the zeroth order diffracted beam. Take this point as the origin for measuring distances along the screen. Then the intersection of the direct beam is at $-y_0$, of the zeroth-, first-, second-, $\cdots$-order diffracted beams are at $y_0, y_1, y_2 \cdots$. For any of these, $\tan\beta = y/x_0$; but β is small, so that $\tan\beta \approx \sin\beta$,

$$\cos\beta = [1-\sin^2\beta]^{\frac{1}{2}} \approx [1-(y/x_0)^2]^{\frac{1}{2}}$$
$$= 1 - \tfrac{1}{2}(y^2/x_0^2),$$
$$\cos\alpha = \cos\beta_0 = 1 - \tfrac{1}{2}(y_0^2/x_0^2),$$
$$\cos\beta_n = 1 - \tfrac{1}{2}(y_n^2/x_0^2),$$
$$n\lambda = d(\cos\alpha - \cos\beta_n)$$
$$= d\left(1 - \frac{1}{2}\frac{y_0^2}{x_0^2} - 1 + \frac{1}{2}\frac{y_n^2}{x_0^2}\right) = \tfrac{1}{2}d\left(\frac{y_n^2 - y_0^2}{x_0^2}\right).$$

Thus, $(y_n^2 - y_0^2)$ is linearly proportional to n.

Since the spot spacings increase as d decreases, a widely spaced pattern is obtained by diffraction from a fine scale, such as $\frac{1}{64}''$ or even $\frac{1}{100}''$. It is worth demonstrating that coarser scales give finer patterns. One good way to show this is to slide the ruler a short distance sideways. Then part of the beam is diffracted from the coarser markings used to set-off every second, fourth, or fifth division of the fine scale. Extra spots appear between those seen originally; they are higher orders from the widely spaced long marks on the scale.

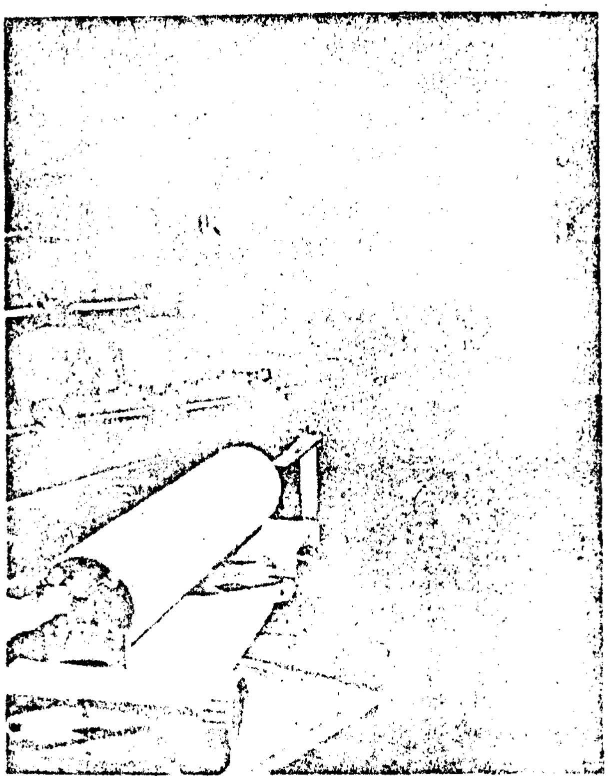

Fig. 1. Arrangement of the apparatus. The laser in the foreground shines on the rulings of a ruler, producing the diffraction pattern on the far wall.

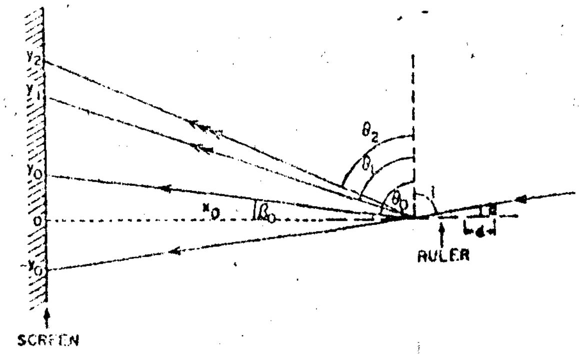

Fig. 2. Angles and distances for calculating wavelength from the diffraction pattern.

It is also possible to demonstrate that the pattern is not clearly developed if the screen is too near the ruler, thus showing that the phenomenon is a case of Fraunhofer diffraction.

In a lecture-demonstration experiment, the distances x_0 and y_n were measured very hastily. Nevertheless, the differences of $y_{n+1}^2 - y_n^2$ all were constant to within two percent of their average value. With a little care, the wavelength of light could be measured to an accuracy about one percent, in a lecture experiment taking only a few minutes, and with all measurements clearly visible to the students. If desired, the theory and calculations can be given as an exercise.

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