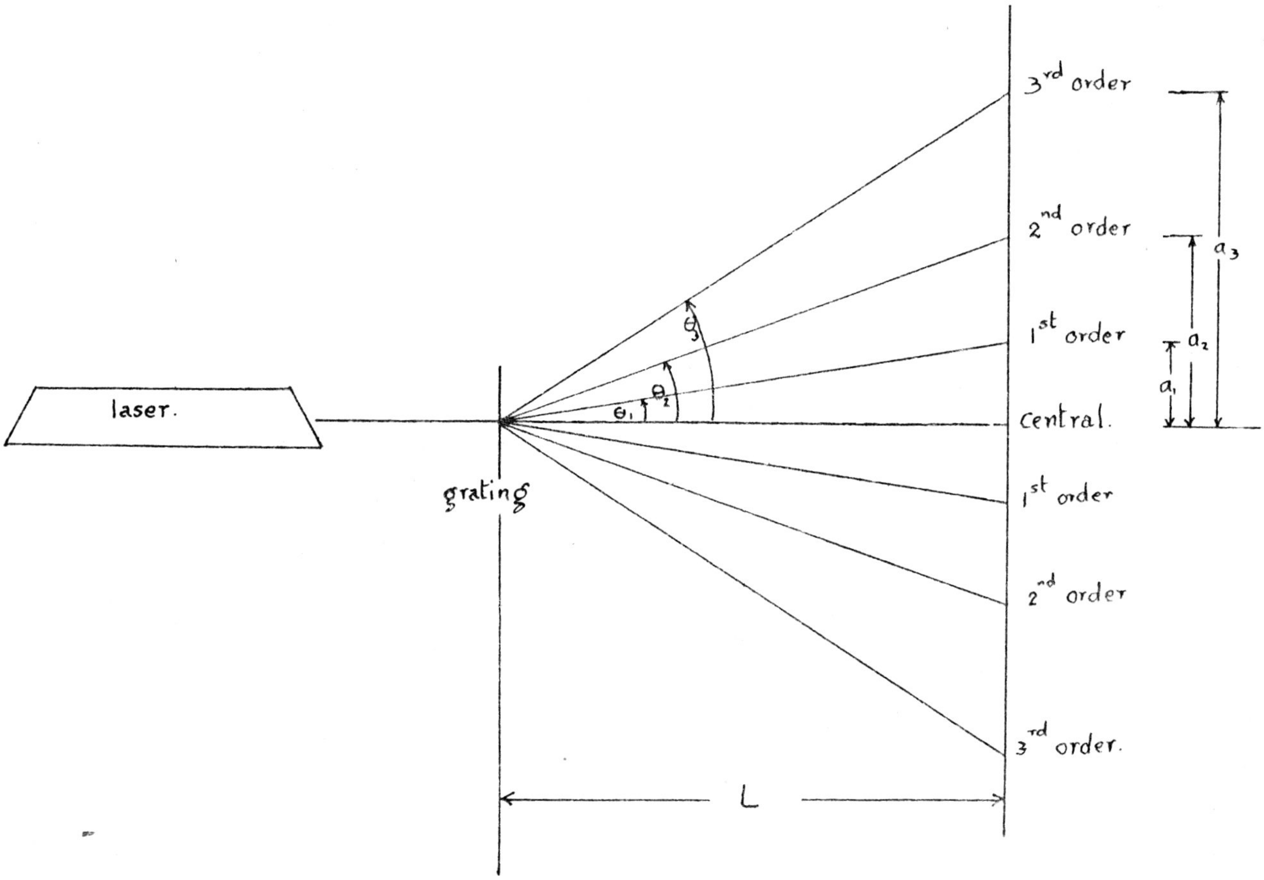
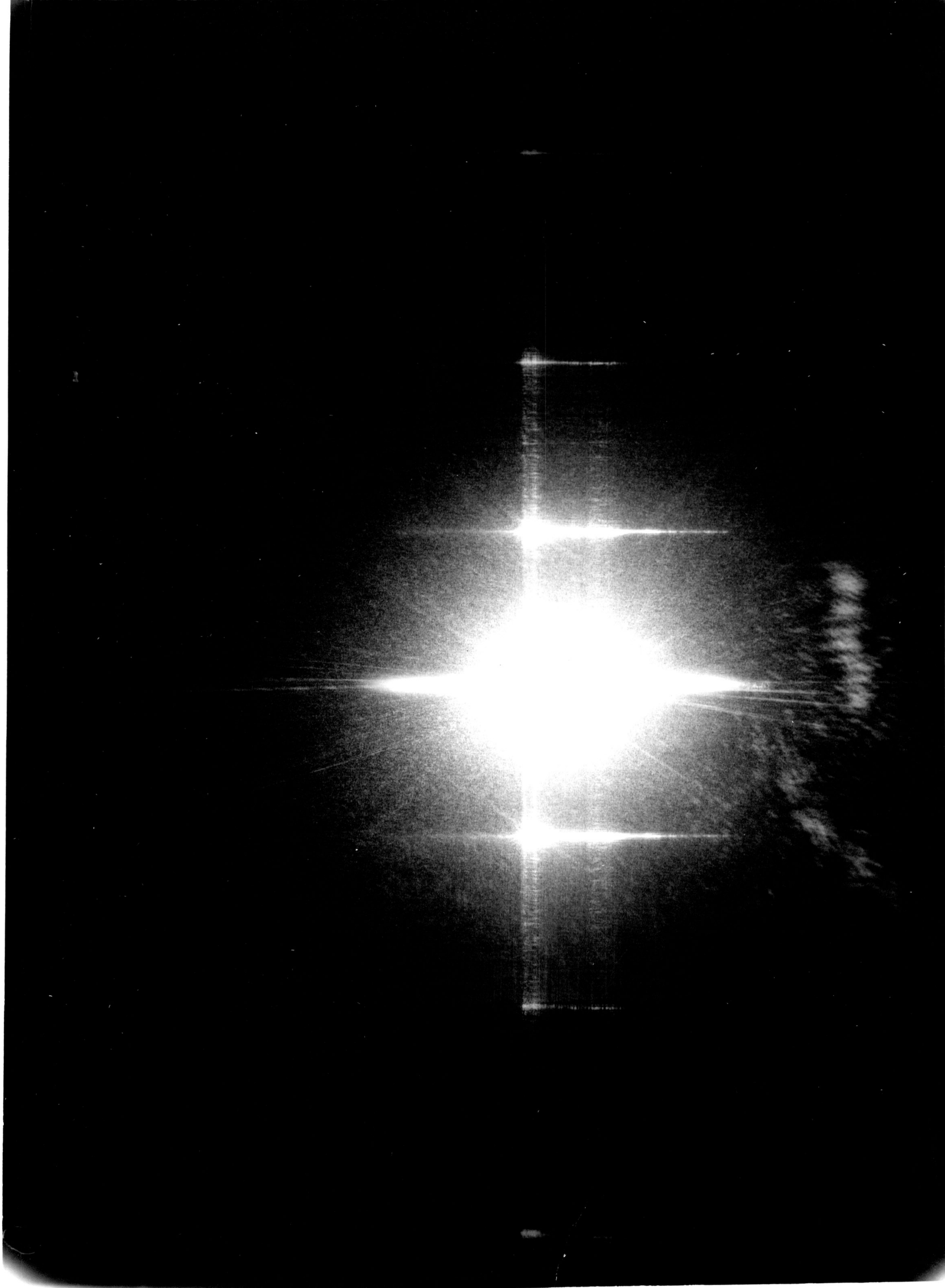


Figure 21 Wavelength measurement by grating method

In this experiment, the grating is 13,400 lines per inch. The interference patterns of the laser beam through the 13,400 lines per inch grating are shown in figure 22

Figure 22 shows the photograph of the interference patterns of the laser beam through the 13,400 lines per inch grating. The patterns are recorded on the photographic film Ilford HP4; scale ~1: 1.8



The output wavelength is determined by calculation via the formula:

$$n\lambda = d\sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (25)$$

where n is the order of fringe

λ is the laser output wavelength.

d is the grating ruling seperation

$\sin\theta$ is the ratio of a/D in figure 21

Table 2 shows different order of interference patterns data.

Order of fringe	Distance from central fringe, a (cm)	screen and grating seperation, L (cm)	$\sin\theta$	λ (Å)
1st order	1.8	10	.1772	3358
2nd order	3.8	10	.3552	3367
3rd order	6.4	10	.5391	3406

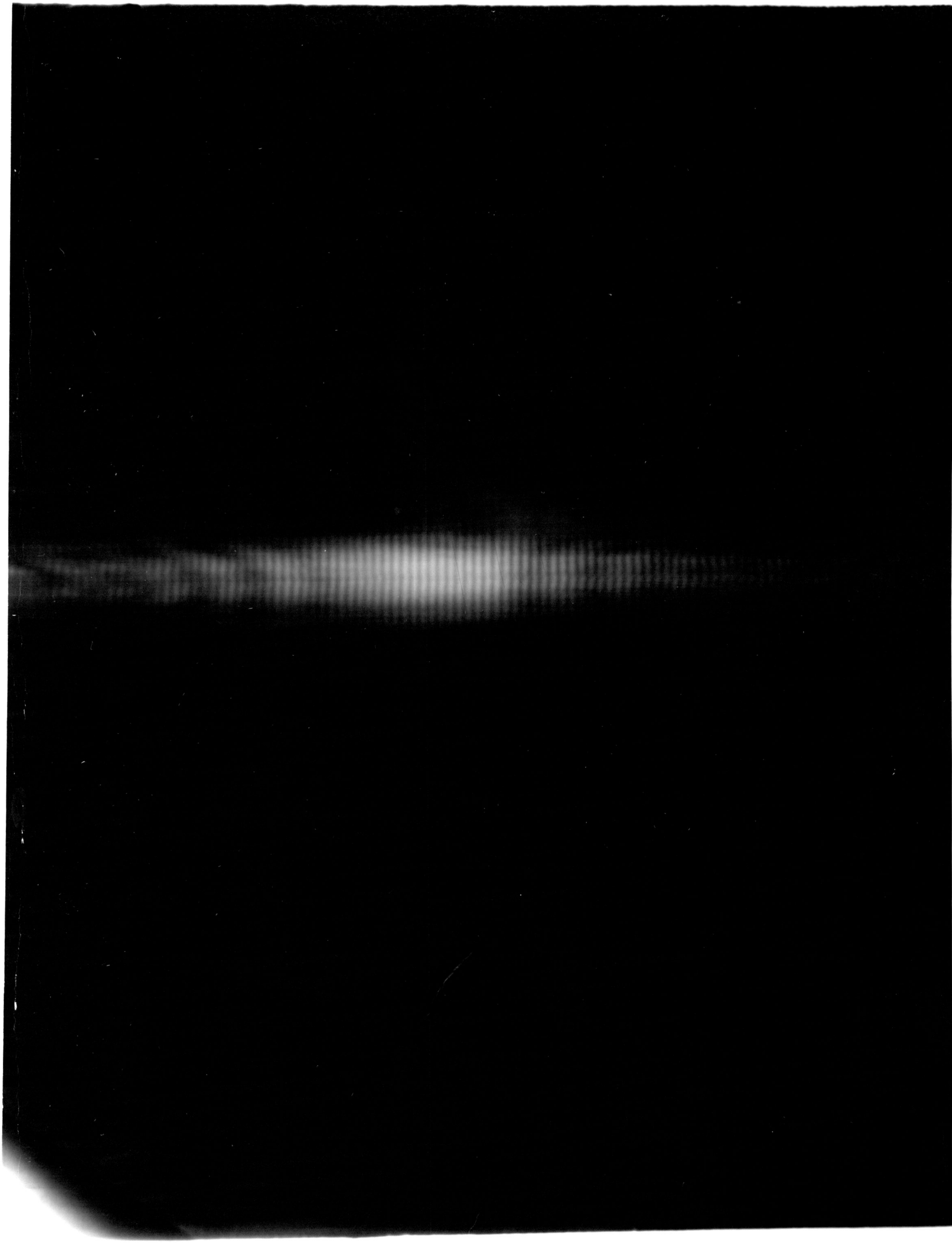
$\lambda_{average}$ = 3377 Å ; $\lambda_{cal.}$ = 3371 Å error = 0.18%.

3.1.2 Test for coherence

As has been discussed in chapter II, of all the properties of the laser, spatial coherence is the most outstanding one. And this can be tested by repeating Young's experiment on double slit diffraction.

In this experiment, the interference patterns of the nitrogen gas laser are obtained and recorded on the photographic film Ilford HP4. The double slit used in this experiment is the slit width of 0.013 cm and separation 0.062 cm. The slit is placed directly against the laser window, see figure 23

Figure 23 shows the double slit interference pattern with the slit being placed directly against the laser chamber window.



3.1.3 Estimation of the laser power.

In the experiment, the capacitance of the capacitor in the Blumlein switching circuit equals to 1200 pF., and the charging voltage is 25 kilovolts. As has been discussed in section 1.5, the energy stored in the capacitor is

$$U = \tfrac{1}{2}\,(1200 \times 10^{-12})\,(25 \times 10^{3})^{2}$$

$$= 3.75 \times 10^{-3} \text{ Joules}$$

In gas lasers, the conversion factor or the efficiency, is 0.01% - 1%, and the typical value is 0.1%.[30] The energy per pulse of the laser will be

$$U_r = (0.1 \times 10^{-2})\,(3.75 \times 10^{-3})$$

$$= 3.75 \times 10^{-6} \text{ joules}$$

Assume the pulse width of the laser, Δt, is 10 nanoseconds. The power of the output pulse can be estimated to be

$$P = \frac{3.75 \times 10^{-6}}{10 \times 10^{-9}}$$

$$= 37.5 \times 10^{3} \text{ watts}$$

$$= 37.5 \text{ kilowatts.}$$

3.2 Discussions

The nitrogen gas laser has been constructed. The laser output is in pulsed form with 120 pulses per minute. The radiation is in ultraviolet region with the wavelength of 337.1 nm. The output is highly monochromatic light source.

With the applied voltage of 25 kilovolts, laser lasing occured with the pressure of the flowing nitrogen gas ranging from 40 to 180 torr. The estimation of the output is 37.5 kilowatts which is not quite high. This is due to the low capacitance, 1200 pF, in the Blumlein switching circuit. The appropriate value of the capacitance should be 3500 pF.[31] If the power of the output pulse is high enough, the nitrogen gas laser is an ideal pump for organic dye laser.[32] In the experiment, a cylindrical lens is used to focus the output beam on the surface of the organic dye, rhodamine 6 G, but the power of the output pulse is not high enough to produce a secondary laser lasing on the dye surface. The actual power of the laser in the experiment is not measured since the oscilloscope with fast writing time (Tektronix 7904) is not available, resulting that the pulse width, Δt, of the laser pulse cannot be actually measured.

The nitrogen gas laser is also ideal for demonstrating many of the basic properties of lasers ; by blocking the reflecting mirror with a piece of black paper and then uncovering the mirror provides a dramatic laser output power more than doubles, and the divergence of the output decreases significantly. The results of the experiment agree with the experiment performed by James G. Small[33,34]