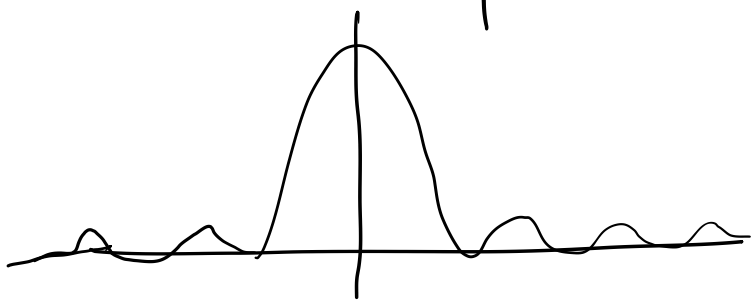
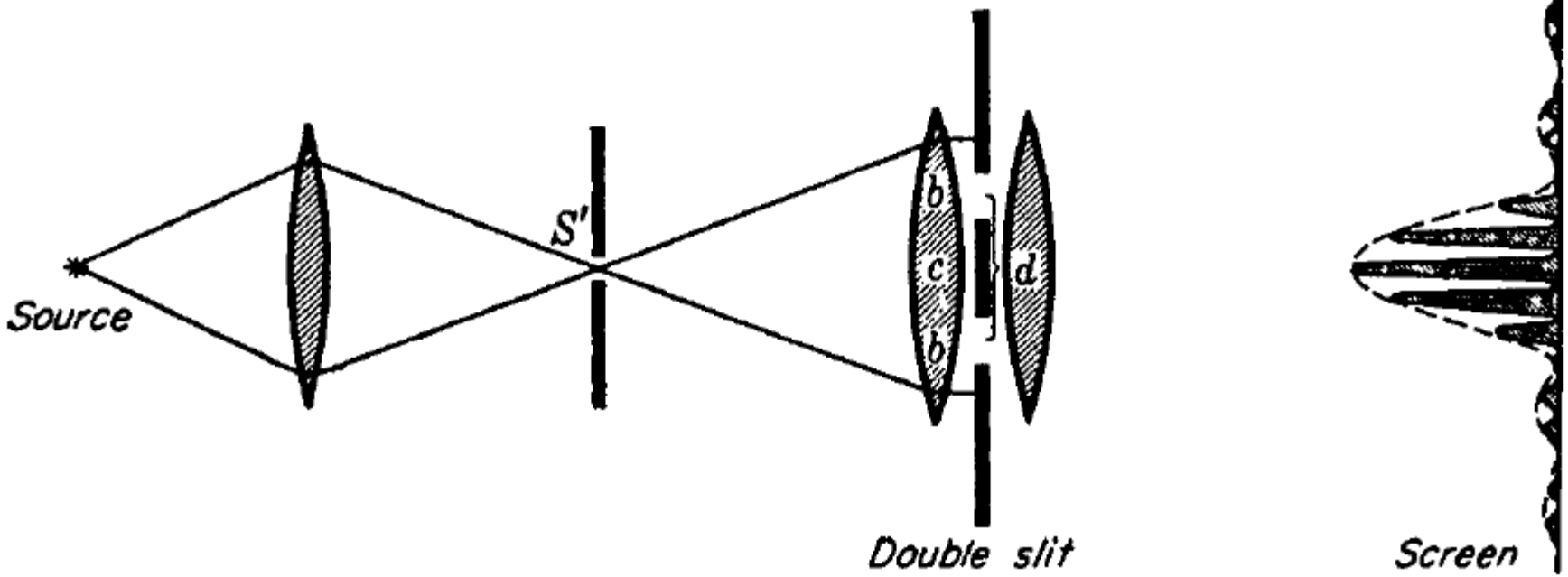
Single slit diffraction

$$I = I_0 \frac{\sin^2 \beta}{\beta^2}$$

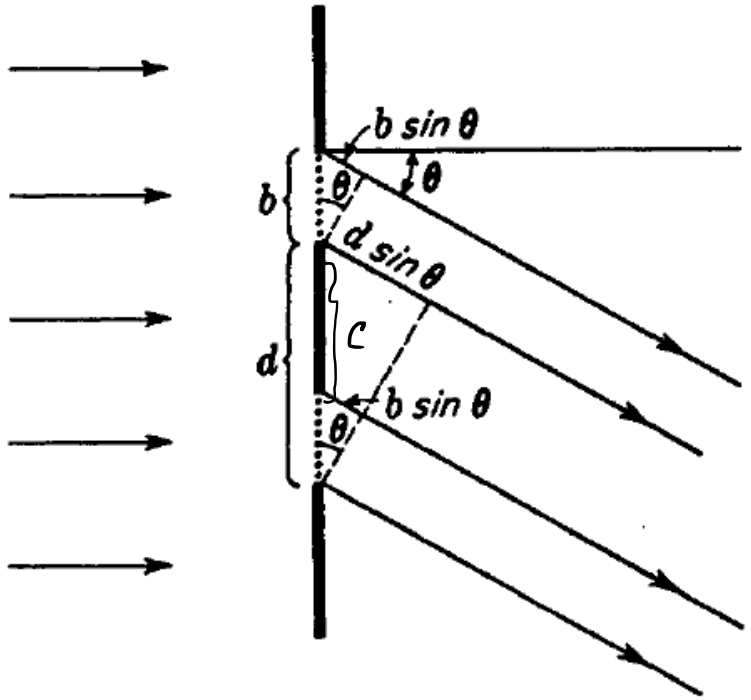



Source
S'
b
c
b
d
Double slit
Screen

slit width = b

separation = d

same calculation as in single slit with changed integration limits



for single slit amplitude of each element of wavefront ads

origin at centre of c

integration from $s = \frac{d}{2} - \frac{b}{2}$ to $s = \frac{d}{2} + \frac{b}{2}$

$$y = \frac{2a}{k\sin\theta}\left[\sin\left[\tfrac{1}{2}k(b+d)\sin\theta\right] - \sin\left[\tfrac{1}{2}k(d-b)\sin\theta\right]\right]\sin(\omega t - kx)$$

$$\boxed{y = 2ab\,\frac{\sin\beta}{\beta}\cos\gamma\,\sin(\omega t - kx)}$$

$$\gamma = \tfrac{1}{2}kd\sin\theta$$

$$\beta = \tfrac{1}{2}kb\sin\theta$$

$$I = \underbrace{4A_0^2}_{I_0} \underbrace{\frac{\sin^2\beta}{\beta^2}} \cos^2\gamma \qquad \gamma = \delta/2$$

single slit diff.

double slit interference

- minima

$$\beta = m\pi \longrightarrow \text{from diffraction}$$

$$\gamma = \left(n + \frac{1}{2}\right)\pi \longrightarrow \text{from interference.}$$

β, γ are not completely independent

$$\frac{\gamma}{\beta} = d/b.$$

Exact positions of maxima are complex.

Approx. positions by neglecting diffraction factor $\frac{\sin^2\beta^2}{\beta^2}$

$\Rightarrow$ Maxima $\boxed{d\sin\theta = m\lambda}$

Missing orders

could happen: diffraction minimum falls exactly on an interference maximum

$\Rightarrow$ that order will be missing.

$d\sin\theta = m\lambda$ $\longrightarrow$ int max.

$b\sin\theta = p\lambda$ $\longrightarrow$ diffraction min.

$\longrightarrow$ $\boxed{d/b = m/p}$ e.g $\frac{d}{b} = 2$, orders 2,4,6 will be missing.

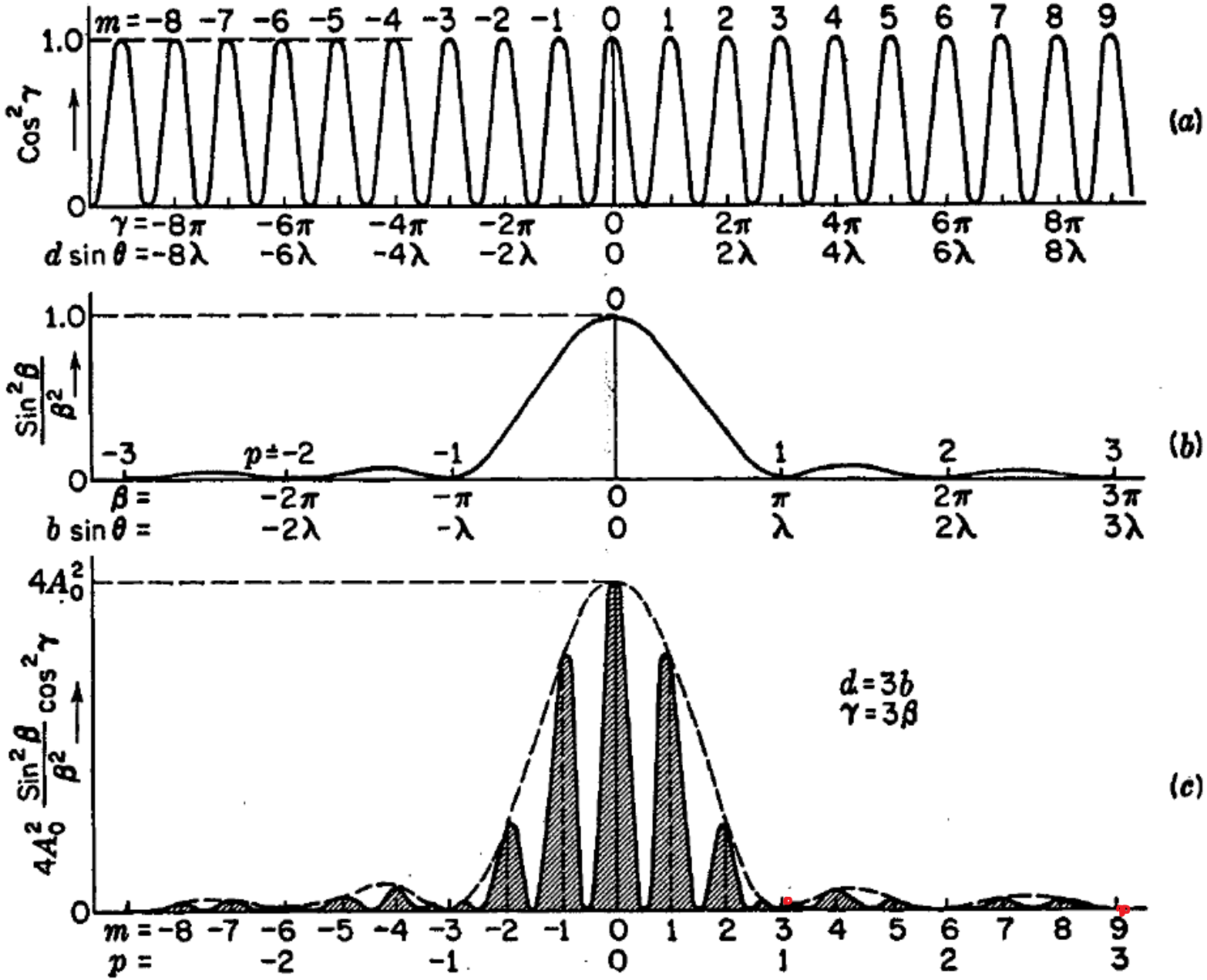


FIGURE 16D
Intensity curves for a double slit where $d = 3b$.

d = fixed

b varying

$I \propto \frac{\sin^2\beta}{\beta^2} \cos^2\gamma$

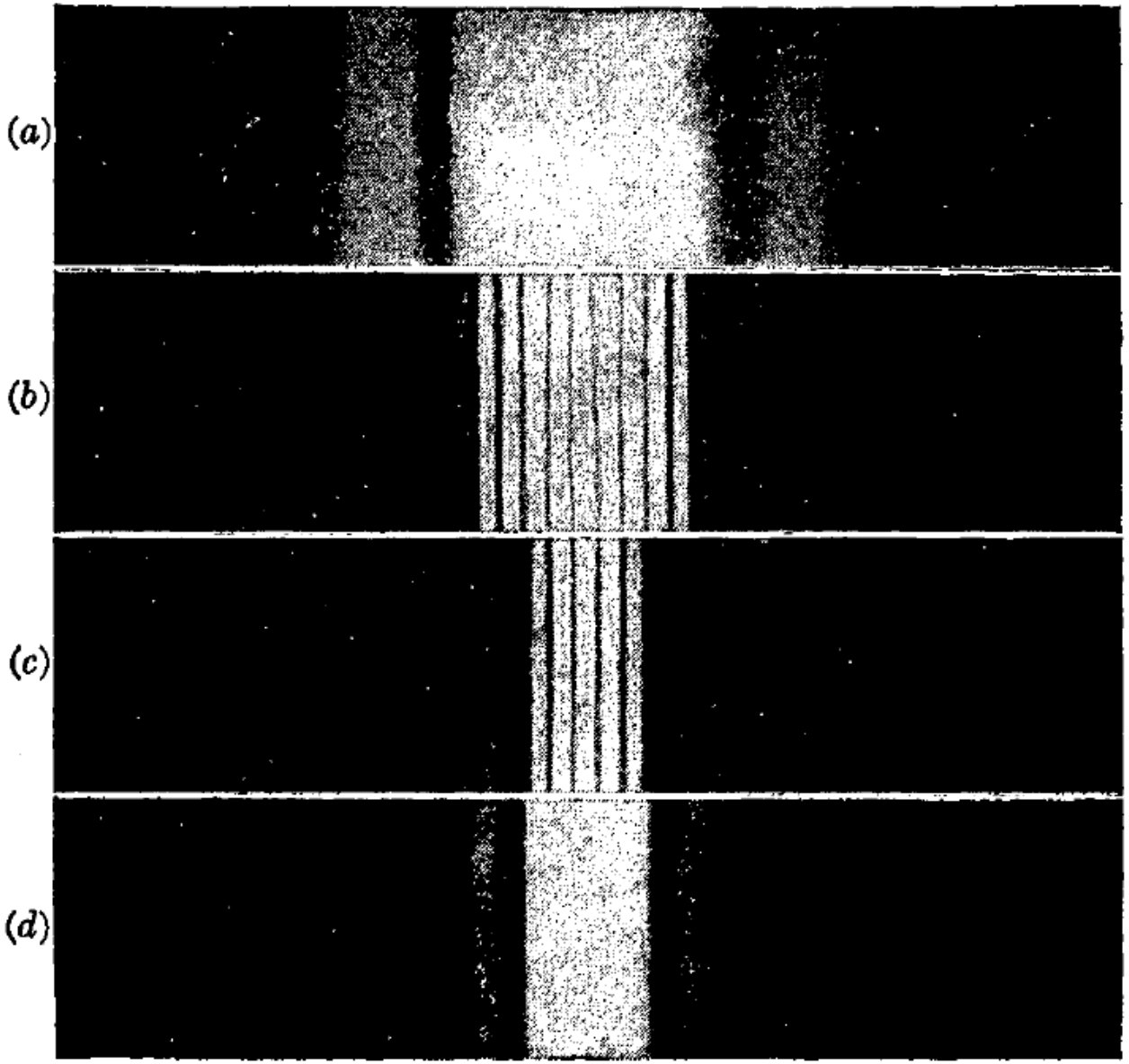


FIGURE 16A
Diffraction patterns from (*a*) a single narrow slit, (*b*) two narrow slits, (*c*) two wider slits, (*d*) one wider slit.

b fixed
changing d.

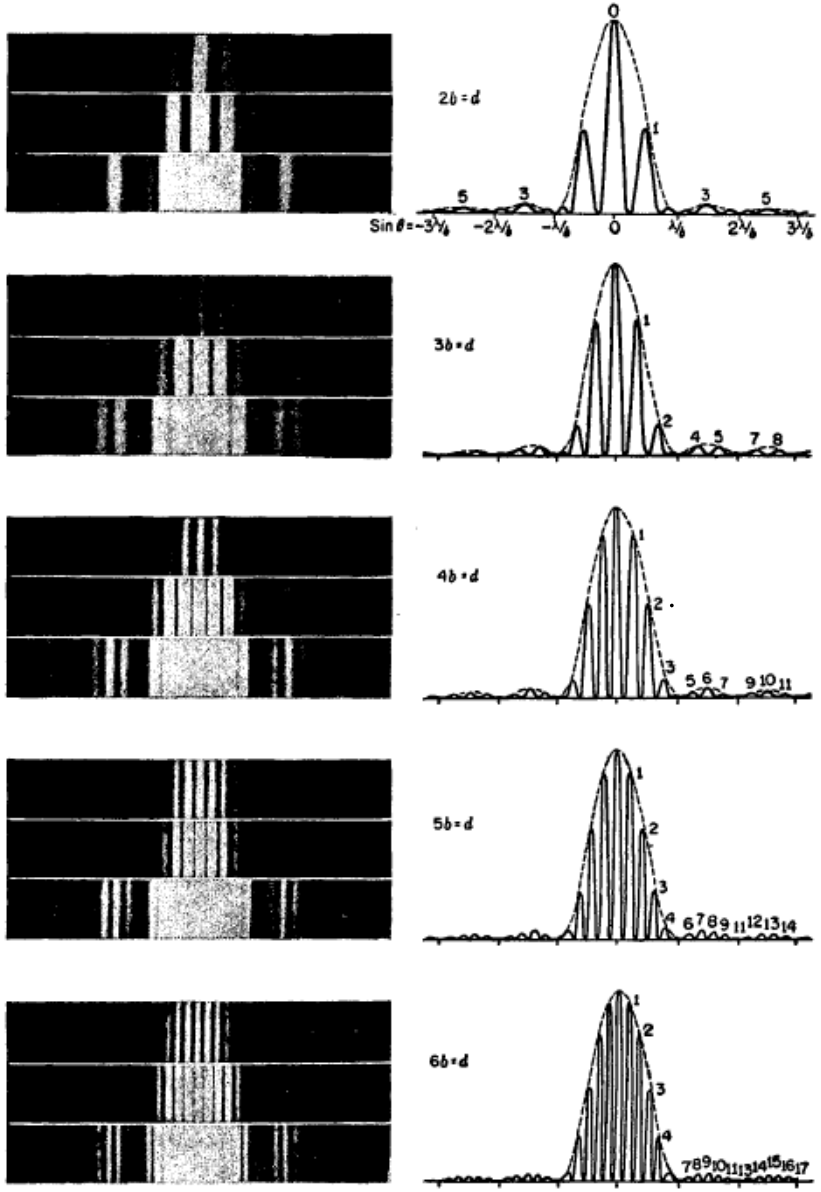


FIGURE 16E
Photographs and intensity curves for double-slit diffraction patterns.

$d = 2b$

$d = 3b$

$d = 4b$

$d = 5b$

$d = 6b$

Diffraction grating

Effect of increasing the # of slits.

→ large no. of parallel equidistant slit.

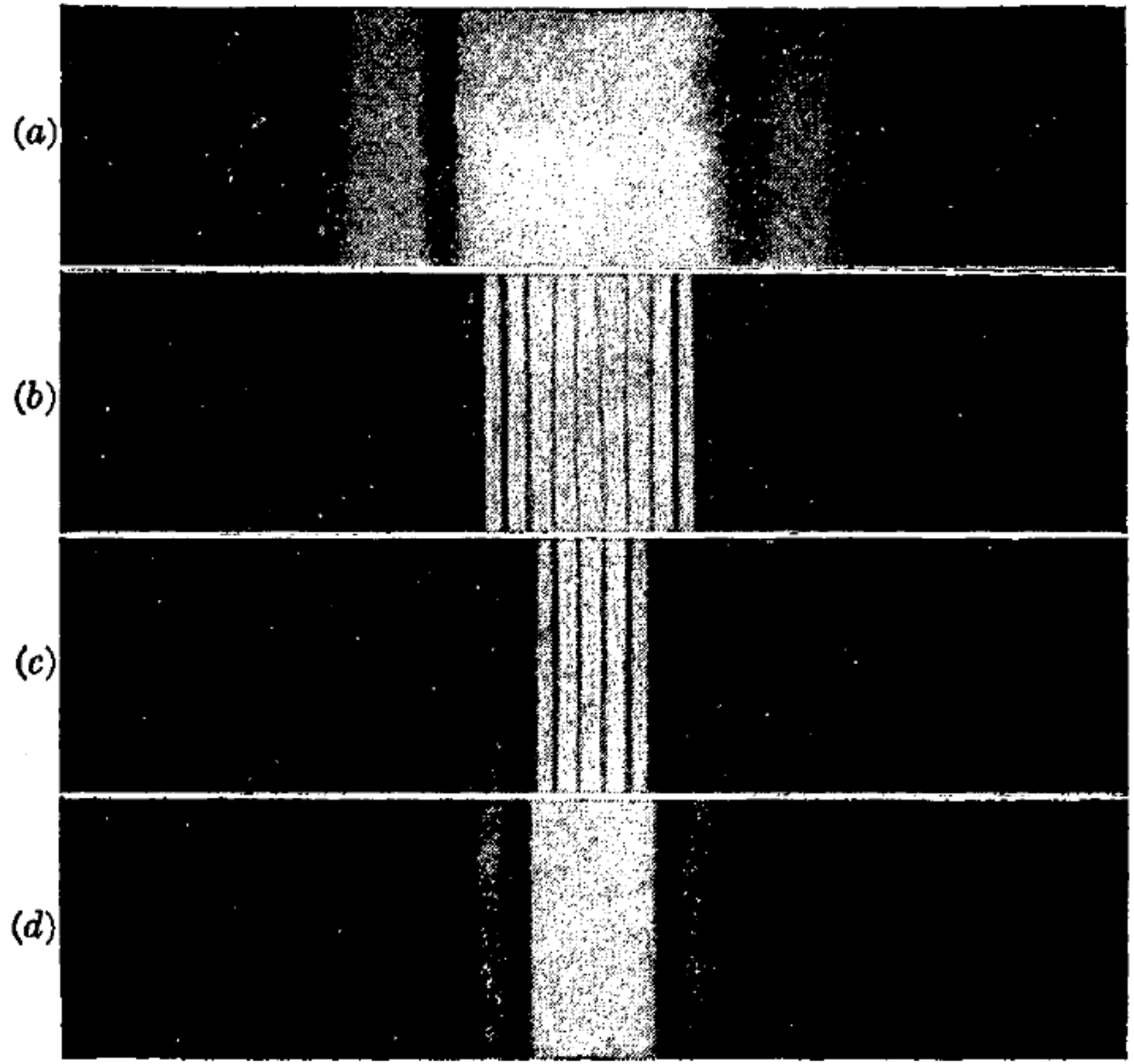
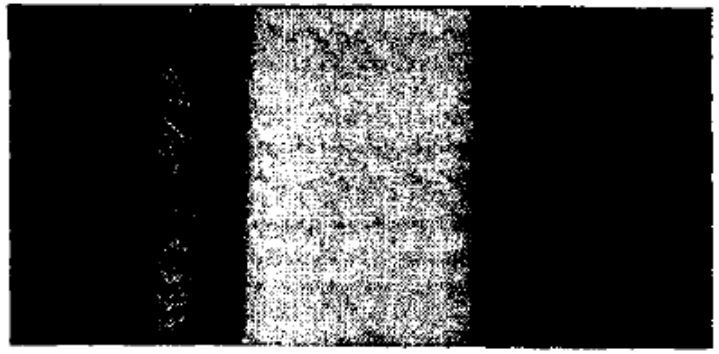
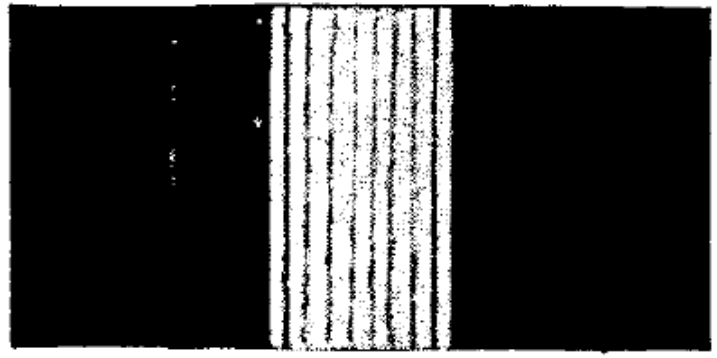


FIGURE 16A
Diffraction patterns from (*a*) a single narrow slit, (*b*) two narrow slits, (*c*) two wider slits, (*d*) one wider slit.

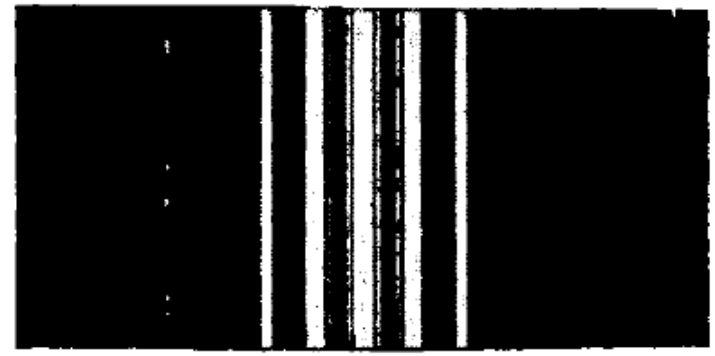


(*a*) *1 slit*



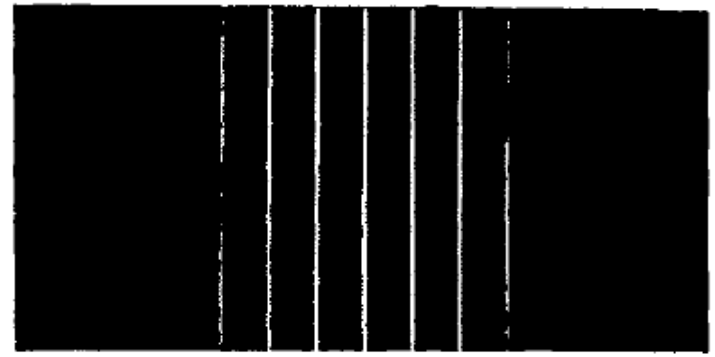
(*b*) *2 slits*

(*c*) *3 slits*

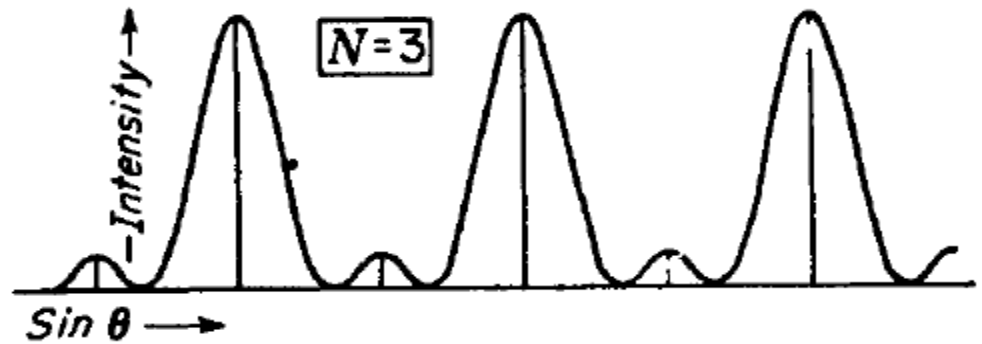


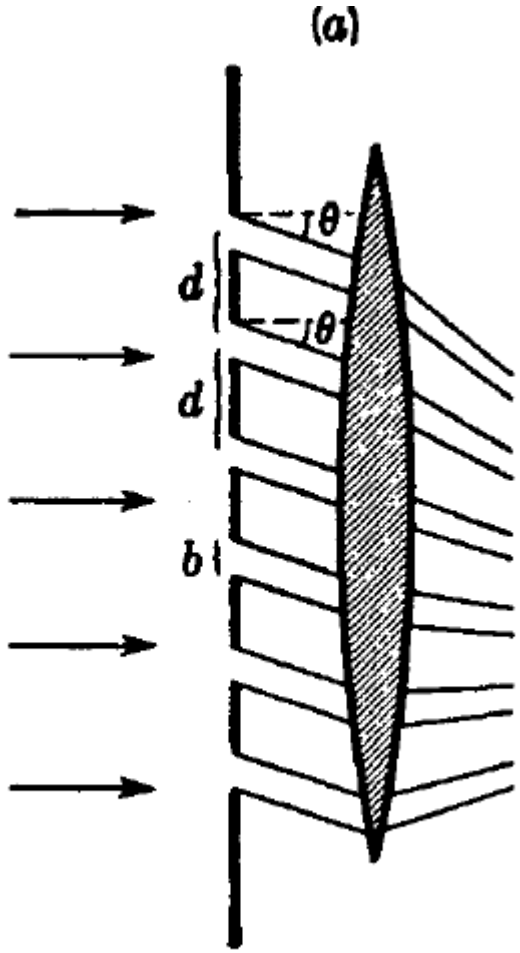
(*d*) *5 slits*

(*e*) *6 slits*



(*f*) *20 slits*


N=3
Intensity
Sin θ


(a)
θ
d
θ
d
b