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THE CONSERVATION OF ENERGY AND MOMENTUM IN NUCLEAR REACTIONS

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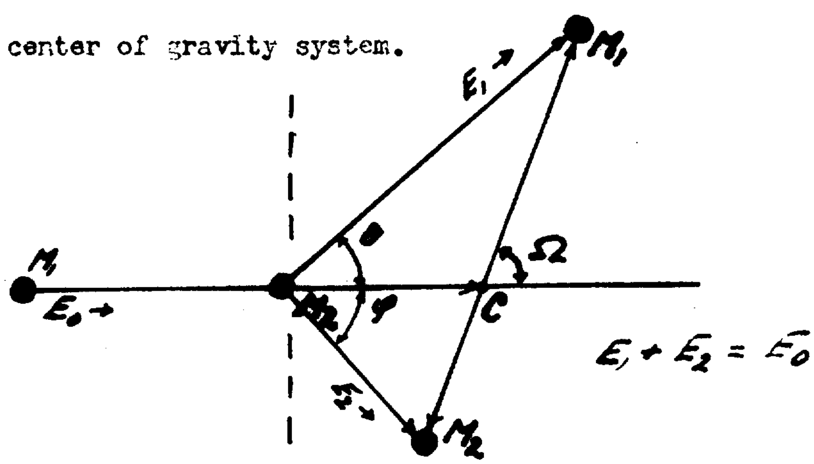
Formulae for the Conservation of Energy and Momentum in Nuclear Reactions.

1. Scattering.

An incident nucleus of mass M_1 and energy E_0 is scattered by a target nucleus of mass M_2 initially at rest. Figure I illustrates a scattering of this kind, the left hand side representing the situation shortly before, the right hand side the situation a short time after the collision. For the discussion of the system after the collision we need some additional notation. We therefore let E_1 and θ denote the energy and scattering angle of the incident nucleus, E_2 and φ the corresponding data for the target nucleus, and Ω and $180-\Omega$ the respective scattering angles in the center of gravity system.

Figure I



Since the right hand side of Figure I represents the situation a given time after the collision, the sides of the two triangles are clearly proportional to velocities. Specifically we have:

The side (M_2M_1) ~ to the velocity of the incident nucleus,

the side (M_2M_2) ~ to the velocity of the target nucleus,

the side (M_2C) ~ to the velocity of the center of gravity of the system,

the side (CM_1) ~ to the velocity (in the center of gravity system) of the incident nucleus, and

the side (CM_2) ~ to the velocity (in the center of gravity system) of the target nucleus.

Once the above-mentioned velocities have been found the problem is essentially solved, for it has then been reduced to the application of trigonometric formulae to the two triangles in Figure I.

In the derivations which follow we shall use the following basic formulae frequently:

(A) Momentum = $\sqrt{2 \times \text{Mass} \times \text{Energy}}$, Energy = $(\text{Momentum})^2/2 \times \text{Mass}$,

(B) Velocity = Momentum/Mass, Momentum = Mass × Velocity.

Using the formulae given above we can readily construct the following two tables. In these we understand by the <u>center of gravity</u> the whole two-particle system regarded as one with its mass concentrated at the center of gravity.

Table I. Before the collision (laboratory system).

Particle	Mass	Energy	Momentum	Velocity
Incident nucleus	M_1	E_0	$\sqrt{2M_1E_0}$	$\sqrt{\frac{2}{M_1}}\sqrt{E_0} = v_1$
Target nucleus	M_2	0	0	0
Center of gravity	M_1+M_2	$\frac{M_1}{M_1+M_2}E_0$	$\sqrt{2M_1E_0}$	$\frac{1}{M_1+M_2}\sqrt{2M_1E_0} = \frac{M_1v_1}{m_1+m_2}$

Table II. After the collision (laboratory system).

Particle	Mass	Energy	Momentum	Velocity
Incident nucleus	M_1	E_1	$\sqrt{2M_1E_1}$	$\sqrt{\frac{2}{M_1}}\sqrt{E_1}$
Target nucleus	M_2	E_2	$\sqrt{2M_2E_2}$	$\sqrt{\frac{2}{M_2}}\sqrt{E_2}$
Center of gravity	M_1+M_2	$\frac{M_1}{M_1+M_2}E_0$	$\sqrt{2M_1E_0}$	$\frac{M_1}{M_1+M_2}\sqrt{\frac{2}{M_1}}\sqrt{E_0} = \frac{m_1v_1}{m_1+m_2}$

The entries for the <u>center of gravity</u> in Table I are derived from its known mass M_1+M_2 and from the fact that its momentum in this case is simply the sum of the individual momenta. Since the momentum of the system is conserved the collision does not affect the center of gravity. The entries for the center of gravity in Table II are therefore identical to those in Table I. Furthermore, the conservation of energy requires that $E_1 + E_2 = E_0$.

Two of the required velocities have to be expressed in a different coordinate system, viz. the center of gravity system. In this system the momenta of the two particles have the same magnitude. We denote this by m. In addition, the total energy available in this coordinate system equals the total energy of the two particles less the energy associated with the center of gravity. With this in mind we can write down the following equation, the solution of which will enable us to construct Table III:

(C) $$\frac{m^2}{2M_1} + \frac{m^2}{2M_2} = E_0 - \frac{M_1}{M_1+M_2} E_0 ,$$

or

(D) $$m = \frac{M_2}{M_1+M_2}\sqrt{2M_1E_0} .$$

Since momentum and energy is conserved Table III applies after as well as before the collision.

$v_1' = \frac{m_2}{m_1+m_2} v_1$

Table III. Before and after the collision (center of gravity system).

Particle	Mass	Energy	Momentum	Velocity
Incident nucleus	M_1	$\left(\frac{M_2}{M_1+M_2}\right)^2 \times E_0$	$\frac{M_2}{M_1+M_2}\sqrt{2M_1E_0}$	$\frac{M_2}{M_1+M_2}\sqrt{\frac{2}{M_1}}\sqrt{E_0}$
Target nucleus	M_2	$\frac{M_1M_2}{(M_1+M_2)^2} \times E_0$	$\frac{M_2}{M_1+M_2}\sqrt{2M_1E_0}$	$\frac{[illegible]}{M_1+M_2}\sqrt{\frac{2}{M_2}}\sqrt{E_0}$
Center of gravity	M_1+M_2	0	0	0

$v_2' = \frac{m_1}{m_1+m_2} v_1$

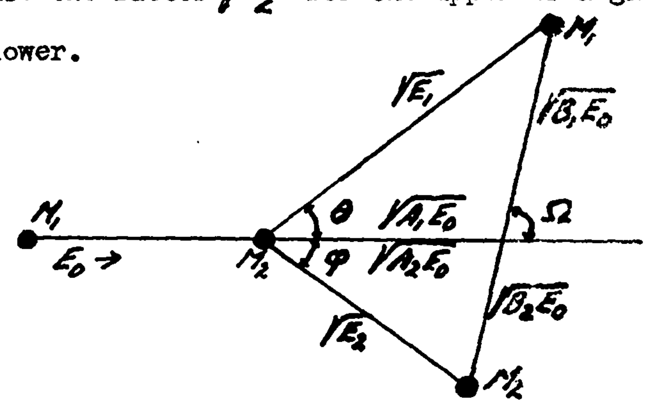
To simplify the trigonometric calculations which follow we introduce the following notation:

$$A_1 = \frac{M_1^2}{(M_1+M_2)^2}, \qquad B_1 = \frac{M_2^2}{(M_1+M_2)^2}, \qquad (1.1)$$

$$A_2 = \frac{M_1 M_2}{(M_1+M_2)^2}, \qquad B_2 = \frac{M_1 M_2}{(M_1+M_2)^2}.$$

We also redraw Figure I (see Figure II below) and assign lengths to the sides of the two triangles, proportional to the appropriate velocities, which are now available in Tables I, II, and III. Since we are going to discuss the upper and lower triangles in Figure II separately we need not use the same factor of proportionality. It turns out to be convenient to use the factor $\sqrt{\frac{M_1}{2}}$ for the upper triangle and the factor $\sqrt{\frac{M_2}{2}}$ for the lower.

Figure II



Using Figure II and the law of cosines we obtain:

$$E_1/E_0 = 1 - 2B_2(1-\cos\Omega), \qquad (1.2)$$

$$E_2/E_0 = 2B_2(1-\cos\Omega), \qquad (1.3)$$

and using the law of sines and the relationship, a = b cos C + c cos B, :

$$\sin\theta = \sqrt{\frac{B_1}{E_1/E_0}}\,\sin\Omega, \qquad (1.4)$$

$$\sin\varphi = \sqrt{\frac{B_2}{E_2/E_0}}\,\sin\Omega. \qquad (1.5)$$

$$\cos\Omega = \sqrt{\frac{E_1/E_0}{B_1}}\cos\theta - \frac{M_1}{M_2} \qquad (1.6)$$

$$\cos\Omega = -\sqrt{\frac{E_2/E_0}{B_2}}\cos\varphi + 1 \qquad (1.7)$$

We can now eliminate Ω between (1.2)and (1.6), between (1.3) and (1.7), and between (1.4) and (1.5), and combine (1.2) with (1.4) and (1.3) with (1.5), obtaining:

(1.8) $$E_1/E_0 = \frac{M_1^2}{(M_1+M_2)^2}\left(\cos\theta \pm \sqrt{\frac{M_2^2}{M_1^2} - \sin^2\theta}\right)^2, \ *)$$

(1.9) $$E_2/E_0 = \frac{4M_1M_2}{(M_1+M_2)^2}\cos^2\varphi,$$

(1.10) $$\tan\theta = \frac{\sin 2\varphi}{\frac{M_1}{M_2} - \cos 2\varphi}$$

(1.11) $$\Omega = \pi - 2\varphi = \theta + \arcsin\left(\frac{M_1}{M_2}\sin\theta\right)$$

The relative intensities $I(\Omega)/I(\theta)$ and $I(\Omega)/I(\varphi)$ are defined below and are obtained by differentiating (1.4) and (1.5) regarding E_1/E_0 and E_2/E_0 as functions of Ω.

(1.12) $$I(\Omega)/I(\theta) = \frac{\sin\theta\, d\theta}{\sin\Omega\, d\Omega} = \frac{\frac{M_1M_2}{(M_1+M_2)^2}\sqrt{\frac{M_2^2}{M_1^2} - \sin^2\theta}}{E_1/E_0}$$

(1.13) $$I(\Omega)/I(\varphi) = \frac{\sin\varphi\, d\varphi}{\sin\Omega\, d\Omega} = \frac{1}{4\cos\varphi}$$

Formulae (1.8), (1.9), and (1.10) can also be obtained from the set of equations given below, which is a straightforward statement of the laws of conservation of energy and momentum. But to proceed from this set would be much more difficult.

(1.14) $$\begin{cases} E_0 = E_1 + E_2 \\ \sqrt{2M_1E_0} = \sqrt{2M_1E_1}\cos\theta + \sqrt{2M_2E_2}\cos\varphi \\ 0 = \sqrt{2M_1E_1}\sin\theta + \sqrt{2M_2E_2}\sin\varphi \end{cases}$$

Note. If the incident nucleus is heavier than the target nucleus it can scatter with two different energies in a given direction θ, depending on how it was scattered in the center of gravity system. The two energies are referred to as the slow and the fast component of the scattering.

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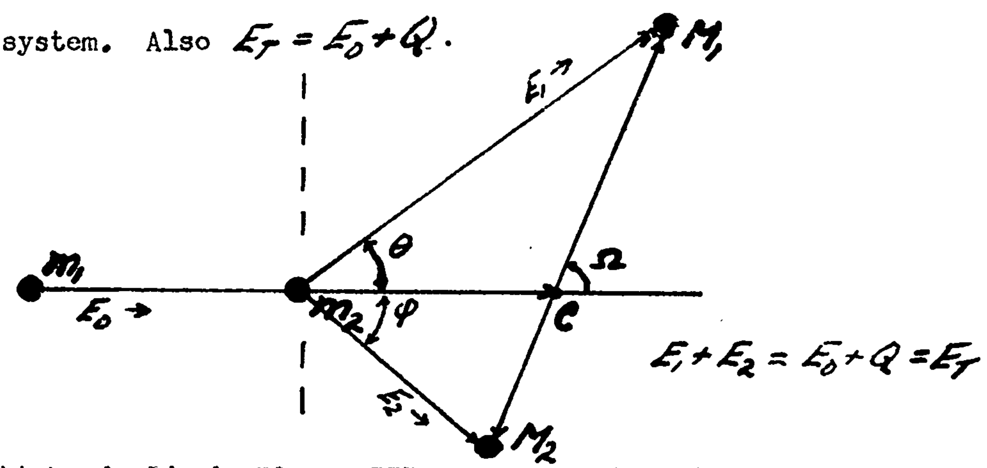
*) Use both signs if $M_1 > M_2$, in which case $\theta_{max} = \arcsin\frac{M_2}{M_1}$. Use only the plus sign if $M_1 \leq M_2$. See also note above.

2. Reactions.

An incident nucleus of mass m_1 and energy E_0 reacts with a target nucleus of mass m_2 initially at rest, giving rise to two nuclei of masses M_1 and M_2, where M_1 denotes the heavier nucleus. The energy released in the reation is denoted by Q, which in the case Q is negative is interpreted as the energy required for the reaction. It is customary to take $M_1 + M_2 = m_1 + m_2$ even though this is strictly speaking not correct, the mass defect being $Q/931$.

Figure III illustrates a reaction of this kind, the left hand side representing the situation shortly before, the right hand side the situation a short time after the reaction. For the discussion of the system after the nuclear reaction we need some additional notation. We therefore let E_1 and θ denote the energy and scattering angle of the heavier nucleus, E_2 and φ the corresponding data for the lighter nucleus, and Ω and $180-\Omega$ the respective scattering angles in the center of gravity system. Also $E_T = E_0 + Q$.

Figure III



Since the right hand side in Figure III represents the situation a given time after the reaction, the sides of the two triangles are clearly proportional to velocities. Specifically we have:

The side $(m_2 M_1) \sim$ to the velocity of the heavier emerging nucleus,

the side $(m_2 M_2) \sim$ to the velocity of the lighter emerging nucleus,

the side $(m_2 C) \sim$ to the velocity of the center of gravity of the system, the side (CM_1) $\sim$ to the velocity (in the center of gravity system) of the heavier nucleus, and

the side (CM_2) $\sim$ to the velocity (in the center of gravity system) of the lighter nucleus.

Once the above-mentioned velocities have been found the problem is essentially solved, for it has then been reduced to the appplication of trigonometric formulae to the two triangles in Figure III.

We repeat here Formulae (A) and (B) which will be used frequently in what follows.

(A) Momentum = $\sqrt{2 \times \text{Mass} \times \text{Energy}}$, Energy = $(\text{Momentum})^2/2 \times \text{Mass}$,

(B) Velocity = Momentum/Mass, Momentum = Mass $\times$ Velocity.

Using the above formulae we can readily construct the following two tables in which we understand by the <u>center of gravity</u> the whole system regarded as one with its mass concentrated at the center of gravity.

Table IV. Before the reaction (laboratory system).

Particle	Mass	Energy	Momentum	Velocity
Incident nucleus	m_1	E_0	$\sqrt{2m_1E_0}$	$\sqrt{\frac{2}{m_1}}\sqrt{E_0}$
Target nucleus	m_2	0	0	0
Center of gravity	m_1+m_2	$\frac{m_1}{m_1+m_2}E_0$	$\sqrt{2m_1E_0}$	$\frac{1}{m_1+m_2}\sqrt{2m_1E_0}$

Table V. After the reaction (laboratory system).

Particle	Mass	Energy	Momentum	Velocity
Heavier nucleus	M_1	E_1	$\sqrt{2M_1E_1}$	$\sqrt{\frac{2}{M_1}}\sqrt{E_1}$
Lighter nucleus	M_2	E_2	$\sqrt{2M_2E_2}$	$\sqrt{\frac{2}{M_2}}\sqrt{E_2}$
Center of gravity	M_1+M_2	$\frac{m_1}{M_1+M_2}E_0$	$\sqrt{2m_1E_0}$	$\frac{\sqrt{m_1M_1}}{M_1+M_2}\sqrt{\frac{2}{M_1}}\sqrt{E_0}$

The entries for the center of gravity in Table IV are derived from its known mass m_1+m_2 and from the fact that its momentum in this case is simply the sum of the individual momenta. Since the momentum of the system is conserved the collision does not affect the center of gravity. The entries for the center of gravity in Table V are therefore identical to those in Table IV, except that m_1+m_2 has been replaced by M_1+M_2.

Two of the required velocities have to be expressed in a different coordinate system, viz. the center of gravity system. We denote this magnitude by m . In addition, the total energy available in this coordinate system equals the total energy of the two particles less the energy associated with the center of gravity. However, energy is not conserved in the case of reactions, the total energy of the two particles being E_0 before the reaction and $E_0+Q=E_T$ after. We can now write down the equation for m , the common momentum of the two particles emerging after the reaction:

$$\text{(C)} \qquad \frac{m^2}{2M_1}+\frac{m^2}{2M_2}=(E_0+Q)-\frac{m_1}{M_1+M_2}E_0 ,$$

the solution of which is given by

$$\text{(D)} \qquad m=\frac{\sqrt{m_2M_2}}{M_1+M_2}\sqrt{1+\frac{m_1}{m_2}\frac{Q}{E_T}}\sqrt{2M_1E_T} .$$

We can now construct a table which applies to the system after the reaction has taken place.

Table VI. After the reaction (center of gravity system).

Particle	Mass	Energy	Momentum	Velocity
Heavier nucleus	M_1	$\frac{m_2M_2}{(M_1+M_2)^2}\left(1+\frac{m_1Q}{m_2E_T}\right)E_T$	$\frac{\sqrt{m_2M_2}}{M_1+M_2}\sqrt{1+\frac{m_1Q}{m_2E_T}}\sqrt{2M_1E_T}$	$\sqrt{\frac{2}{M_1}}\frac{\sqrt{m_2M_2}}{M_1+M_2}\sqrt{1+\frac{m_1Q}{m_2E_T}}\sqrt{E_T}$
Lighter nucleus	M_2	$\frac{m_2M_1}{(M_1+M_2)^2}\left(1+\frac{m_1Q}{m_2E_T}\right)E_T$	$\frac{\sqrt{m_2M_2}}{M_1+M_2}\sqrt{1+\frac{m_1Q}{m_2E_T}}\sqrt{2M_1E_T}$	$\sqrt{\frac{2}{M_2}}\frac{\sqrt{m_2M_1}}{M_1+M_2}\sqrt{1+\frac{m_1Q}{m_2E_T}}\sqrt{E_T}$
Center of gravity	M_1+M_2	0	0	0

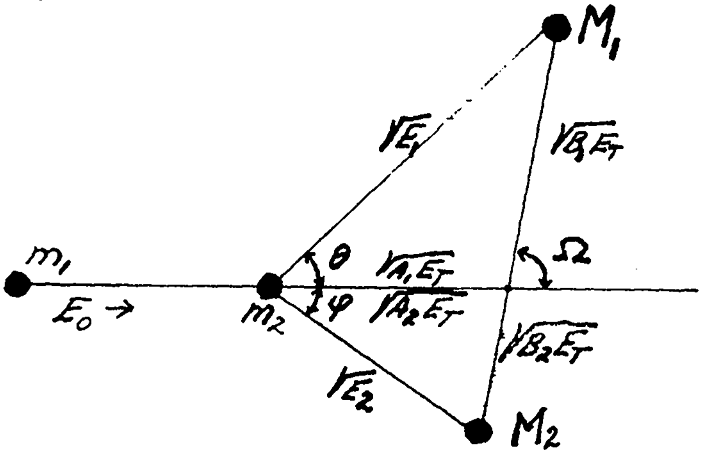
To simplify the trigonometric calculations which follow we introduce the following notation:

$$A_1 = \frac{m_1 M_1}{(M_1+M_2)^2}\left(1-\frac{Q}{E_T}\right), \quad B_1 = \frac{m_2 M_2}{(M_1+M_2)^2}\left(1+\frac{m_1}{m_2}\frac{Q}{E_T}\right), \tag{2.1}$$

$$A_2 = \frac{m_1 M_2}{(M_1+M_2)^2}\left(1-\frac{Q}{E_T}\right), \quad B_2 = \frac{m_2 M_1}{(M_1+M_2)^2}\left(1+\frac{m_1}{m_2}\frac{Q}{E_T}\right).$$

We also redraw Figure III (see Figure IV below) and assign lengths to the sides of the two triangles, proportional to the appropriate velocities now available in Tables IV, V, and VI. Since we are going to discuss the upper and lower triangles in Figure IV separately we need not use the same factor of proportionality. It turns out to be convenient to use the factor $\sqrt{\frac{M_1}{2}}$ for the upper triangle and the factor $\sqrt{\frac{M_2}{2}}$ for the lower.

Figure IV



Using Figure IV and the law of cosines we obtain:

$$E_1/E_T = (A_1+B_1) + 2\sqrt{A_1B_1}\cos\Omega, \tag{2.2}$$

$$E_2/E_T = (A_2+B_2) - 2\sqrt{A_1B_1}\cos\Omega, \tag{2.3}$$

and using the law of sines and the relationship, a = b cos G + c cos B, :

$$\sin\theta = \sqrt{\frac{B_1}{E_1/E_T}}\sin\Omega \tag{2.4}$$

$$\sin\varphi = \sqrt{\frac{B_2}{E_2/E_T}}\sin\Omega \tag{2.5}$$

$$\cos\Omega = \sqrt{\frac{E_1/E_T}{B_1}}\cos\theta - \sqrt{\frac{A_1}{B_1}} \tag{2.6}$$

$$\cos\Omega = -\sqrt{\frac{E_2/E_T}{B_2}}\cos\varphi + \sqrt{\frac{A_2}{B_2}} \tag{2.7}$$

We can now eliminate Ω between (2.2) and (2.6), between (2.3) and (2.7), and between (2.4) and (2.5), obtaining:

(2.8) $$E_1/E_T = A_1\left(\cos\theta \pm \sqrt{\frac{B_1}{A_1} - \sin^2\theta}\right)^2, \quad *)$$

(2.9) $$E_2/E_T = A_2\left(\cos\varphi \pm \sqrt{\frac{B_2}{A_2} - \sin^2\varphi}\right)^2, \quad **)$$

(2.10) $$\sin\theta = \sqrt{\frac{M_2}{M_1}\frac{E_2/E_T}{1-(E_2/E_T)}}\,\sin\varphi$$

The relative intensities $I(\Omega)/I(\theta)$ and $I(\Omega)/I(\varphi)$ are defined below and are obtained by differentiating (2.4) and (2.5) regarding E_1/E_T and E_2/E_T as functions of Ω.

(2.11) $$I(\Omega)/I(\theta) \equiv \frac{\sin\theta\, d\theta}{\sin\Omega\, d\Omega} = \frac{\sqrt{A_1B_1}\sqrt{\frac{B_1}{A_1} - \sin^2\theta}}{E_1/E_T}$$

(2.12) $$I(\Omega)/I(\varphi) \equiv \frac{\sin\varphi\, d\varphi}{\sin\Omega\, d\Omega} = \frac{\sqrt{A_2B_2}\sqrt{\frac{B_2}{A_2} - \sin^2\varphi}}{E_2/E_T}$$

The values of Q used in this report are uncertain since they were computed from the experimental masses of n, p, D, T, He^3, and He^4 (see page 14). Nevertheless the tables and figures in this report may be used for modified values of Q using the following formulae:

(2.13) $$Q' = Q + \Delta Q$$

(2.14) $$E_0' = E_0\left(1 + \frac{\Delta Q}{Q}\right)$$

(2.15) $$E_T' = E_T\left(1 + \frac{\Delta Q}{Q}\right)$$

where Q, E_0, and E_T are the values used in this report.

Suppose Q for the reaction $D + D \rightarrow n + He^3 + Q$ is actually 3.28 MEV instead of the value, 3.24 MEV, which was used, then $\Delta Q = 0.04$ MEV and for $E_0 = 6$ MEV we have: $E_0' = 6.07$ MEV and $E_T' = 9.35$ MEV.

The tables and corresponding figures will now give the desired values simply by replacing the given E_0 and E_T by E_0' and E_T'.

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*) Use both signs if $A_1 > B_1$, in which case $\theta_{max} = \arcsin\sqrt{\frac{B_1}{A_1}}$. Use only the plus sign if $A_1 \leq B_1$. See also note under formula (1.14).

**) Use both signs if $A_2 > B_2$, in which case $\varphi_{max} = \arcsin\sqrt{\frac{B_2}{A_2}}$. Use only the plus sign if $A_2 \leq B_2$. See also note under formula (1.14).

3. Rutherford Scattering.

The crossection for Rutherford Scattering in the θ-interval, (θ_1, θ_2), is given by:

$$2\pi\int_{\Omega_1}^{\Omega_2} I(\Omega)\sin\Omega\, d\Omega \equiv 2\pi\int_{\theta_1}^{\theta_2} I(\theta)\sin\theta\, d\theta \qquad (3.1)$$

where Ω is the angle in the center of gravity system, and θ is the angle in the laboratory system, and the relationship between Ω and θ is given by (1.4) and (1.6). In (3.1), which we refer to as the partial **crossection,** the functions, $I(\Omega)$ and $I(\theta)$ are given by:

$$I(\Omega) = \frac{C}{2\pi}\frac{(M_1+M_2)^2}{M_2^2}\frac{1}{4\sin^4\frac{\Omega}{2}} \qquad (3.2) \quad (A)$$

$$I(\theta) = \frac{C}{2\pi}\frac{\left[\cos\theta \pm \sqrt{1-\frac{M_1^2}{M_2^2}\sin^2\theta}\right]^2}{\sin^4\theta\sqrt{1-\frac{M_1^2}{M_2^2}\sin^2\theta}} \qquad (3.3) \quad (A)$$

where

$$C = \frac{\pi}{2}\left(\frac{Z_1 Z_2 e^2}{E_0}\right)^2 = .03256\left(\frac{Z_1 Z_2}{E_0}\right)^2 \text{ barns} \qquad (3.4)$$

In the above formulae M_1, Z_1, and E_0 denote mass, charge, and energy of the incident nucleus; M_2 and Z_2 denote the mass and charge of the target nucleus, which is initially assumed to be at rest; and $e^2 = 1.4397 \cdot 10^{-13}$ MEV-cm.

Subsituting (3.3) into (3.1), integrating, and omitting the factor, C, we obtain what we term the <u>relative partial crossection</u>. The formulae are given below:

$$\frac{1}{2}\left[\cot^2\frac{\theta_1}{2} - \cot^2\frac{\theta_2}{2}\right], \quad M_1 << M_2, \quad 0 < \theta_1 < \theta_2 \leq \pi, \qquad (3.5)$$

$$\frac{1}{\sin^2\theta_1}\left[1+\cos\theta_1\sqrt{1-\frac{M_1^2}{M_2^2}\sin^2\theta_1}\right] - \frac{1}{\sin^2\theta_2}\left[1+\cos\theta_2\sqrt{1-\frac{M_1^2}{M_2^2}\sin^2\theta_2}\right], \quad M_1 < M_2, \quad 0 < \theta_1 < \theta_2 \leq \pi \qquad (3.6) \quad (B)$$

$$2\left[\cot^2\theta_1 - \cot^2\theta_2\right], \quad M_1 = M_2, \quad Z_1 \neq Z_2, \quad 0 < \theta_1 < \theta_2 \leq \frac{\pi}{2}, \qquad (3.7) \quad (C)$$

$$2\left[\frac{\cos\theta_1}{\sin^2\theta_1}\sqrt{1-\frac{M_1^2}{M_2^2}\sin^2\theta_1} - \frac{\cos\theta_2}{\sin^2\theta_2}\sqrt{1-\frac{M_1^2}{M_2^2}\sin^2\theta_2}\right], \quad M_1 > M_2. \qquad (3.8) \quad (D)$$

(A) See G. Gamow, ATOMIC NUCLEI AND NUCLEAR TRANSFORMATIONS, pages 162-163.

(B) The second term in (3.6) approaches $\frac{1}{2}\left(1+\frac{M_1^2}{M_2^2}\right)$ as θ_2 approaches π.

(C) In (3.7) it should be noted that the formula is valid only when $Z_1 \neq Z_2$.
If $Z_1 = Z_2$: $I(\theta) = \frac{C}{2\pi}\left[\frac{1}{\sin^4\theta} + \frac{1}{\cos^4\theta} + \frac{2\psi}{\sin^2\theta\cos^2\theta}\right] \cdot 4\cos\theta$, where $\psi = \cos\left[\frac{(Z_1 e)^2}{\hbar v}\log\tan^2\theta\right]$.

(D) $0 < \theta_1 < \theta_2 \leq \arcsin\frac{M_2}{M_1}$.

INDEX OF TABLES

(See the Figure with number corresponding to the Table number for the graphs of the tabulated functions.)

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* NOTE: SINCE $\Omega = 180 - 2\phi$, THE TABLES AND CORRESPONDING FIGURES ALSO GIVE Θ AS A FUNCTION OF Ω.

Particle	Mass
n	1.00893
p	1.00812
D	2.01472
T	3.01703
He^3	3.01703
He^4	4.00387

1.008982

931.162

INDEX OF TABLES (con't.)

Table 1
(See Fig. 1)

TABLE OF E_1/E_0

$M_1 = 1$

θ \ M_2	1	θ \ M_2	2	3	4	6	7	8	9	10	11	12	14	16
0	1.000	0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	.992	10	.985	.990	.992	.995	.996	.996	.997	.997	.997	.997	.998	.998
10	.970	20	.941	.960	.970	.980	.983	.985	.987	.988	.989	.990	.991	.992
15	.933	30	.873	.914	.935	.956	.962	.967	.971	.974	.976	.978	.981	.983
20	.883	40	.786	.854	.889	.925	.935	.943	.949	.954	.958	.962	.967	.971
25	.821	50	.689	.785	.835	.887	.903	.914	.924	.931	.937	.942	.950	.956
30	.750	60	.589	.711	.776	.846	.866	.882	.895	.905	.913	.920	.931	.939
35	.671	70	.494	.636	.716	.802	.828	.848	.864	.876	.887	.896	.910	.921
40	.587	80	.407	.565	.656	.757	.789	.813	.832	.847	.860	.871	.888	.902
45	.500	90	.333	.500	.600	.714	.750	.778	.800	.818	.833	.846	.867	.882
50	.413	100	.273	.442	.549	.674	.713	.744	.770	.790	.807	.822	.845	.863
55	.329	110	.225	.393	.503	.636	.680	.714	.741	.764	.783	.799	.825	.845
60	.250	120	.189	.352	.464	.603	.649	.686	.715	.740	.761	.778	.807	.829
65	.179	130	.161	.319	.431	.575	.623	.661	.693	.719	.741	.760	.790	.814
70	.117	140	.141	.293	.405	.552	.601	.642	.674	.702	.725	.744	.777	.802
75	.067	150	.127	.274	.385	.534	.584	.626	.659	.688	.712	.732	.766	.792
80	.030	160	.118	.260	.371	.521	.572	.614	.649	.678	.702	.723	.758	.784
85	.008	170	.113	.253	.363	.513	.565	.607	.642	.671	.696	.718	.753	.780
90	.000	180	.111	.250	.360	.510	.562	.605	.640	.669	.694	.716	.751	.779

Table 2
(See Fig. 2)

TABLE OF E_2/E_0

$M_1 = 1$

ϕ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16
0	1.000	.889	.750	.640	.490	.438	.395	.360	.331	.306	.284	.249	.221
5	.992	.882	.744	.635	.486	.434	.392	.357	.328	.303	.282	.247	.220
10	.970	.862	.727	.621	.475	.424	.383	.349	.321	.296	.275	.241	.215
15	.933	.829	.700	.597	.457	.408	.369	.336	.308	.285	.265	.232	.207
20	.883	.785	.662	.565	.433	.386	.349	.318	.292	.270	.251	.220	.196
25	.821	.730	.616	.526	.402	.359	.324	.296	.272	.251	.233	.204	.182
30	.750	.667	.562	.480	.367	.328	.296	.270	.248	.229	.213	.187	.166
35	.671	.596	.503	.429	.329	.294	.265	.242	.222	.205	.191	.167	.149
40	.587	.522	.440	.376	.287	.257	.232	.211	.194	.179	.167	.146	.130
45	.500	.444	.375	.320	.245	.219	.198	.180	.165	.153	.142	.124	.111
50	.413	.367	.310	.264	.202	.181	.163	.149	.137	.126	.117	.103	.091
55	.329	.292	.247	.211	.161	.144	.130	.118	.109	.101	.093	.082	.073
60	.250	.222	.188	.160	.122	.109	.099	.090	.083	.076	.071	.062	.055
65	.179	.159	.134	.114	.087	.078	.071	.064	.059	.055	.051	.044	.040
70	.117	.104	.088	.075	.057	.051	.046	.042	.039	.036	.033	.029	.026
75	.067	.060	.050	.043	.033	.029	.026	.024	.022	.020	.019	.017	.015
80	.030	.027	.023	.019	.015	.013	.012	.011	.010	.009	.009	.008	.007
85	.008	.007	.006	.005	.004	.003	.003	.003	.003	.002	.002	.002	.002
90	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

TABLE OF I (Ω)/ I (θ)

Table 3
(See Fig. 3)

$M_1 = 1$

θ \ M_2	1	θ \ M_2	2	3	4	6	7	8	9	10	11	12	14	16
0	.250	0	.444	.562	.640	.735	.766	.790	.810	.826	.840	.852	.871	.886
5	.251	10	.450	.567	.644	.738	.769	.793	.813	.829	.842	.854	.873	.887
10	.254	20	.465	.582	.657	.748	.778	.801	.820	.836	.849	.860	.878	.892
15	.259	30	.493	.607	.679	.766	.794	.815	.833	.848	.860	.871	.887	.900
20	.266	40	.535	.643	.711	.790	.815	.835	.851	.864	.875	.885	.900	.911
25	.276	50	.596	.693	.752	.821	.843	.860	.874	.885	.894	.903	.915	.925
30	.289	60	.680	.758	.805	.860	.877	.890	.901	.910	.918	.924	.934	.942
35	.305	70	.795	.839	.869	.905	.917	.926	.933	.939	.944	.948	.955	.960
40	.326	80	.950	.940	.945	.957	.961	.965	.968	.971	.973	.975	.978	.980
45	.354	90	1.155	1.061	1.033	1.014	1.010	1.008	1.006	1.005	1.004	1.003	1.003	1.002
50	.389	100	1.418	1.201	1.131	1.076	1.062	1.053	1.046	1.041	1.037	1.033	1.028	1.024
55	.436	110	1.742	1.360	1.237	1.140	1.117	1.100	1.087	1.077	1.069	1.063	1.053	1.046
60	.500	120	2.124	1.531	1.347	1.205	1.170	1.145	1.127	1.113	1.101	1.092	1.078	1.067
65	.592	130	2.546	1.707	1.457	1.267	1.221	1.189	1.165	1.146	1.131	1.119	1.100	1.087
70	.731	140	2.978	1.877	1.560	1.324	1.268	1.228	1.198	1.176	1.158	1.143	1.120	1.104
75	.966	150	3.380	2.028	1.649	1.372	1.307	1.261	1.227	1.200	1.180	1.163	1.137	1.118
80	1.440	160	3.709	2.147	1.719	1.409	1.336	1.285	1.248	1.219	1.196	1.178	1.149	1.129
85	2.868	170	3.924	2.224	1.763	1.432	1.355	1.301	1.261	1.231	1.206	1.187	1.157	1.136
90	∞	180	4.000	2.250	1.778	1.440	1.361	1.306	1.266	1.235	1.210	1.190	1.160	1.138

Table 4
(See Fig. 4)

TABLE OF θ AS A FUNCTION OF φ

$M_1 = 1$

φ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16
0	90.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00
5	85.00	160.33	165.08	166.70	168.02	168.35	168.58	168.76	168.90	169.01	169.10	169.24	169.34
10	80.00	142.12	150.58	153.62	156.13	156.77	157.23	157.57	157.84	158.05	158.23	158.50	158.70
15	75.00	126.21	136.81	140.94	144.44	145.34	145.99	146.48	146.87	147.17	147.43	147.82	148.11
20	70.00	112.48	123.95	128.76	133.00	134.11	134.92	135.54	136.02	136.41	136.72	137.22	137.58
25	65.00	100.56	112.00	117.15	121.86	123.13	124.06	124.76	125.32	125.77	126.14	126.72	127.14
30	60.00	90.00	100.89	106.10	111.05	112.41	113.41	114.18	114.79	115.28	115.69	116.33	116.80
35	55.00	80.46	90.53	95.59	100.57	101.97	103.00	103.81	104.44	104.96	105.39	106.06	106.57
40	50.00	71.67	80.79	85.57	90.41	91.79	92.83	93.63	94.28	94.80	95.24	95.93	96.44
45	45.00	63.44	71.56	75.96	80.54	81.87	82.88	83.66	84.29	84.81	85.24	85.91	86.42
50	40.00	55.63	62.76	66.72	70.94	72.18	73.13	73.87	74.47	75.18	75.38	76.02	76.52
55	35.00	48.14	54.30	57.79	61.57	62.71	63.57	64.26	64.81	65.26	65.65	66.25	66.71
60	30.00	40.89	46.10	49.10	52.41	53.41	54.18	54.79	55.28	55.69	56.04	56.58	57.00
65	25.00	33.84	38.12	40.63	43.42	44.26	44.94	45.46	45.88	46.24	46.53	47.00	47.36
70	20.00	26.92	30.32	32.32	34.57	35.27	35.81	36.24	36.58	36.87	37.12	37.51	37.80
75	15.00	20.10	22.63	24.13	25.84	26.36	26.77	27.10	27.36	27.59	27.78	28.07	28.30
80	10.00	13.36	15.04	16.04	17.18	17.53	17.81	18.03	18.21	18.36	18.49	18.69	18.84
85	5.00	6.67	7.50	8.00	8.58	8.76	8.89	9.00	9.09	9.17	9.23	9.34	9.41
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig. 1 (See Table 1)

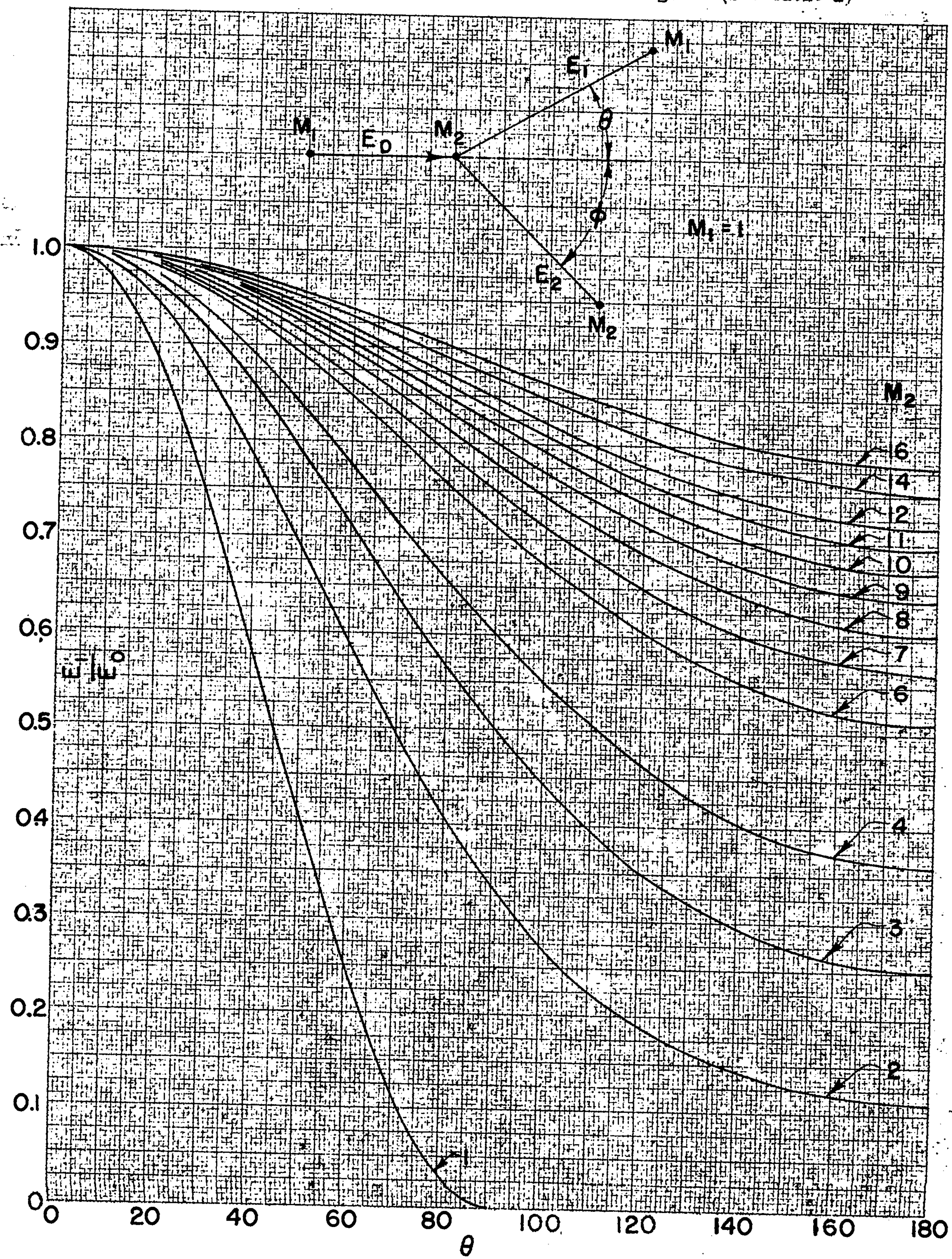


Fig. 2 (See Table 2)

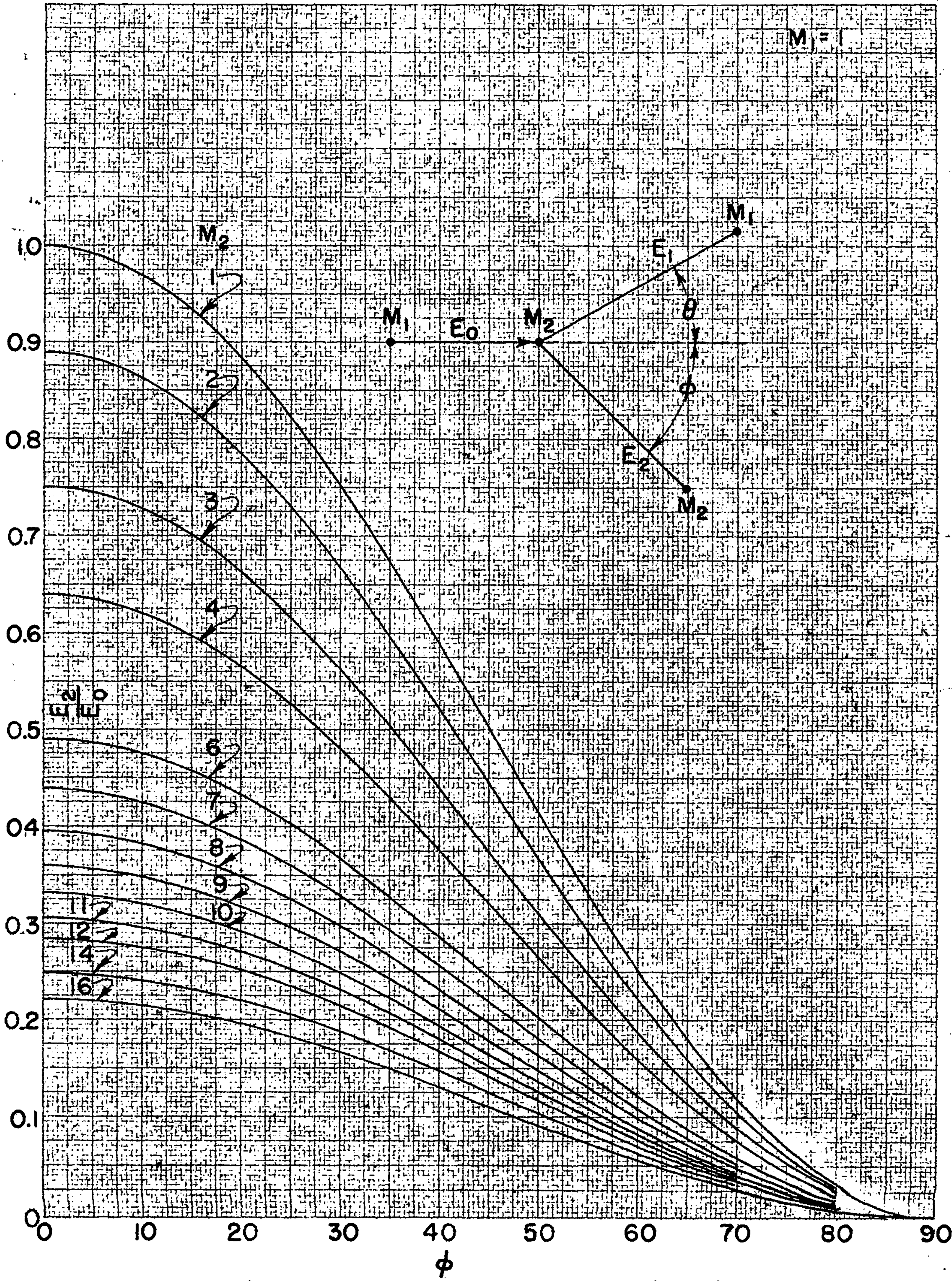


Fig. 3 (See Table 3)

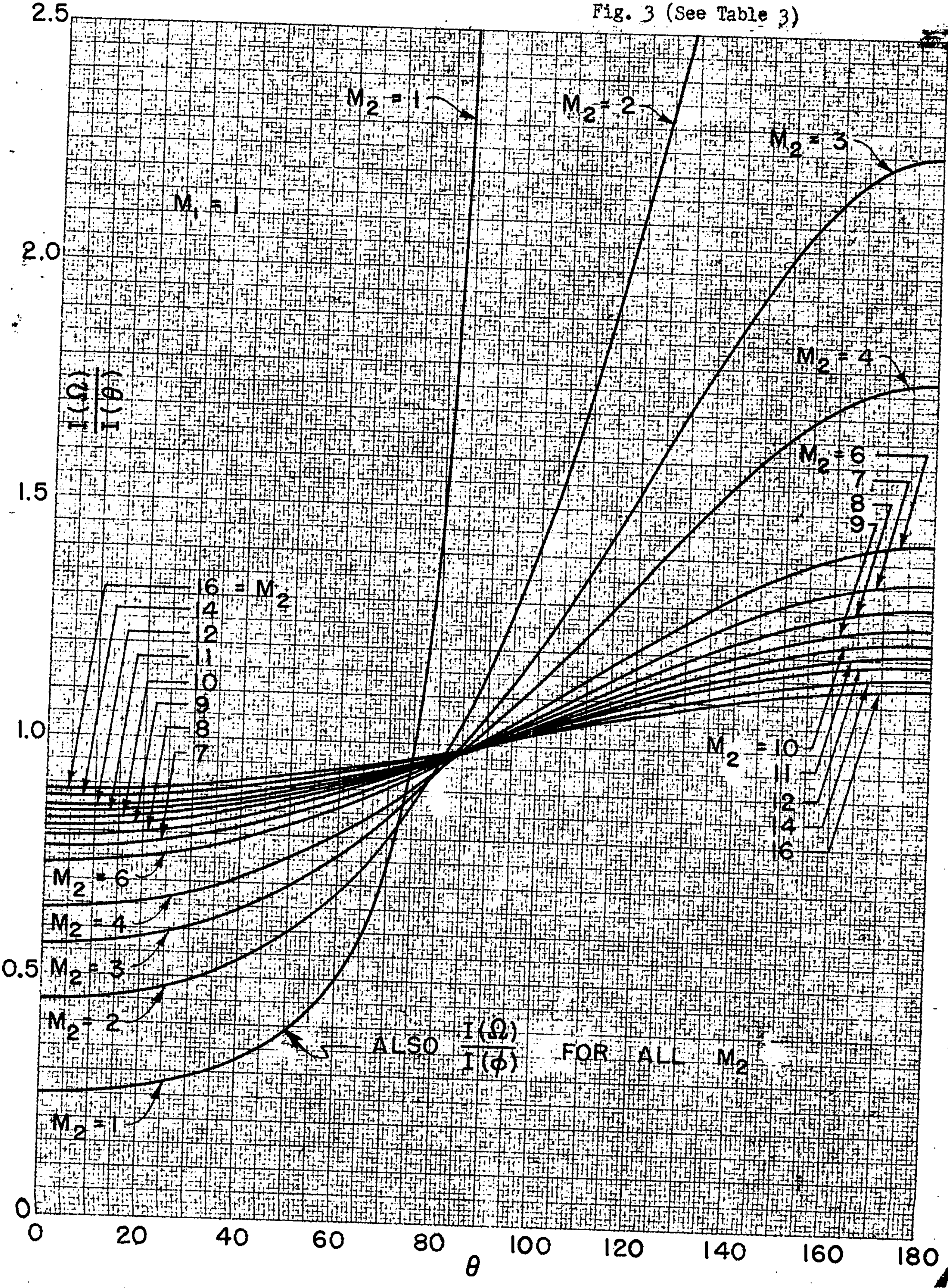


Fig. 4 (See Table 4)

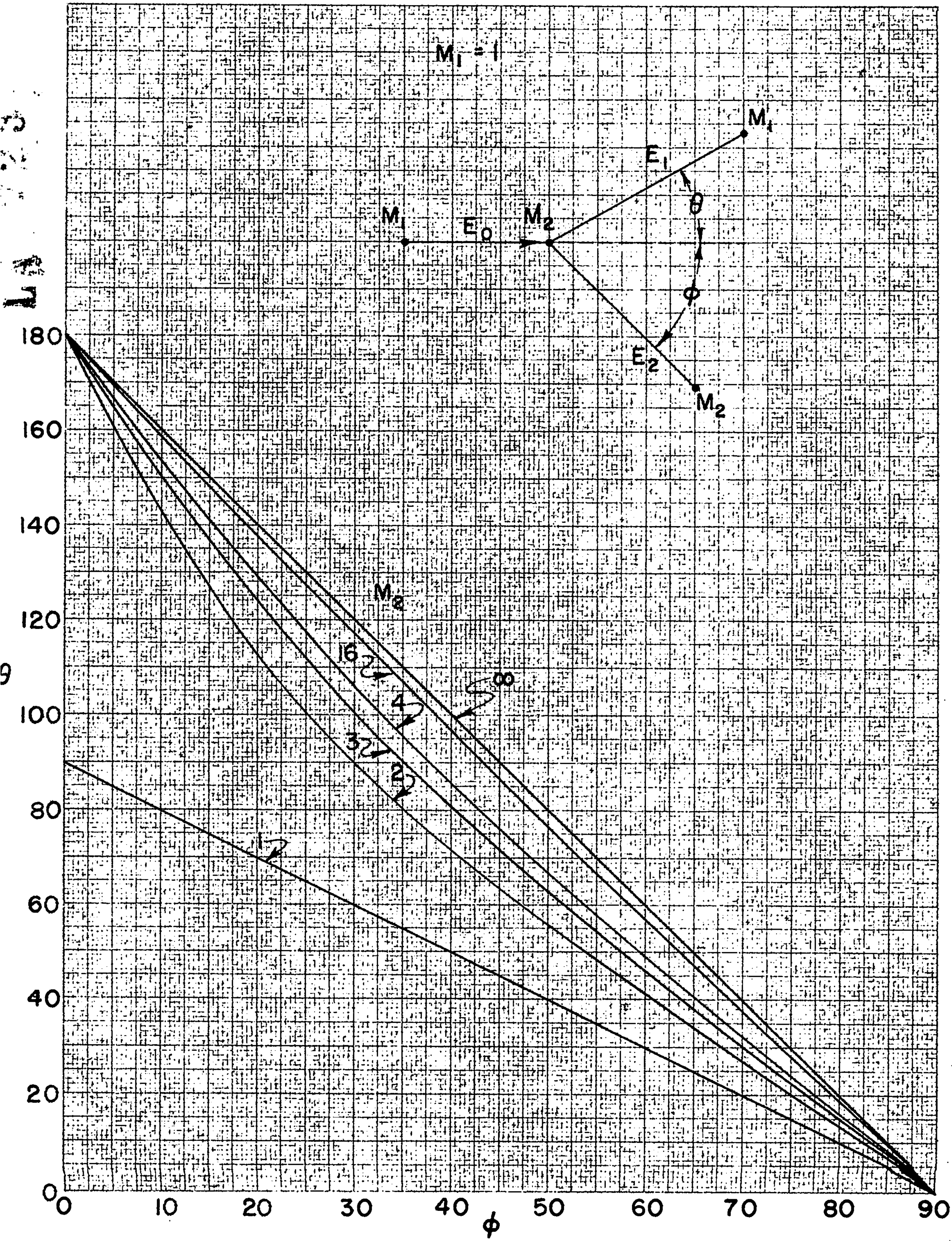


Table 5
(See Fig. 5)

TABLE OF E_1/E_0

$M_1 = 2$

θ \ M_2	1 Fast	1 Slow	2	ε \ M_2	3	4	6	7	8	9	10	11	12	14	16
0	1.000	.111	1.000	0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	.985	.113	.992	10	.980	.985	.990	.991	.992	.993	.994	.994	.995	.996	.996
10	.939	.118	.970	20	.922	.941	.960	.966	.970	.974	.976	.978	.980	.983	.985
15	.863	.129	.933	30	.832	.873	.914	.926	.935	.942	.948	.952	.956	.962	.967
20	.756	.147	.883	40	.720	.786	.854	.874	.889	.901	.910	.918	.925	.935	.943
25	.612	.182	.821	50	.598	.689	.785	.813	.835	.852	.866	.878	.887	.903	.914
30	.333	.333	.750	60	.476	.589	.711	.748	.776	.799	.817	.833	.846	.866	.882
35			.671	70	.365	.494	.636	.681	.716	.744	.766	.786	.802	.828	.848
40			.587	80	.273	.407	.565	.616	.656	.689	.716	.738	.757	.789	.813
45			.500	90	.200	.333	.500	.556	.600	.636	.667	.692	.714	.750	.778
50			.413	100	.147	.273	.442	.501	.549	.588	.621	.649	.674	.713	.744
55			.329	110	.109	.225	.393	.453	.503	.545	.580	.610	.636	.680	.714
60			.250	120	.084	.189	.352	.413	.464	.507	.544	.576	.603	.649	.686
65			.179	130	.067	.161	.319	.380	.431	.475	.513	.546	.575	.623	.661
70			.117	140	.056	.141	.293	.353	.405	.450	.488	.522	.552	.601	.642
75			.067	150	.048	.127	.274	.333	.385	.430	.469	.503	.534	.584	.62[illegible]
80			.030	160	.043	.118	.260	.319	.371	.416	.455	.490	.521	.572	.614
85			.008	170	.041	.113	.253	.311	.363	.408	.447	.482	.513	.565	.607
90			.000	180	.040	.111	.250	.309	.360	.405	.444	.479	.510	.562	.6[illegible]

θ max.	30.00	
E_1/E_0 for θ max.	.333	

TABLE OF E_2/E_0

Table 6
(See Fig. 6)

$M_1 = 2$

ϕ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16
0	.889	1.000	.960	.889	.750	.691	.640	.595	.556	.521	.490	.438	.395
5	.882	.992	.953	.882	.744	.686	.635	.591	.551	.517	.486	.434	.392
10	.862	.970	.931	.862	.727	.671	.621	.577	.539	.505	.475	.424	.383
15	.829	.933	.896	.829	.700	.645	.597	.555	.518	.486	.457	.408	.369
20	.785	.883	.848	.785	.662	.610	.565	.525	.491	.460	.433	.386	.349
25	.730	.821	.789	.730	.616	.568	.526	.489	.456	.428	.402	.359	.324
30	.667	.750	.720	.667	.562	.519	.480	.446	.417	.391	.367	.328	.296
35	.596	.671	.644	.596	.503	.464	.429	.399	.373	.349	.329	.294	.265
40	.522	.587	.563	.522	.440	.406	.376	.349	.326	.306	.287	.257	.232
45	.444	.500	.480	.444	.375	.346	.320	.298	.278	.260	.245	.219	.198
50	.367	.413	.397	.367	.310	.286	.264	.246	.230	.215	.202	.181	.163
55	.292	.329	.316	.292	.247	.227	.211	.196	.183	.171	.161	.144	.130
60	.222	.250	.240	.222	.188	.173	.160	.149	.139	.130	.122	.109	.099
65	.159	.179	.171	.159	.134	.123	.114	.106	.099	.093	.087	.078	.071
70	.104	.117	.112	.104	.088	.081	.075	.070	.065	.061	.057	.051	.046
75	.060	.067	.064	.060	.050	.046	.043	.040	.037	.035	.033	.029	.026
80	.027	.030	.029	.027	.023	.021	.019	.018	.017	.016	.015	.013	.012
85	.007	.008	.007	.007	.006	.005	.005	.005	.004	.004	.004	.003	.003
90	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 7
(See Fig. 7)

TABLE OF I (Ω)/ I (θ)

$M_1 = 2$

θ \ M_2	1 Fast	1 Slow	2	θ \ M_2	3	4	6	7	8	9	10	11	12	14	16
0	.111	1.000	.250	0	.360	.444	.562	.605	.640	.669	.694	.716	.735	.766	.790
5	.111	.970	.251	10	.365	.450	.567	.609	.644	.673	.698	.720	.738	.769	.793
10	.111	.881	.254	20	.380	.465	.582	.623	.657	.686	.710	.730	.748	.778	.801
15	.110	.739	.259	30	.408	.493	.607	.646	.679	.706	.729	.749	.766	.794	.815
20	.107	.552	.266	40	.452	.535	.643	.681	.711	.736	.757	.774	.790	.815	.835
25	.097	.327	.276	50	.518	.596	.693	.726	.752	.774	.792	.808	.821	.843	.860
30	.000	.000	.289	60	.618	.680	.758	.784	.805	.822	.837	.849	.860	.877	.890
35			.305	70	.768	.795	.839	.856	.869	.880	.890	.898	.905	.917	.926
40			.326	80	.996	.950	.940	.942	.945	.948	.951	.954	.957	.961	.965
45			.354	90	1.342	1.155	1.061	1.043	1.033	1.026	1.021	1.017	1.014	1.010	1.008
50			.389	100	1.850	1.418	1.201	1.159	1.131	1.111	1.096	1.085	1.076	1.062	1.053
55			.436	110	2.563	1.742	1.360	1.286	1.237	1.202	1.176	1.156	1.140	1.117	1.100
60			.500	120	3.499	2.124	1.531	1.420	1.347	1.296	1.258	1.228	1.205	1.170	1.145
65			.592	130	4.623	2.546	1.707	1.555	1.457	1.388	1.337	1.298	1.267	1.221	1.189
70			.731	140	5.857	2.978	1.877	1.683	1.560	1.474	1.410	1.362	1.324	1.268	1.228
75			.966	150	7.062	3.380	2.028	1.796	1.649	1.548	1.473	1.417	1.372	1.307	1.261
80			1.440	160	8.077	3.709	2.147	1.884	1.719	1.605	1.522	1.458	1.409	1.336	1.285
85			2.868	170	8.757	3.924	2.224	1.941	1.763	1.641	1.552	1.485	1.432	1.355	1.301
90			∞	180	9.000	4.000	2.250	1.960	1.778	1.653	1.562	1.494	1.440	1.361	1.306
θ max.	30.00														
I(Ω)/ I(θ) for θ max.	.000														

Table 8
(See Fig. 8)

TABLE OF θ AS A FUNCTION OF φ

$M_1 = 2$

φ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16
0	0.00	90.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00
5	9.71	85.00	151.37	160.33	165.08	166.05	166.70	167.17	167.53	167.80	168.02	168.35	168.58
10	17.88	80.00	128.60	142.12	150.58	152.39	153.62	154.51	155.18	155.71	156.13	156.77	157.23
15	23.79	75.00	111.74	126.21	136.81	139.25	140.94	142.17	143.10	143.84	144.44	145.34	145.99
20	27.52	70.00	98.79	112.48	123.95	126.77	128.76	130.23	131.37	132.27	133.00	134.11	134.92
25	29.44	65.00	88.20	100.56	112.00	114.99	117.15	118.77	120.03	121.04	121.86	123.13	124.06
30	30.00	60.00	79.10	90.00	100.89	103.90	106.10	107.78	109.11	110.17	111.05	112.41	113.41
35	29.54	55.00	70.94	80.46	90.53	93.43	95.59	97.26	98.59	99.68	100.57	101.97	103.00
40	28.34	50.00	63.41	71.67	80.79	83.51	85.57	87.18	88.47	90.48	90.41	91.79	92.83
45	26.56	45.00	56.31	63.44	71.56	74.06	75.96	77.47	78.69	79.70	80.54	81.87	82.88
50	24.37	40.00	49.53	55.63	62.76	64.99	66.72	68.10	69.22	70.15	70.94	72.18	73.13
55	21.86	35.00	42.97	48.14	54.30	56.26	57.79	59.02	60.02	60.86	61.57	62.71	63.57
60	19.11	30.00	36.59	40.89	46.10	47.78	49.11	50.17	51.05	51.79	52.41	53.41	54.18
65	16.16	25.00	30.33	33.84	38.12	39.52	40.63	41.53	42.27	42.89	43.42	44.26	44.94
70	13.08	20.00	24.16	26.92	30.32	31.43	32.32	33.04	33.64	34.14	34.57	35.27	35.81
75	9.90	15.00	18.07	20.10	22.63	23.47	24.13	24.68	25.13	25.51	25.84	26.36	26.77
80	6.64	10.00	12.02	13.36	15.04	15.60	16.04	16.40	16.70	16.96	17.18	17.53	17.81
85	3.33	5.00	6.00	6.67	7.50	7.78	8.00	8.19	8.34	8.47	8.58	8.76	8.89
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig. 5 (See Table 5)

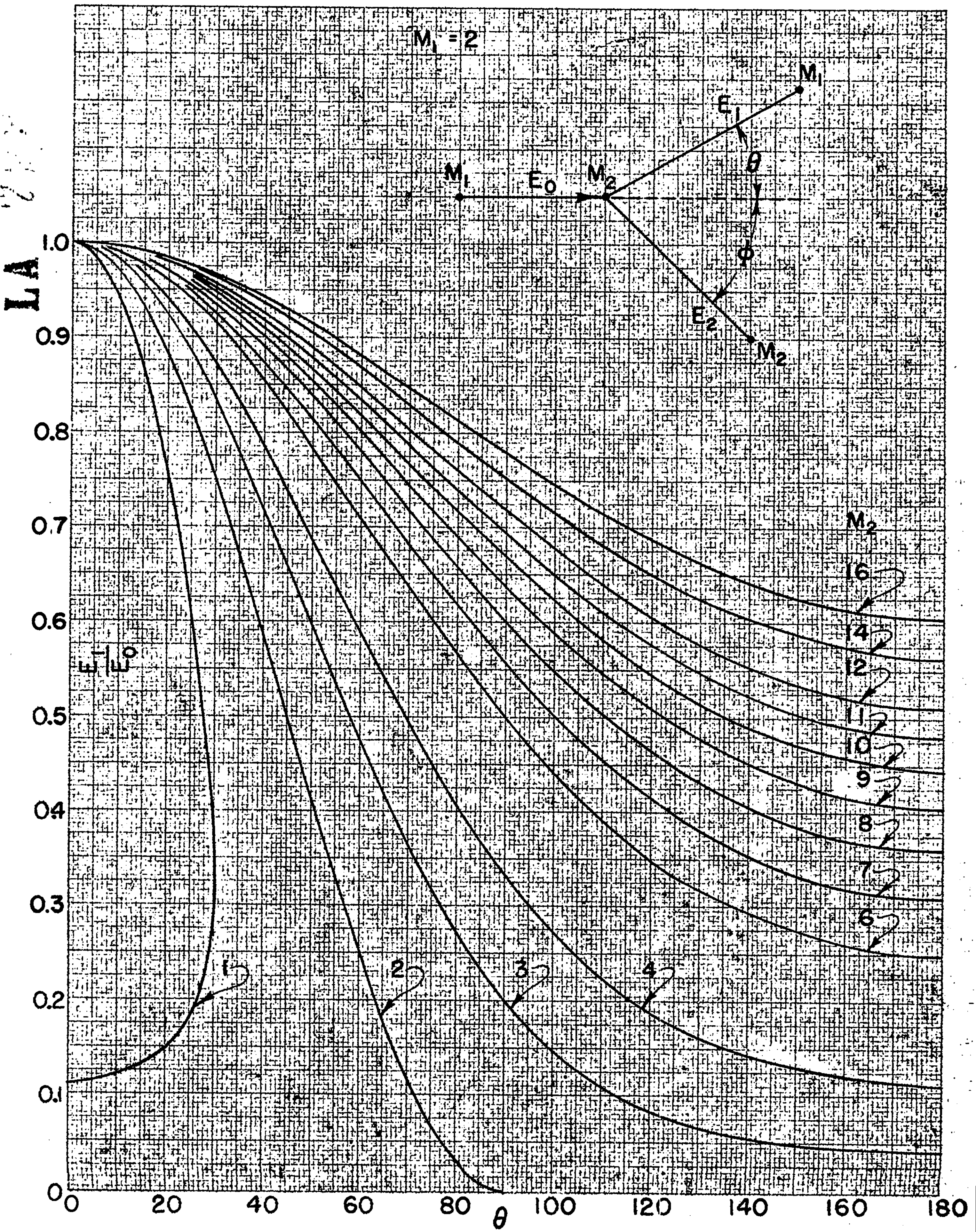


Fig. 6 (See Table 6)

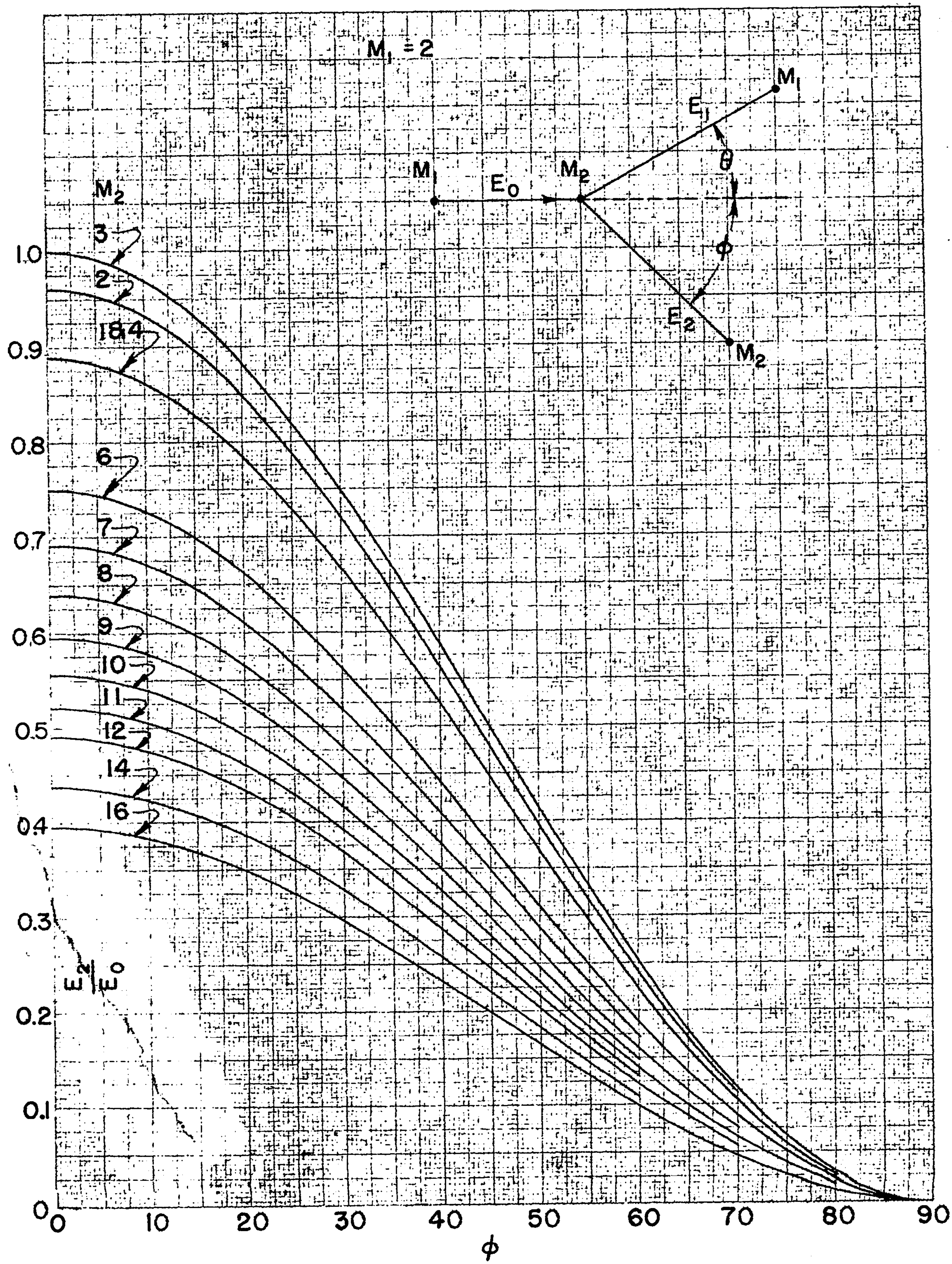


Fig. 7 (See Table 7)

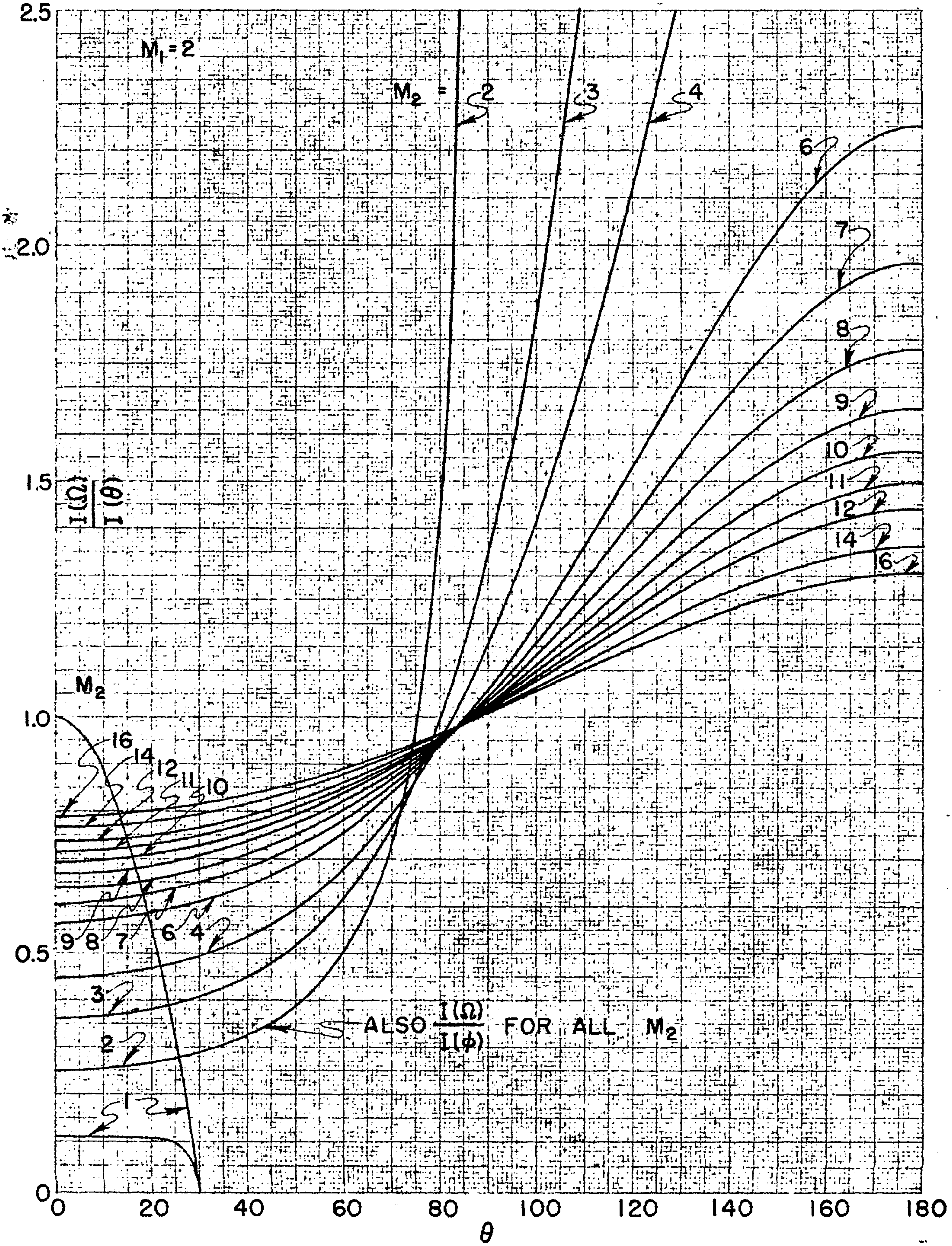


Fig. 8 (See Table 8)

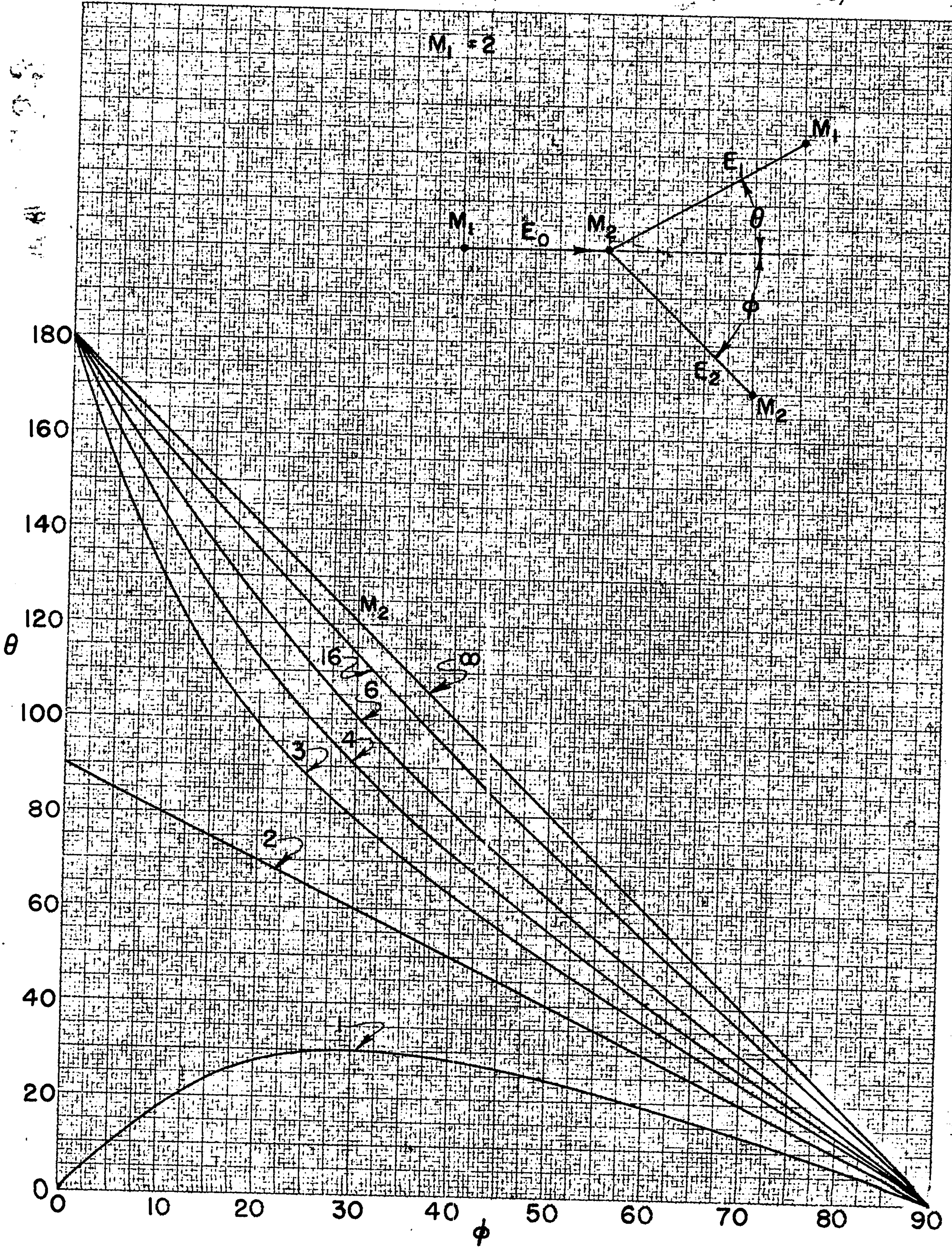


Table 9
(See Fig. 9)

TABLE OF E_1/E_0

$M_1 = 3$

θ \ M_2	1 Fast	1 Slow	2 Fast	2 Slow	3
0	1.000	.250	1.000	.040	1.000
5	.977	.256	.989	.040	.992
10	.906	.276	.955	.042	.970
15	.778	.321	.899	.044	.933
20			.823	.049	.883
25			.728	.055	.821
30			.615	.065	.750
35			.484	.083	.671
40			.320	.125	.587
45					.500
50					.413
55					.329
60					.250
65					.179
70					.117
75					.067
80					.030
85					.008
90					.000
θ max.	19.47		41.81		
E_1/E_0 for θ max.	.500		.200		

θ \ M_2	4	6	7	8	9	10	11	12	14	16
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	.977	.985	.987	.989	.990	.991	.992	.992	.993	.994
20	.912	.941	.949	.956	.960	.964	.968	.970	.974	.978
30	.812	.873	.890	.904	.914	.922	.929	.935	.944	.951
40	.687	.786	.815	.837	.854	.868	.879	.889	.904	.916
50	.552	.689	.729	.760	.785	.805	.821	.835	.857	.874
60	.421	.589	.640	.679	.711	.736	.758	.776	.805	.828
70	.305	.494	.553	.599	.636	.667	.693	.716	.752	.780
80	.211	.407	.472	.523	.565	.601	.631	.656	.698	.731
90	.143	.333	.400	.455	.500	.538	.571	.600	.647	.684
100	.097	.273	.339	.395	.442	.483	.518	.549	.600	.640
110	.067	.225	.290	.345	.393	.434	.471	.503	.557	.601
120	.048	.189	.250	.304	.352	.394	.431	.464	.520	.565
130	.037	.161	.219	.272	.319	.360	.398	.431	.488	.536
140	.030	.141	.196	.247	.293	.334	.371	.405	.463	.511
150	.025	.127	.180	.229	.274	.314	.351	.385	.443	.492
160	.022	.118	.169	.216	.260	.301	.337	.371	.430	.479
170	.021	.113	.162	.209	.253	.293	.329	.363	.421	.471
180	.020	.111	.160	.207	.250	.290	.327	.360	.419	.468

Table 10
(See Fig. 10)

TABLE OF E_2/E_0

$M_1 = 3$

ϕ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16
0	.750	.960	1.000	.980	.889	.840	.793	.750	.710	.673	.640	.581	.532
5	.744	.953	.992	.972	.882	.834	.787	.744	.705	.668	.635	.577	.528
10	.727	.931	.970	.950	.862	.815	.769	.727	.689	.653	.621	.564	.516
15	.700	.896	.933	.914	.829	.784	.740	.700	.662	.628	.597	.542	.496
20	.662	.848	.883	.865	.785	.742	.701	.662	.627	.595	.565	.513	.470
25	.616	.789	.821	.805	.730	.690	.652	.616	.583	.553	.526	.477	.437
30	.562	.720	.750	.735	.667	.630	.595	.562	.533	.505	.480	.436	.399
35	.503	.644	.671	.657	.596	.564	.532	.503	.476	.452	.429	.390	.357
40	.440	.563	.587	.575	.522	.493	.466	.440	.417	.395	.376	.341	.312
45	.375	.480	.500	.490	.444	.420	.397	.375	.355	.337	.320	.291	.266
50	.310	.397	.413	.405	.367	.347	.328	.310	.293	.278	.264	.240	.220
55	.247	.316	.329	.322	.292	.276	.261	.247	.234	.222	.211	.191	.175
60	.188	.240	.250	.245	.222	.210	.198	.188	.178	.168	.160	.145	.133
65	.134	.171	.179	.175	.159	.150	.142	.134	.127	.120	.114	.104	.095
70	.088	.112	.117	.115	.104	.098	.093	.088	.083	.079	.075	.068	.062
75	.050	.064	.067	.066	.060	.056	.053	.050	.048	.045	.043	.039	.036
80	.023	.029	.030	.030	.027	.025	.024	.023	.021	.020	.019	.018	.016
85	.006	.007	.008	.007	.007	.006	.006	.006	.005	.005	.005	.004	.004
90	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

$M_1 = 3$

TABLE OF I (Ω)/ I (θ)

Table 11
(See Fig. 11)

θ \ M_2	1 Fast	1 Slow	2 Fast	2 Slow	3
0	.062	.250	.160	4.000	.250
5	.062	.236	.160	3.921	.251
10	.059	.193	.162	3.687	.254
15	.051	.123	.164	3.314	.259
20			.167	2.826	.266
25			.170	2.252	.276
30			.172	1.627	.289
35			.169	.986	.305
40			.133	.340	.326
45					.354
50					.389
55					.436
60					.500
65					.592
70					.731
75					.966
80					1.440
85					2.868
90					∞
θ max.	19.47		41.81		
I (Ω)/ I (θ) for θ max.	.000		.000		

θ \ M_2	4	6	7	8	9	10	11	12	14	16
0	.327	.444	.490	.529	.562	.592	.617	.640	.678	.709
10	.331	.450	.495	.534	.567	.596	.622	.644	.682	.713
20	.346	.465	.511	.549	.582	.610	.635	.657	.694	.724
30	.373	.493	.538	.575	.607	.634	.658	.679	.714	.742
40	.416	.535	.578	.613	.643	.669	.691	.711	.743	.769
50	.484	.596	.635	.666	.693	.716	.735	.752	.781	.803
60	.590	.680	.711	.736	.758	.776	.791	.805	.827	.845
70	.760	.795	.812	.826	.839	.853	.861	.869	.884	.895
80	1.042	.950	.942	.940	.940	.941	.943	.945	.949	.953
90	1.512	1.155	1.107	1.079	1.061	1.048	1.039	1.033	1.024	1.018
100	2.279	1.418	1.309	1.244	1.201	1.171	1.148	1.131	1.106	1.088
110	3.458	1.742	1.549	1.435	1.360	1.311	1.267	1.237	1.193	1.162
120	5.121	2.124	1.820	1.645	1.531	1.452	1.393	1.347	1.282	1.237
130	7.233	2.546	2.110	1.864	1.707	1.598	1.518	1.457	1.370	1.310
140	9.633	2.978	2.399	2.079	1.877	1.738	1.637	1.560	1.451	1.377
150	12.036	3.380	2.663	2.272	2.028	1.861	1.740	1.649	1.520	1.434
160	14.102	3.709	2.876	2.426	2.147	1.958	1.821	1.719	1.574	1.478
170	15.506	3.924	3.014	2.526	2.224	2.020	1.873	1.763	1.608	1.505
180	15.999	4.000	3.062	2.560	2.250	2.041	1.891	1.778	1.620	1.515

Table 12
(See Fig. 12)

TABLE OF θ AS A FUNCTION OF ϕ

$M_1 = 3$

ϕ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16
0	0.00	0.00	90.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00
5	4.92	18.63	85.00	143.52	160.33	162.66	164.11	165.08	165.77	166.30	166.70	167.30	167.71
10	9.42	31.40	80.00	119.09	142.12	146.21	148.80	150.58	151.87	152.85	153.62	154.77	155.55
15	13.19	38.26	75.00	103.06	126.21	131.18	134.48	136.81	138.55	139.88	140.94	142.51	143.61
20	16.05	41.21	70.00	91.43	112.48	117.70	121.31	123.95	125.94	127.50	128.76	130.64	131.99
25	18.00	41.79	65.00	82.03	100.56	105.62	109.27	112.00	114.11	115.78	117.15	119.22	120.72
30	19.11	40.89	60.00	73.90	90.00	94.72	98.21	100.89	103.00	104.70	106.10	108.26	109.84
35	19.47	39.06	55.00	66.53	80.46	84.74	87.99	90.53	92.56	94.22	95.59	97.74	99.34
40	19.21	36.59	50.00	59.66	71.67	75.49	78.44	80.79	82.69	84.26	85.57	87.64	89.20
45	18.44	33.69	45.00	53.13	63.44	66.80	69.44	71.56	73.30	74.74	75.96	77.90	79.38
50	17.24	30.47	40.00	46.84	55.63	58.55	60.88	62.76	64.31	65.62	66.72	68.50	69.86
55	15.70	27.03	35.00	40.71	48.14	50.65	52.66	54.30	55.66	56.81	57.79	59.37	60.60
60	13.90	23.41	30.00	34.72	40.89	43.00	44.70	46.10	47.27	48.26	49.11	50.48	51.56
65	11.88	19.67	25.00	28.81	33.84	35.56	36.97	38.12	39.10	39.92	40.63	41.79	42.69
70	9.69	15.84	20.00	22.98	26.92	28.28	29.40	30.32	31.09	31.75	32.32	33.25	33.98
75	7.37	11.93	15.00	17.19	20.10	21.12	21.94	22.63	23.21	23.70	24.13	24.84	25.39
80	4.96	7.98	10.00	11.44	13.36	14.03	14.58	15.04	15.42	15.75	16.04	16.51	16.88
85	2.50	4.00	5.00	5.72	6.67	7.00	7.28	7.50	7.70	7.86	8.00	8.24	8.43
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig. 9 (See Table 9)

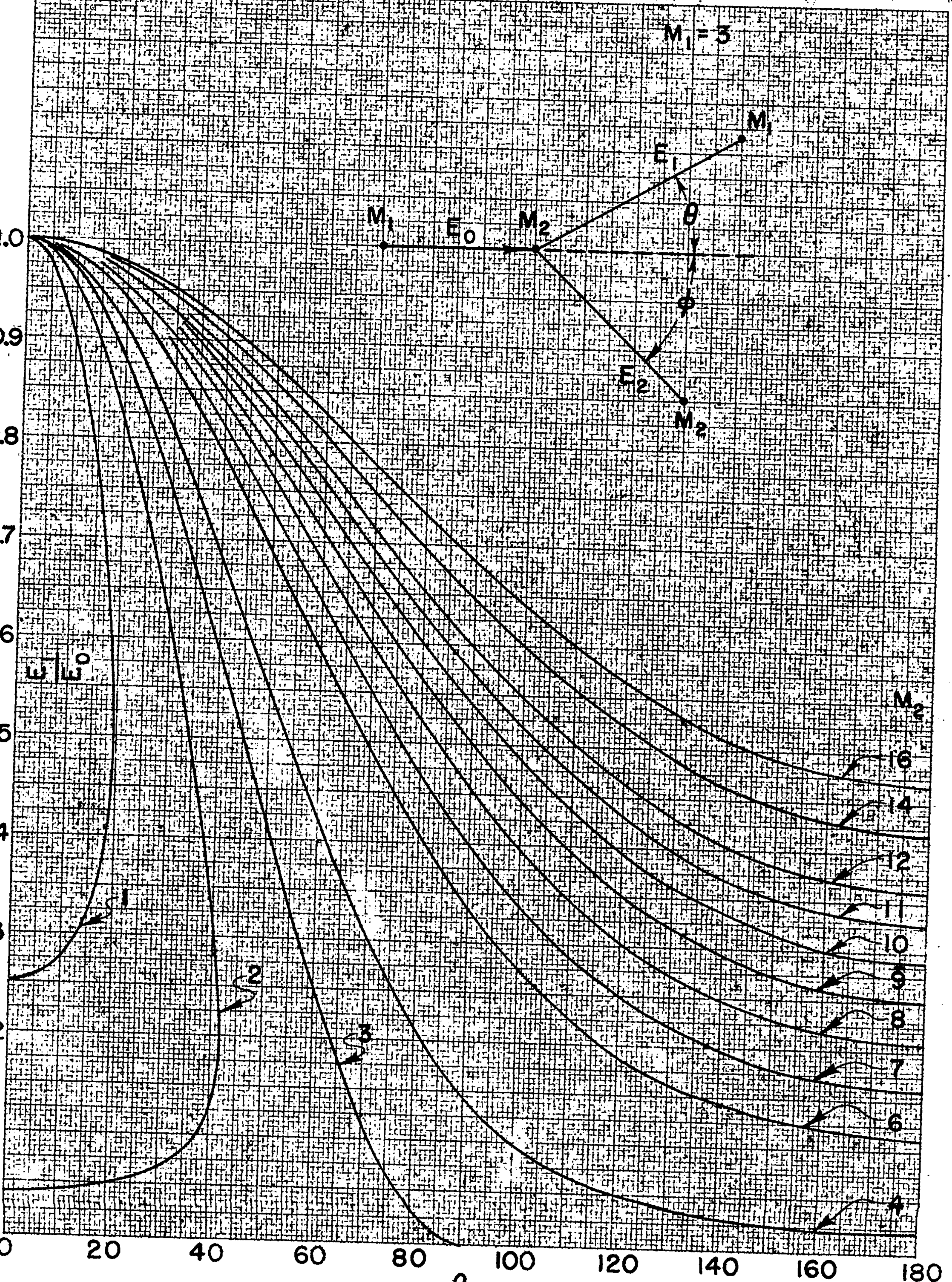


Fig. 10 (See Table 10)

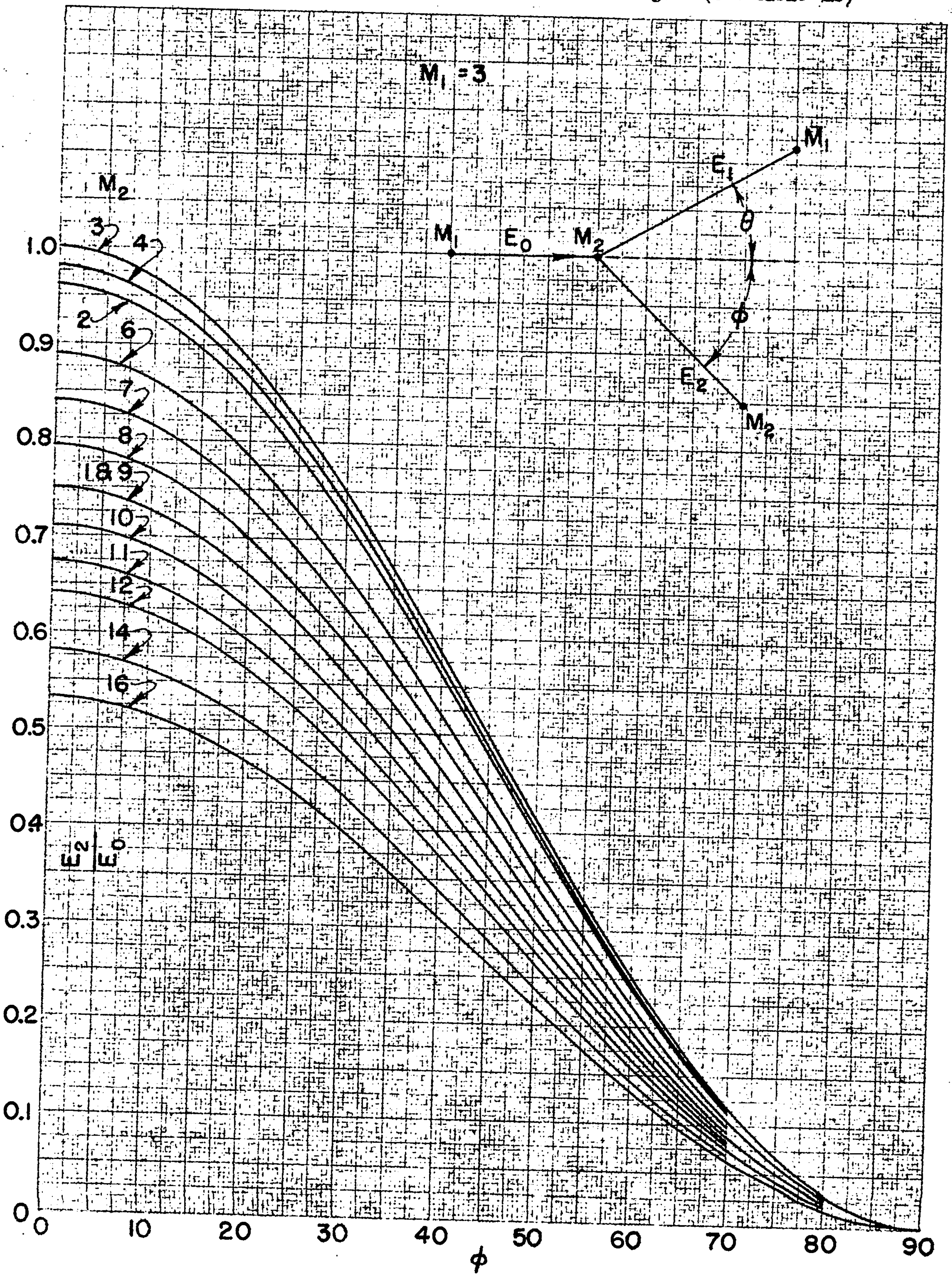


Fig. 11 (See Table 11)

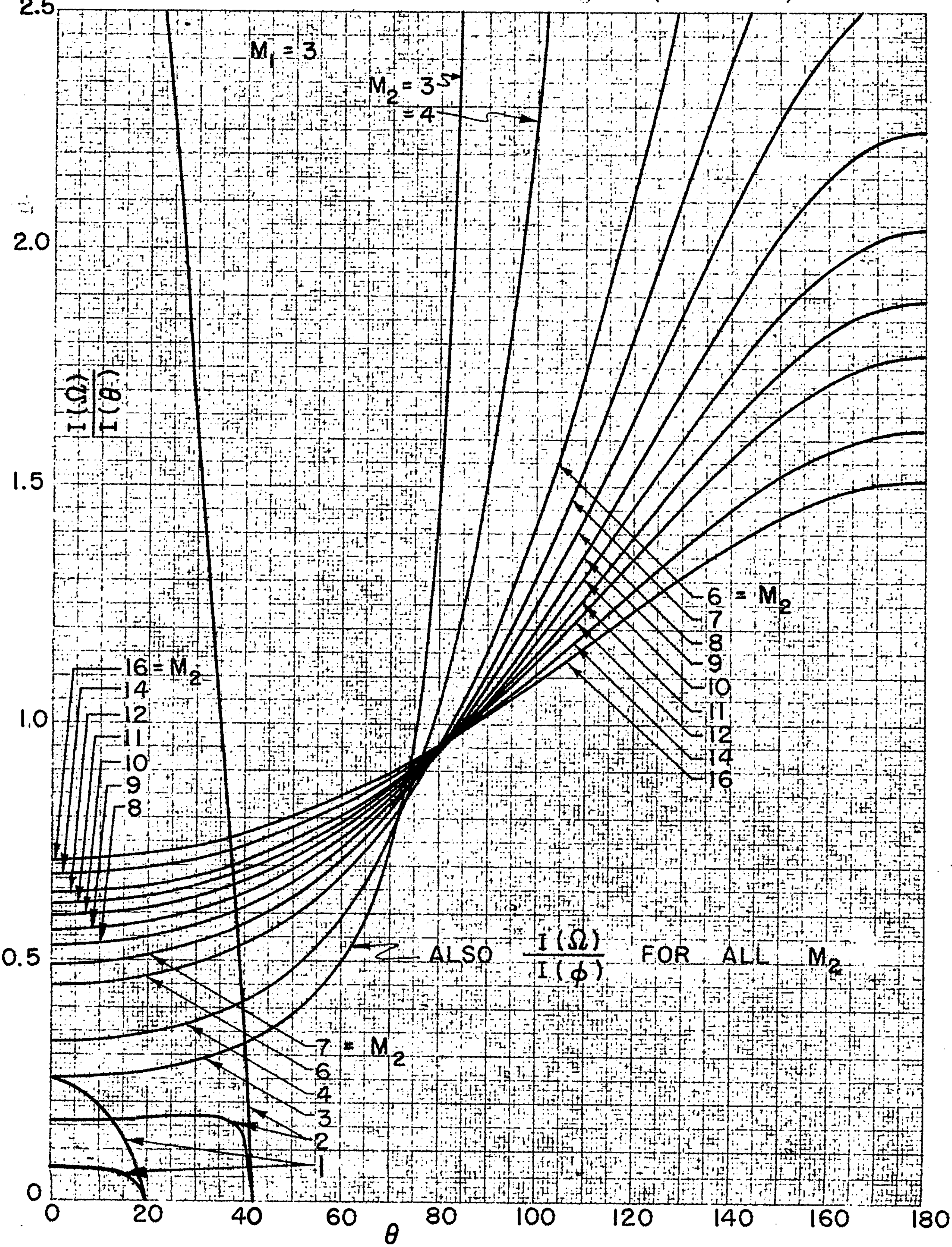


Fig. 12 (See Table 12)

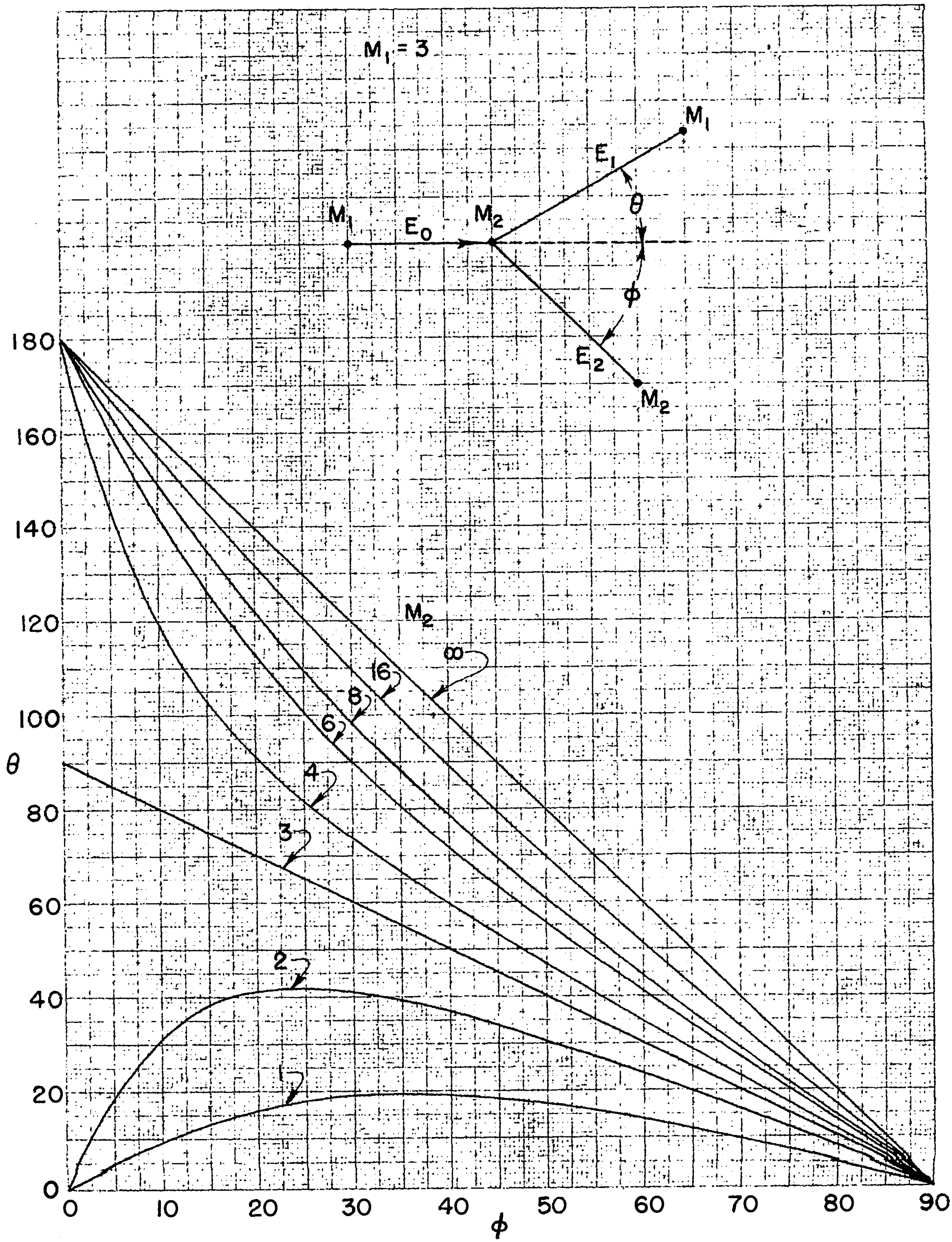


Table 13
(See Fig. 13)

TABLE OF E_1/E_0

$M_1 = 4$

θ \ M_2	1 Fast	1 Slow	2 Fast	2 Slow	3 Fast	3 Slow	4
0	1.000	.360	1.000	.111	1.000	.020	1.000
5	.969	.371	.985	.113	.990	.021	.992
10	.868	.415	.939	.118	.960	.021	.970
15			.863	.129	.910	.022	.933
20			.756	.147	.843	.024	.883
25			.612	.182	.760	.027	.821
30			.333	.333	.663	.031	.750
35					.554	.037	.671
40					.434	.047	.587
45					.299	.068	.500
50							.413
55							.329
60							.250
65							.179
70							.117
75							.067
80							.030
85							.008
90							.000
θ max.		14.48		30.00		48.59	
E_1/E_0 for θ max.		.600		.333		.143	

θ \ M_2	6	7	8	9	10	11	12	14	16	30
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	.980	.983	.985	.987	.988	.989	.990	.991	.992	.996
20	.922	.933	.941	.948	.953	.957	.960	.966	.970	.984
30	.832	.855	.873	.886	.897	.906	.914	.926	.935	.965
40	.720	.758	.786	.808	.827	.841	.854	.874	.889	.939
50	.598	.649	.689	.720	.746	.767	.785	.813	.835	.909
60	.476	.540	.589	.629	.661	.688	.711	.748	.776	.875
70	.365	.437	.494	.539	.577	.609	.636	.681	.716	.838
80	.273	.347	.407	.457	.499	.534	.565	.616	.656	.801
90	.200	.273	.333	.385	.429	.467	.500	.556	.600	.765
100	.147	.214	.273	.324	.368	.408	.442	.501	.549	.730
110	.109	.170	.225	.274	.318	.358	.393	.453	.503	.697
120	.084	.138	.189	.235	.278	.317	.352	.413	.464	.669
130	.067	.115	.161	.205	.246	.284	.319	.38[illegible]	.431	.643
140	.056	.098	.141	.183	.222	.259	.293	.353	.405	.622
150	.048	.087	.127	.167	.205	.240	.274	.333	.385	.606
160	.043	.080	.118	.156	.193	.228	.260	.319	.371	.594
170	.041	.076	.113	.150	.186	.220	.253	.311	.363	.587
180	.040	.074	.111	.148	.184	.218	.250	.309	.360	.585

Table 14
(See Fig. 14)

TABLE OF E_2/E_0

$M_1 = 4$

ϕ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16	30
0	.640	.889	.980	1.000	.960	.926	.889	.852	.816	.782	.750	.691	.640	.415
5	.635	.882	.972	.992	.953	.919	.882	.846	.810	.776	.744	.686	.635	.412
10	.621	.862	.950	.970	.931	.898	.862	.826	.792	.759	.727	.671	.621	.403
15	.597	.829	.914	.933	.896	.864	.829	.795	.762	.730	.700	.645	.597	.387
20	.565	.785	.865	.883	.848	.817	.785	.752	.721	.691	.662	.610	.565	.367
25	.526	.730	.805	.821	.789	.760	.730	.700	.671	.643	.616	.568	.526	.341
30	.480	.667	.735	.750	.720	.694	.667	.639	.612	.587	.562	.519	.480	.311
35	.429	.596	.657	.671	.644	.621	.596	.572	.548	.525	.503	.464	.429	.279
40	.376	.522	.575	.587	.563	.543	.522	.500	.479	.459	.440	.406	.376	.244
45	.320	.444	.490	.500	.480	.463	.444	.426	.408	.391	.375	.346	.320	.208
50	.264	.367	.405	.413	.397	.382	.367	.352	.337	.323	.310	.286	.264	.172
55	.211	.292	.322	.329	.316	.305	.292	.280	.269	.257	.247	.227	.211	.137
60	.160	.222	.245	.250	.240	.231	.222	.213	.204	.196	.188	.173	.160	.104
65	.114	.159	.175	.179	.171	.165	.159	.152	.146	.140	.134	.123	.114	.074
70	.075	.104	.115	.117	.112	.108	.104	.100	.095	.092	.088	.081	.075	.049
75	.043	.060	.066	.067	.064	.062	.060	.057	.055	.052	.050	.046	.043	.028
80	.019	.027	.030	.030	.029	.028	.027	.026	.025	.024	.023	.021	.019	.013
85	.005	.007	.007	.008	.007	.007	.007	.006	.006	.006	.006	.005	.005	.003
90	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

<u>TABLE OF I(Ω)/ I(θ)</u>

Table 15
(See Fig. 15)

$M_1 = 4$

θ \ M2	1 Fast	1 Slow	2 Fast	2 Slow	3 Fast	3 Slow	4
0	.040	.111	.111	1.000	.184	9.000	.250
5	.039	.101	.111	.970	.184	8.848	.251
10	.033	.069	.111	.881	.186	8.403	.254
15			.110	.739	.189	7.691	.259
20			.107	.552	.194	6.755	.266
25			.097	.327	.200	5.653	.276
30			.000	.000	.206	4.448	.289
35					.214	3.212	.305
40					.218	2.011	.326
45					.205	.897	.354
50							.389
55							.436
60							.500
65							.592
70							.731
75							.966
80							1.440
85							2.868
90							∞
θ max.	14.48		30.00		48.59		
I( )/ I(θ) for θ max.	.000		.000		.000		

θ \ M_2	6	7	8	9	10	11	12	14	16	30
0	.360	.405	.444	.479	.510	.538	.562	.605	.640	.779
10	.365	.410	.450	.484	.515	.543	.567	.609	.644	.782
20	.380	.426	.465	.500	.530	.558	.582	.623	.657	.790
30	.408	.454	.493	.527	.557	.583	.607	.646	.679	.805
40	.452	.497	.535	.568	.596	.621	.643	.681	.711	.826
50	.518	.561	.596	.626	.651	.674	.693	.726	.752	.852
60	.618	.652	.680	.704	.724	.742	.758	.784	.805	.884
70	.768	.781	.795	.808	.819	.830	.839	.856	.869	.921
80	.996	.964	.950	.943	.940	.940	.940	.942	.945	.963
90	1.342	1.219	1.155	1.116	1.091	1.074	1.061	1.043	1.033	1.009
100	1.850	1.562	1.418	1.331	1.273	1.232	1.201	1.159	1.131	1.058
110	2.563	2.008	1.742	1.587	1.485	1.413	1.360	1.286	1.237	1.107
120	3.499	2.555	2.124	1.880	1.722	1.612	1.531	1.420	1.347	1.157
130	4.623	3.179	2.546	2.194	1.972	1.819	1.707	1.555	1.457	1.204
140	5.857	3.837	2.978	2.510	2.219	2.020	1.877	1.683	1.560	1.246
150	7.062	4.462	3.380	2.800	2.442	2.201	2.028	1.796	1.649	1.282
160	8.077	4.981	3.709	3.034	2.621	2.345	2.147	1.884	1.719	1.309
170	8.757	5.234	3.924	3.187	2.737	2.437	2.224	1.941	1.763	1.326
180	9.000	5.445	4.000	3.240	2.778	2.470	2.250	1.960	1.778	1.331

Table 16
(See Fig. 16)

TABLE OF θ AS A FUNCTION OF ϕ

$M_1 = 4$

ϕ \ M_2	1	2	3	4	6	7	8	9	10	11	12	14	16	30
0	0.00	0.00	0.00	90.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00
5	3.30	9.71	26.48	85.00	151.37	157.21	160.33	162.28	163.46	164.38	165.08	166.05	166.70	168.47
10	6.38	17.88	40.99	80.00	128.60	137.12	142.12	146.10	147.64	149.30	150.58	152.39	153.62	157.02
15	9.06	23.79	46.94	75.00	111.74	120.51	126.21	130.14	132.99	135.14	136.81	139.25	140.94	145.69
20	11.24	27.52	48.57	70.00	98.79	106.84	112.48	116.58	119.66	122.05	123.95	126.77	128.76	134.55
25	12.85	29.44	47.97	65.00	88.20	95.32	100.56	104.52	107.59	110.02	112.00	114.99	117.15	123.63
30	13.90	30.00	46.10	60.00	79.10	85.28	90.00	93.67	96.59	98.95	100.89	103.90	106.10	112.95
35	14.41	29.54	43.47	55.00	70.94	76.28	80.46	83.78	86.47	88.68	90.53	93.43	95.59	102.52
40	14.43	28.34	40.34	50.00	63.41	68.00	71.67	74.62	77.06	79.08	80.79	83.51	85.57	92.34
45	14.04	26.56	36.87	45.00	56.31	60.26	63.44	66.04	68.20	70.02	71.56	74.06	75.96	82.41
50	13.28	24.37	33.16	40.00	49.53	52.89	55.63	57.89	59.78	61.38	62.76	64.99	66.72	72.69
55	12.21	21.86	29.29	35.00	42.97	45.81	48.14	50.07	51.70	53.10	54.30	56.26	57.79	63.17
60	10.89	19.11	25.29	30.00	36.59	38.95	40.89	42.52	43.90	45.08	46.10	47.78	49.11	53.82
65	9.37	16.16	21.19	25.00	30.33	32.25	33.84	35.17	36.30	37.28	38.12	39.52	40.63	44.62
70	7.68	13.08	17.02	20.00	24.16	25.67	26.92	27.97	28.87	29.64	30.32	31.43	32.32	35.55
75	5.86	9.90	12.81	15.00	18.07	19.18	20.10	20.88	21.55	22.13	22.63	23.47	24.13	26.58
80	3.96	6.64	8.56	10.00	12.02	12.75	13.36	13.88	14.32	14.70	15.04	15.60	16.04	17.68
85	2.00	3.33	4.28	5.00	6.00	6.37	6.67	6.93	7.15	7.34	7.50	7.78	8.00	8.83
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig. 13(See Table 13)

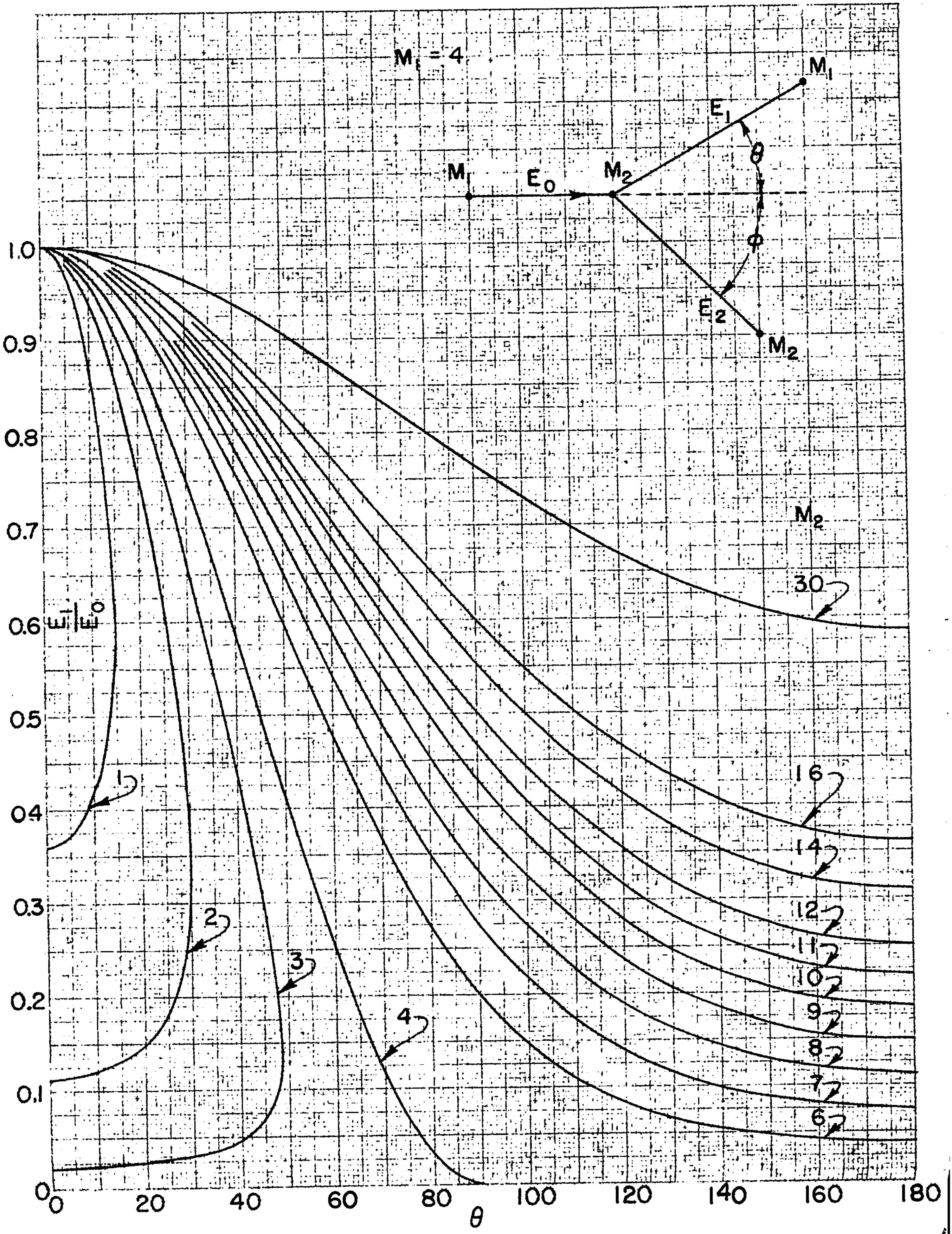


Fig. 14 (See Table 14)

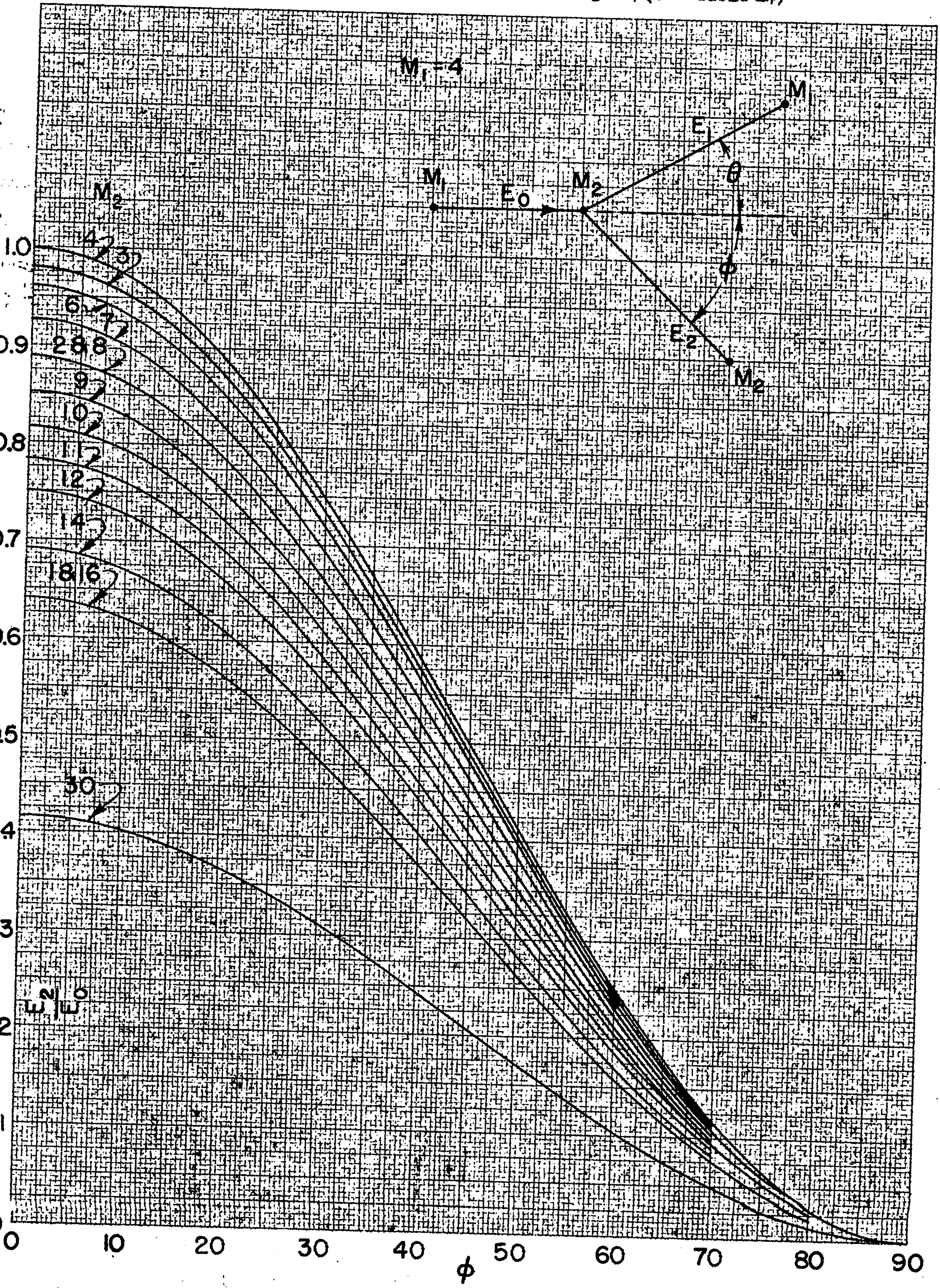


Fig. 15 (See Table 15)

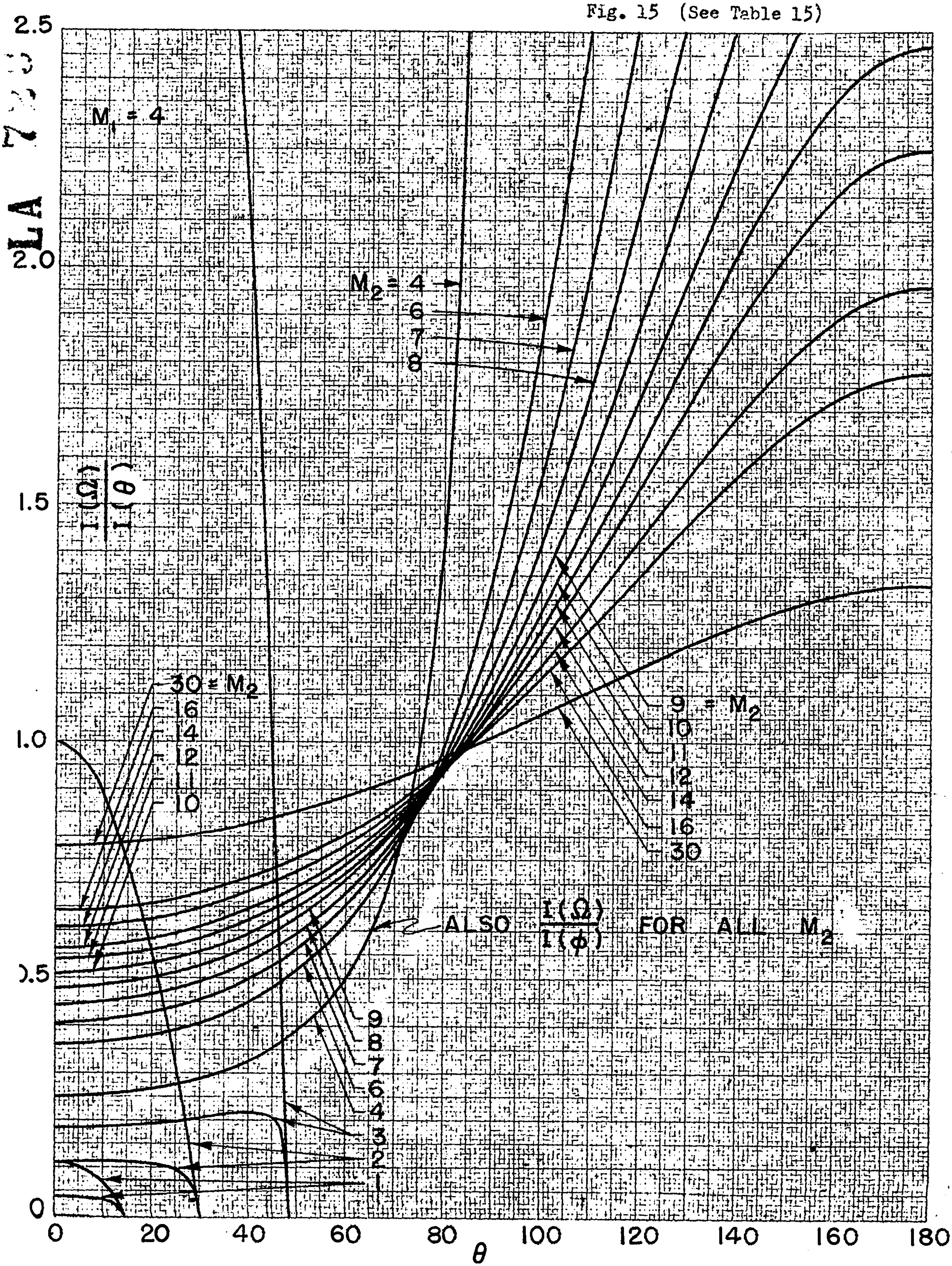


Fig. 16 (See Table 16)

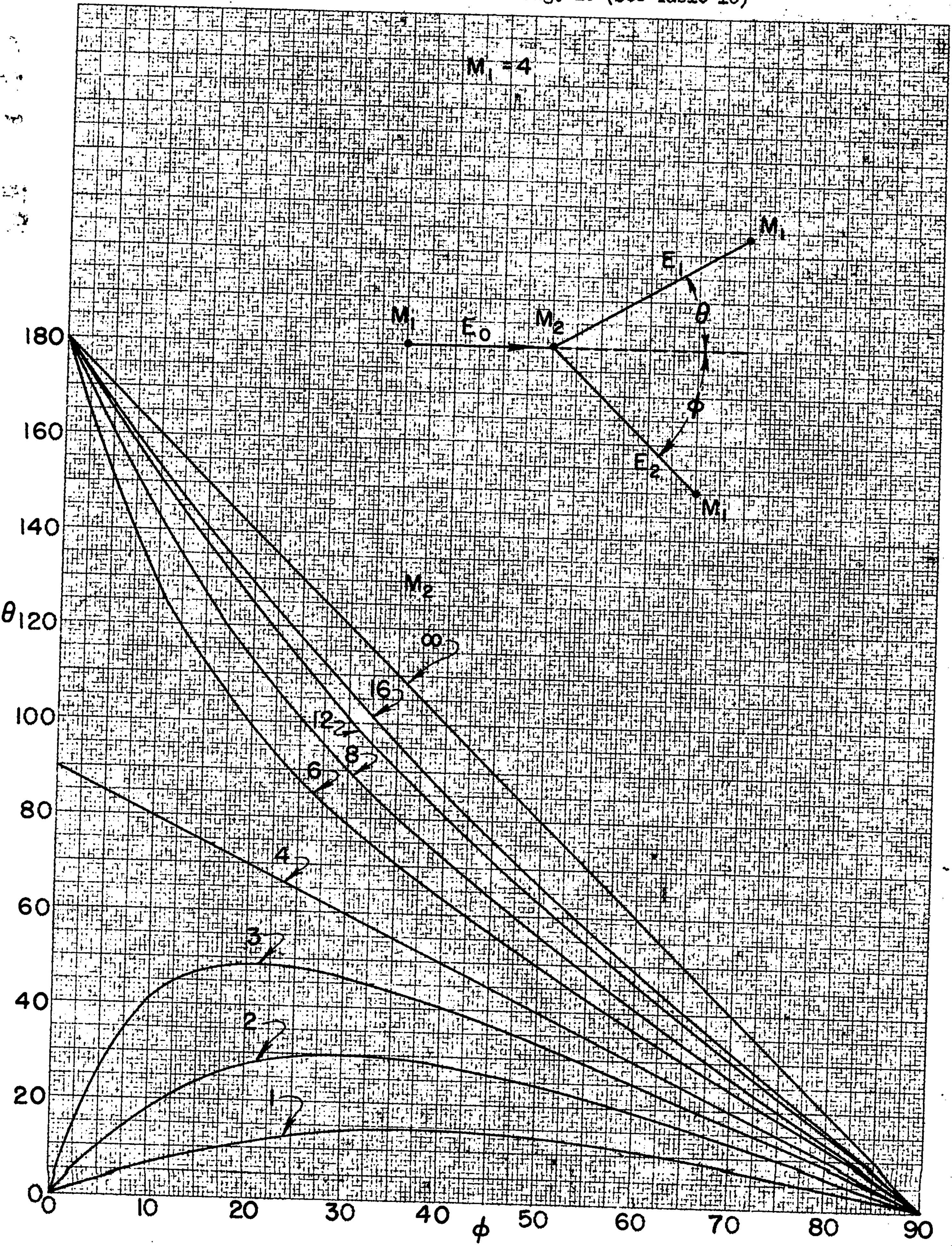


TABLE OF E_1/E_T FOR $D + D \rightarrow p + T$

Table 17
(See Fig. 17)

$$E_T = E_0 + 3.98$$

θ \ E_0	6 Fast	6 Slow	8 Fast	8 Slow	10 Fast	10 Slow	12 Fast	12 Slow	∞ Fast	∞ Slow
0	.797	.003	.825	.009	.844	.014	.857	.018	.933	.067
5	.791	.003	.818	.009	.836	.014	.848	.019	.922	.069
10	.770	.003	.795	.009	.811	.014	.822	.019	.884	.071
15	.737	.003	.758	.009	.771	.015	.780	.020	.824	.076
20	.691	.004	.707	.010	.716	.016	.722	.022	.740	.084
25	.636	.004	.644	.011	.648	.018	.650	.024	.633	.099
30	.571	.004	.571	.012	.569	.020	.566	.028	.500	.125
35	.499	.005	.490	.014	.481	.024	.472	.033	.294	.213
40	.422	.006	.403	.017	.384	.030	.367	.043		
45	.342	.007	.310	.023	.280	.041	.249	.063		
50	.262	.010	.213	.033	.152	.076				
55	.181	.014								
60	.098	.026								
θ max.	61.74		54.64		50.69		48.13		35.27	
E_1/E_T for θ max.	.051		.084		.108		.125		.250	

TABLE OF I (Ω)/I (θ) FOR D + D $\rightarrow$ p + T

Table 18
(See Figs. 18a & 18b)

$$E_T = E_0 + 3.98$$

θ \ E_0	6		8		10		12		∞	
	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow
0	.219	54.5	.202	19.5	.190	11.7	.182	8.50	.134	1.87
5	.220	53.7	.202	19.1	.191	11.5	.183	8.35	.134	1.78
10	.223	51.6	.205	18.4	.193	10.9	.185	7.93	.135	1.69
15	.227	48.0	.208	17.0	.196	10.1	.188	7.25	.136	1.47
20	.233	43.5	.214	15.2	.201	8.93	.192	6.36	.136	1.19
25	.241	38.2	.221	13.0	.208	7.52	.198	5.31	.134	.863
30	.252	32.1	.230	10.7	.215	6.02	.204	4.16	.125	.500
35	.266	25.9	.242	8.24	.224	4.47	.211	2.98	.049	.067
40	.283	19.7	.255	5.86	.233	2.96	.215	1.84		
45	.305	13.9	.267	3.66	.233	1.57	.196	.774		
50	.330	8.82	.268	1.73	.149	.296				
55	.354	4.55								
60	.323	1.22								
θ max.	61.72		54.64		50.69		48.13		35.27	
I (Ω)/ I (θ) for θ max.	.000		.000		.000		.000		.000	

TABLE OF E_2/E_T AND $I(\Omega)/I(\phi)$ FOR $D + D \rightarrow p + T$

Table 19
(See Figs. 19a & 19b)

$E_T = E_0 + 3.98$

E_2/E_T

ϕ \ E_0	6	8	10	12	∞
0	.997	.991	.986	.981	.933
10	.985	.979	.973	.968	.917
20	.952	.944	.936	.930	.870
30	.900	.888	.878	.869	.797
40	.833	.816	.803	.792	.705
50	.756	.734	.718	.705	.603
60	.675	.649	.630	.615	.500
70	.594	.565	.543	.527	.404
80	.518	.486	.463	.446	.319
90	.449	.416	.392	.375	.250
100	.390	.356	.332	.315	.196
110	.340	.307	.283	.266	.155
120	.299	.267	.244	.228	.125
130	.267	.237	.214	.199	.104
140	.243	.212	.192	.177	.089
150	.224	.195	.175	.161	.078
160	.212	.184	.164	.151	.072
170	.205	.177	.158	.145	.068
180	.203	.175	.156	.143	.067

$I(\Omega)/I(\phi)$

ϕ \ E_0	6	8	10	12	∞
0	.526	.504	.488	.477	.402
10	.531	.509	.494	.482	.407
20	.546	.524	.509	.498	.423
30	.572	.551	.536	.525	.451
40	.611	.591	.577	.566	.494
50	.664	.646	.633	.624	.558
60	.735	.720	.710	.702	.650
70	.825	.817	.811	.807	.780
80	.940	.941	.942	.944	.966
90	1.080	1.096	1.108	1.118	1.225
100	1.248	1.284	1.312	1.335	1.576
110	1.442	1.504	1.554	1.595	2.035
120	1.655	1.751	1.828	1.892	2.598
130	1.879	2.012	2.122	2.212	3.244
140	2.098	2.272	2.414	2.534	3.926
150	2.295	2.507	2.682	2.829	4.576
160	2.452	2.696	2.898	3.068	5.115
170	2.554	2.819	3.038	3.223	5.472
180	2.589	2.861	3.087	3.278	5.598

TABLE OF θ AND Ω AS A FUNCTION OF ϕ FOR $D + D \rightarrow p + T$

Table 20
(See Figs. 20a & 20b)

θ

ϕ \ E_o	6	8	10	12	∞
0	0.00	0.00	0.00	0.00	0.00
2	19.39	12.19	9.64	8.35	4.29
4	34.38	22.99	18.51	16.16	8.38
6	44.57	31.78	26.15	23.06	12.43
8	51.12	38.48	32.39	28.90	15.50
10	55.39	43.49	37.35	33.68	19.43
20	61.71	53.83	49.07	45.91	30.67
30	59.89	54.20	50.60	48.12	34.83
40	55.87	51.39	48.49	46.46	34.98
50	51.08	47.35	44.90	43.18	33.02
60	46.04	42.82	40.69	39.17	30.00
70	41.08	38.15	36.26	34.90	26.51
80	36.11	33.57	31.87	30.64	22.92
90	31.44	29.17	27.64	26.54	19.47
100	27.04	25.02	23.66	22.67	16.29
110	22.98	21.15	19.95	19.08	13.43
120	19.08	17.56	16.53	15.78	10.89
130	15.55	14.22	13.36	12.73	8.65
140	12.18	11.10	10.41	9.91	6.65
150	8.93	8.17	7.65	7.27	4.83
160	5.88	5.37	5.03	4.77	3.15
170	2.92	2.66	2.49	2.35	1.55
180	0.00	0.00	0.00	0.00	0.00

Ω

ϕ \ E_o	6	8	10	12	∞
0	180.00	180.00	180.00	180.00	180.00
10	166.23	165.93	165.71	165.54	164.25
20	152.56	151.96	151.53	151.19	148.61
30	139.09	138.21	137.56	137.07	133.22
40	125.92	124.77	123.92	123.28	118.21
50	113.14	111.76	110.73	109.94	103.76
60	100.86	99.28	98.10	97.18	90.00
70	89.15	87.40	86.10	85.12	77.15
80	78.12	76.26	74.90	73.84	65.35
90	67.76	65.87	64.48	63.41	54.73
100	58.12	56.26	54.90	53.84	45.35
110	49.17	47.41	46.12	45.12	37.14
120	40.87	39.27	38.09	37.19	30.00
130	33.15	31.75	30.73	29.95	23.75
140	25.92	24.74	23.93	23.28	18.22
150	19.09	18.21	17.56	17.07	13.22
160	12.56	11.96	11.53	11.19	8.61
170	6.23	5.93	5.71	5.54	4.25
180	0.00	0.00	0.00	0.00	0.00

TABLE OF Ω AS A FUNCTION OF θ FOR D + D → p + T

Table 21
(See Fig. 21)

θ \ E_0	6		8		10		12		∞	
	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow
0	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00
5	10.68	179.32	11.14	178.87	11.47	178.53	11.72	178.28	13.68	176.32
10	21.37	178.63	22.30	177.71	22.97	177.04	23.49	176.51	27.51	172.50
15	32.09	177.91	33.51	176.49	34.54	175.46	35.34	174.66	41.64	168.37
20	42.45	177.15	44.80	175.20	46.23	173.77	47.34	172.66	56.33	163.67
25	53.68	176.32	56.22	173.78	58.11	171.89	59.58	170.42	72.06	157.94
30	64.59	175.41	67.82	172.18	70.25	169.74	72.19	167.82	90.00	150.00
35	75.64	174.36	79.70	170.30	82.84	167.16	85.39	164.62	118.44	131.55
40	86.86	173.12	92.00	167.98	96.18	163.82	99.68	160.32		
45	98.41	171.59	105.12	164.87	111.05	158.95	116.74	153.26		
50	110.44	169.56	119.95	160.05	131.91	148.09				
55	123.46	166.54								
60	139.54	160.46								
θ Max.	61.72		54.63		50.69		48.12		35.26	
Ω for θ max.	151.72		144.64		140.69		138.12		125.27	

Fig. 17 (See Table 17)

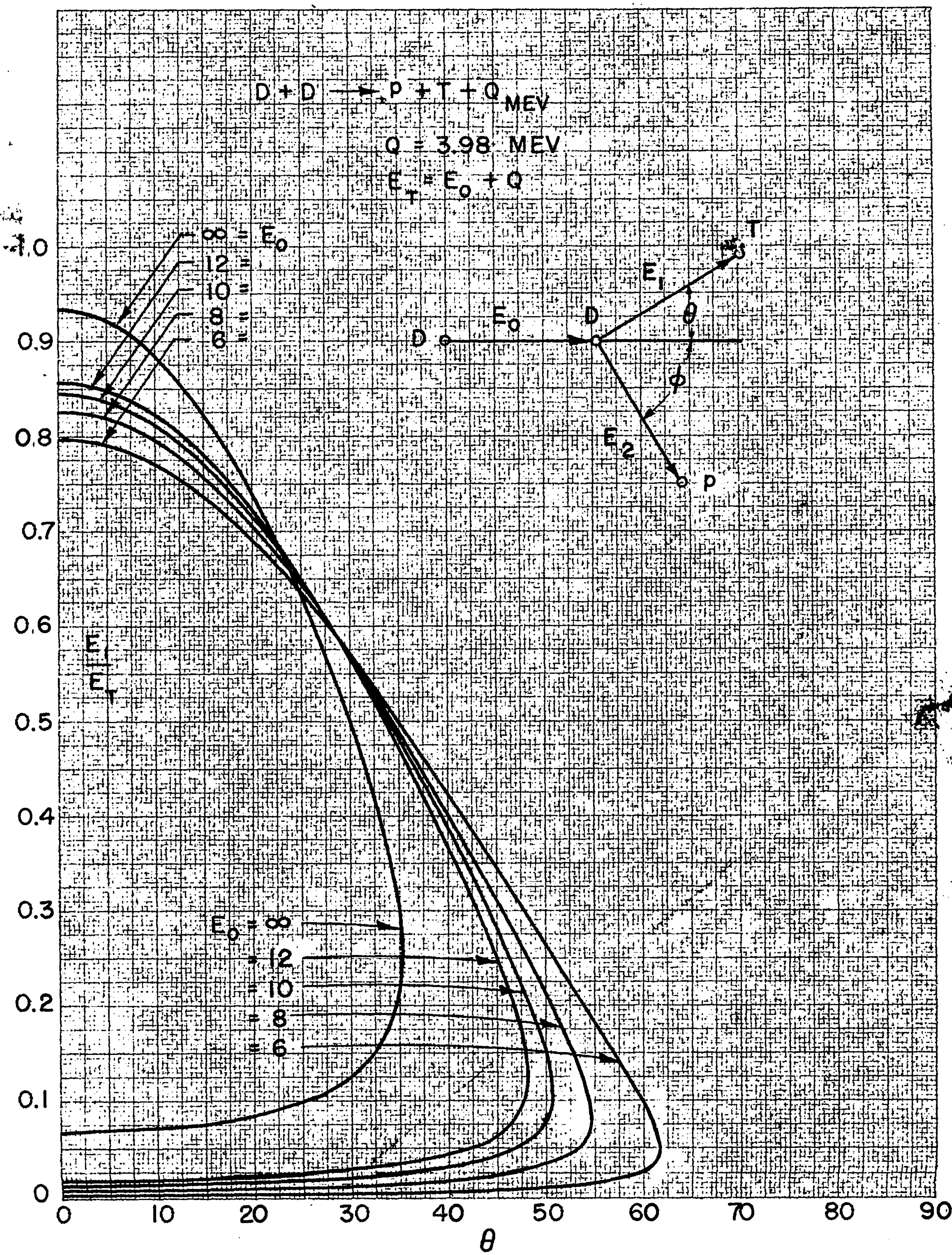


Fig. 18a (See Table 18)

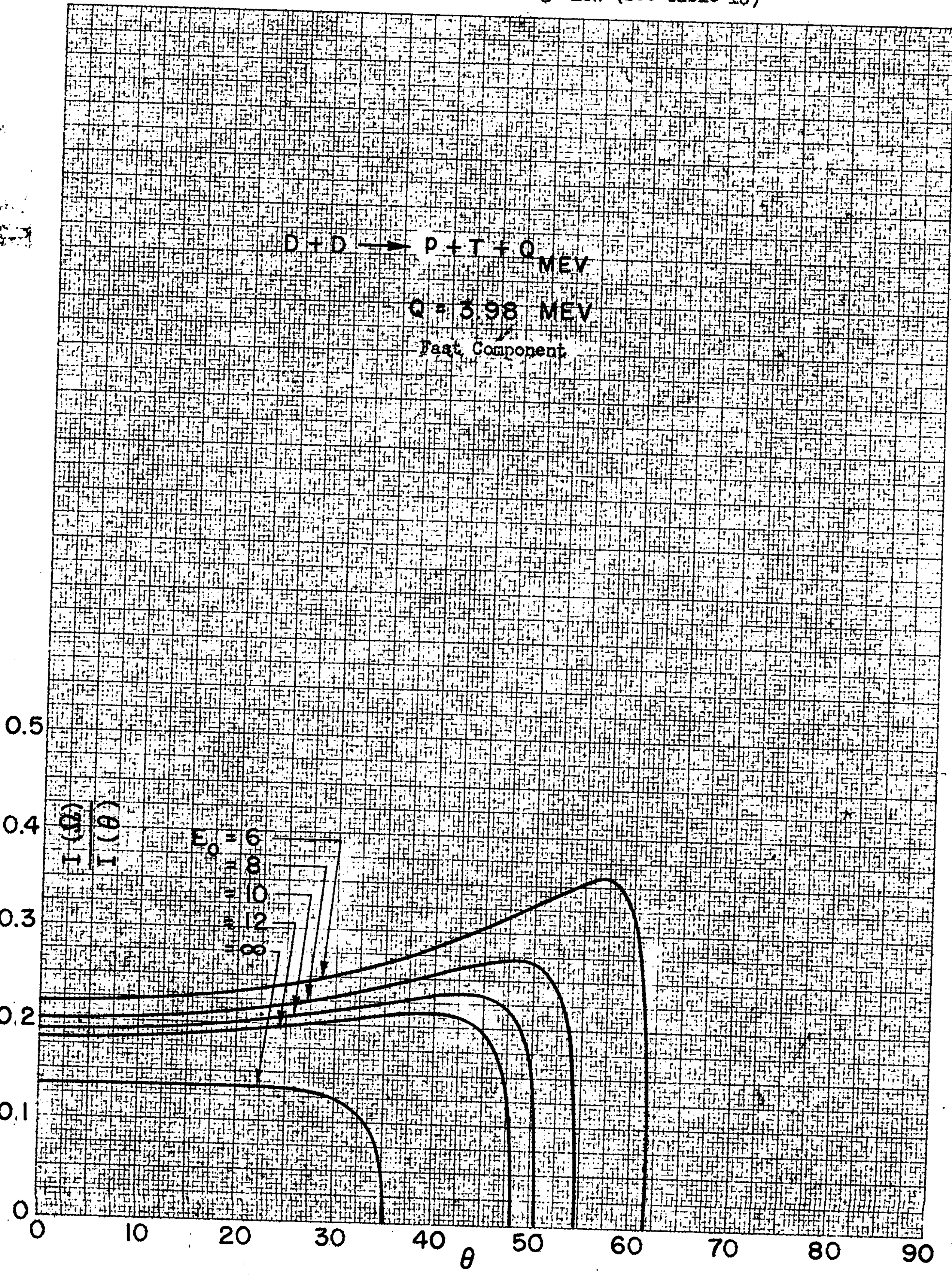


Fig. 18b (See Table 18)

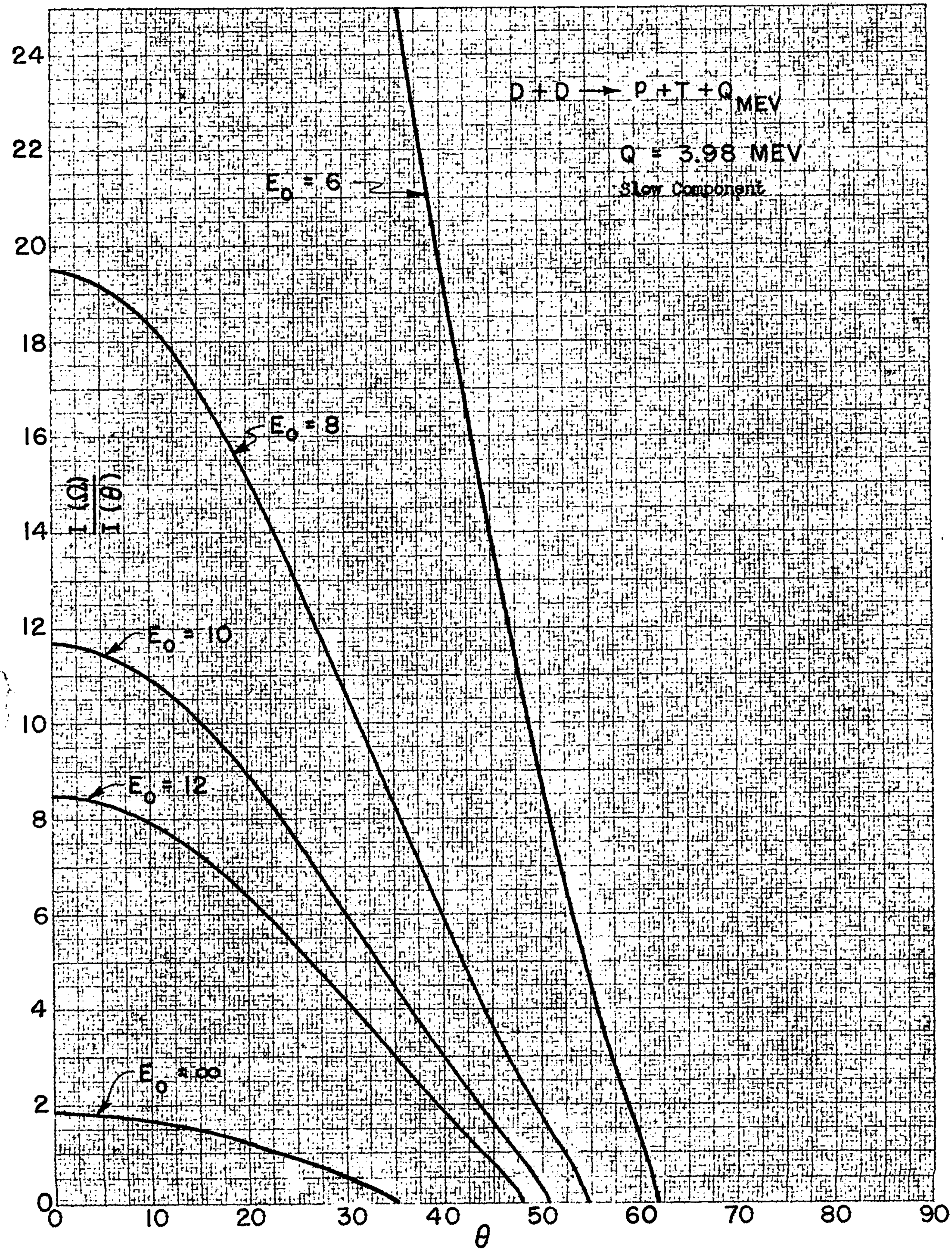


Fig. 19a (See Table 19)

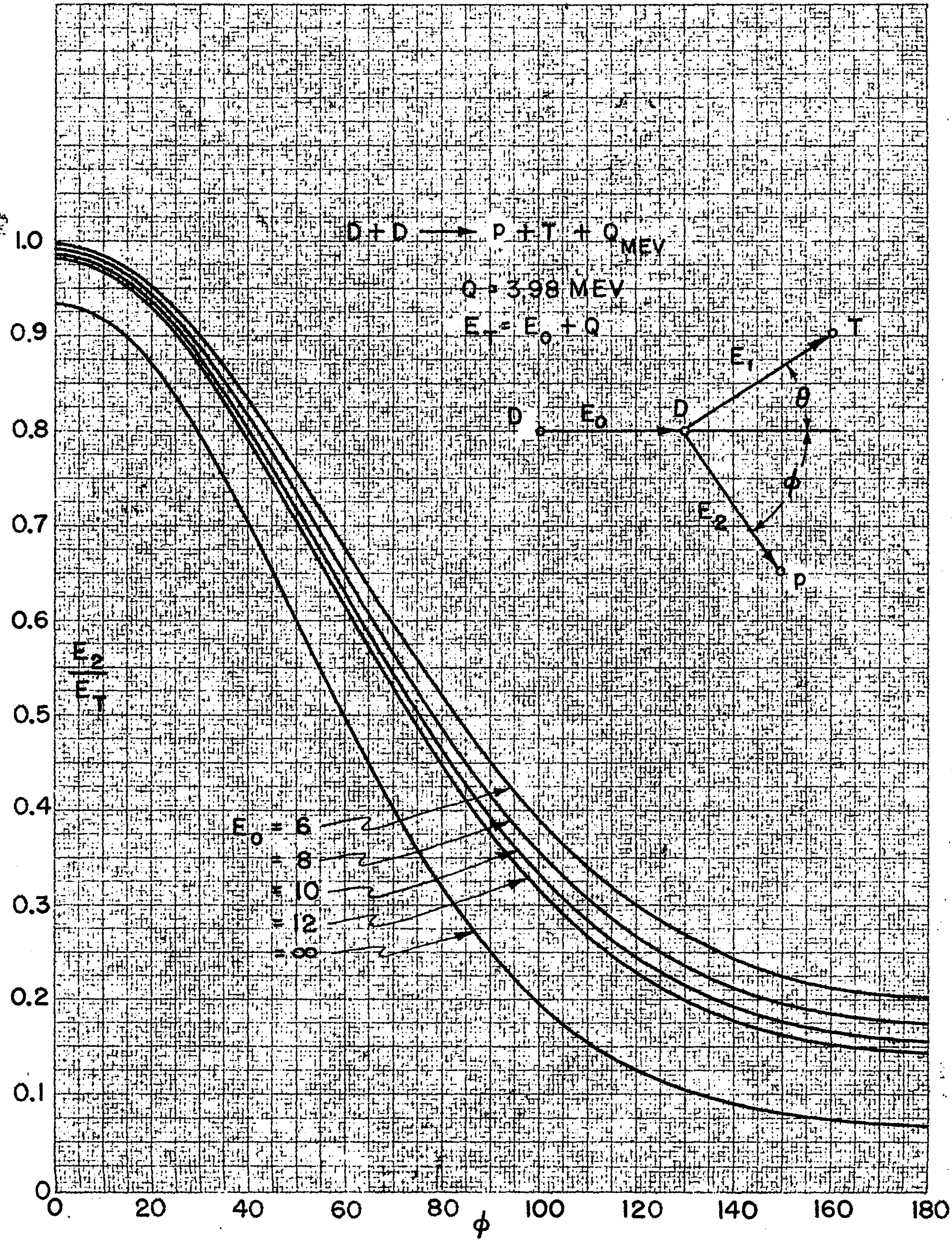


Fig. 19b (See Table 19)

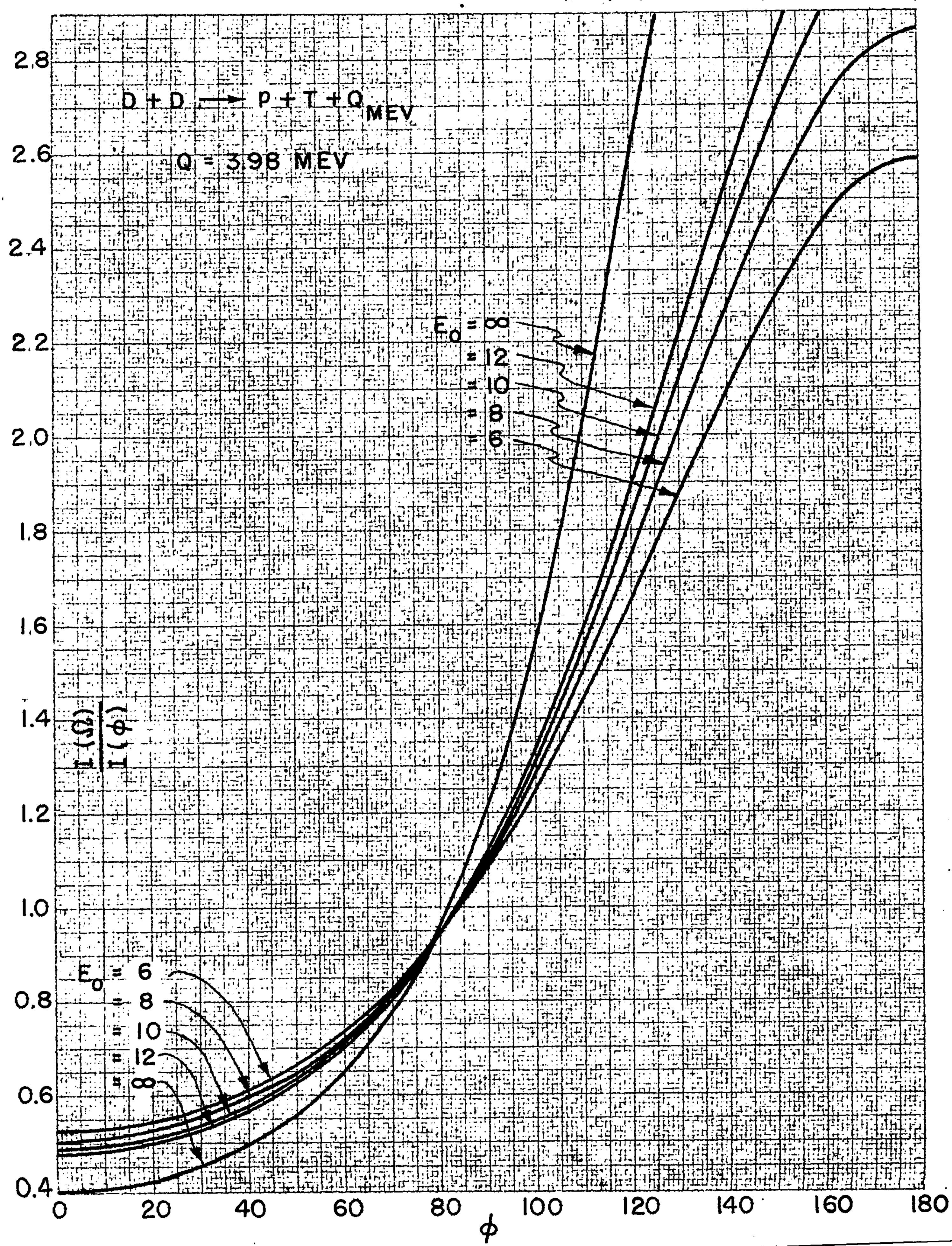


Fig. 20a (See Table 20)

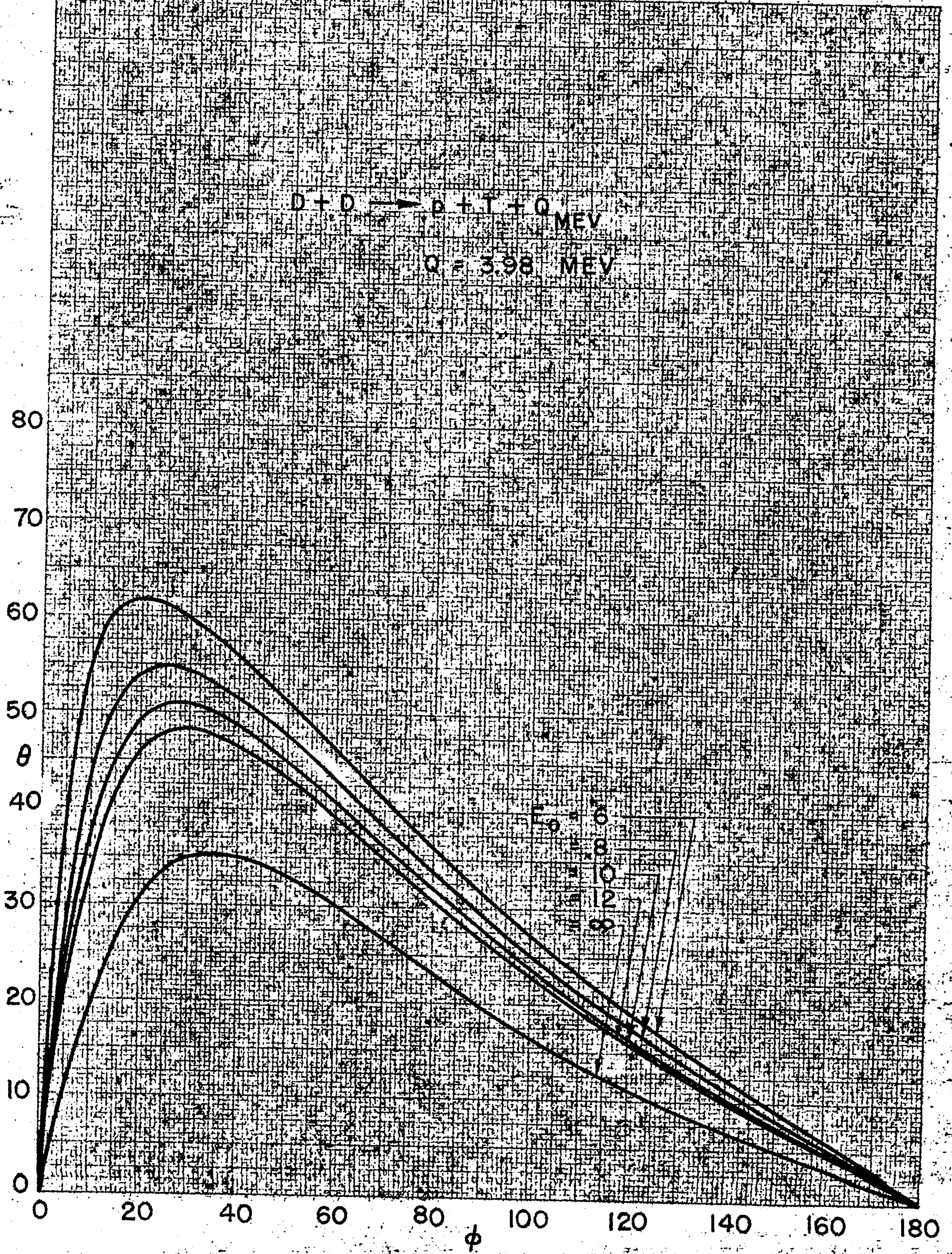


Fig. 20b (See Table 20)

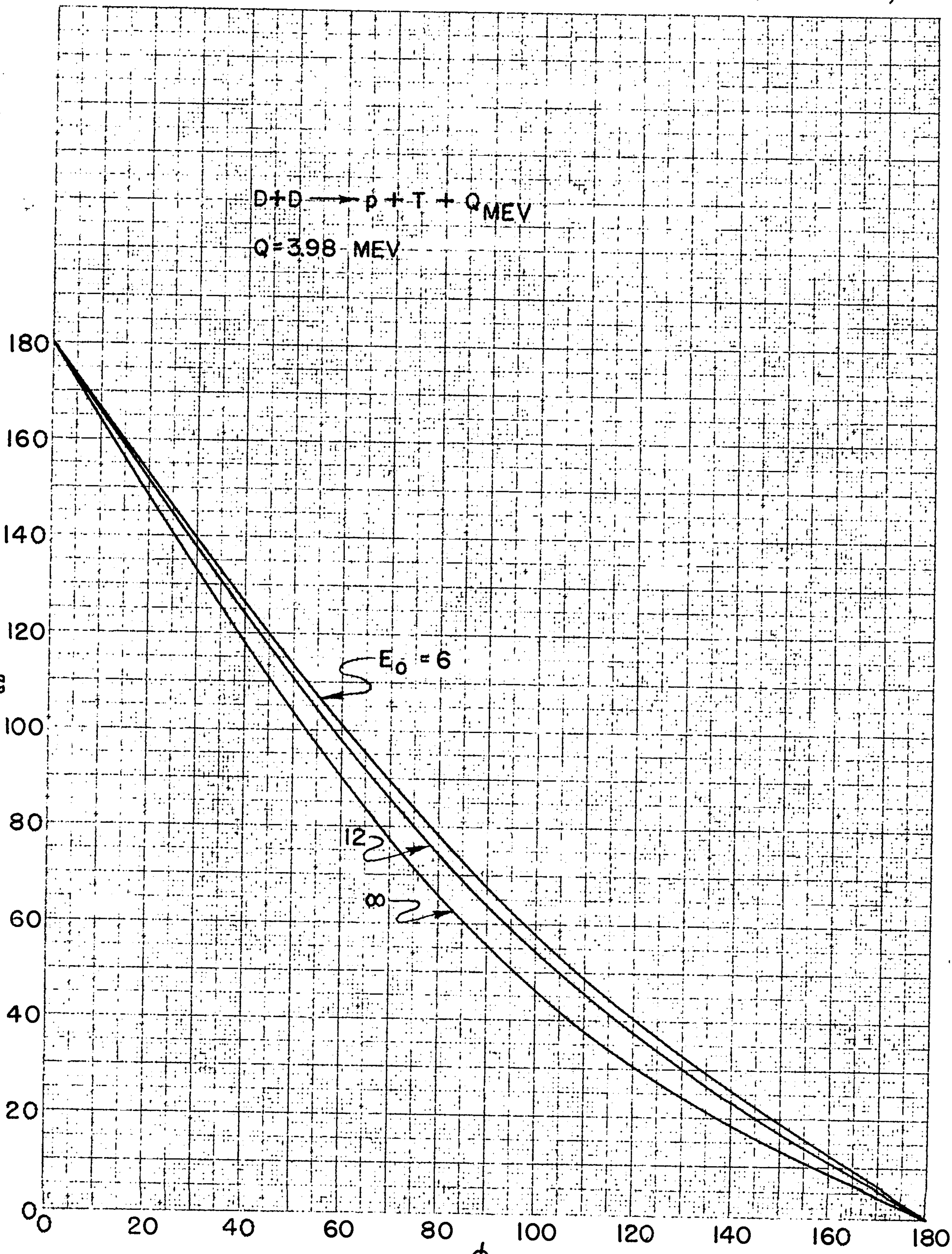


Fig. 21 (See Table 21)

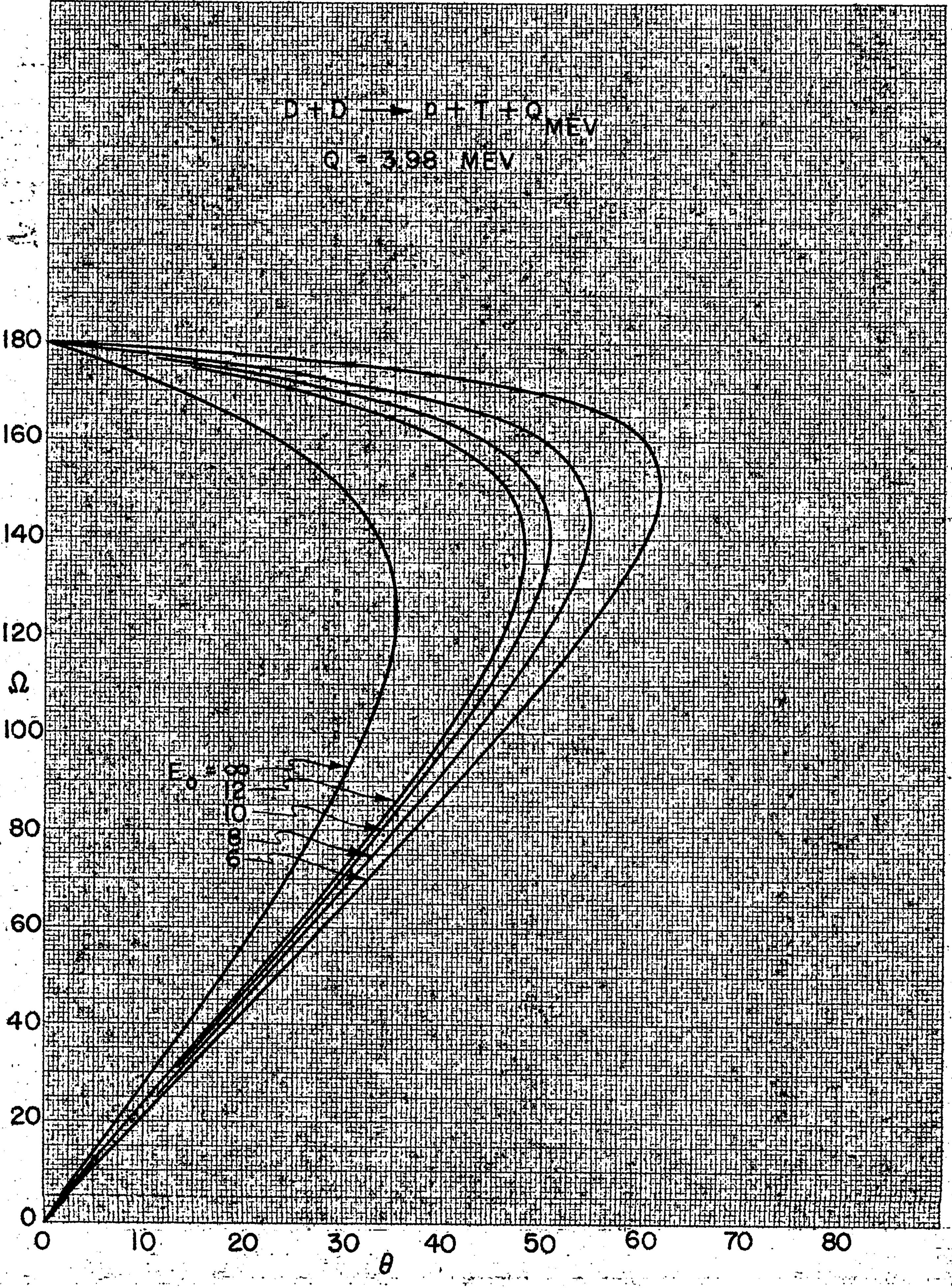


TABLE OF E_1/E_T FOR $D + D \rightarrow n + He^3$

Table 22
(See Fig. 22)

$$E_T = E_0 + 3.24$$

E_0 / θ	6		8		10		12		∞	
	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow
0	.818	.007	.843	.013	.859	.019	.870	.024	.933	.067
5	.810	.007	.834	.013	.850	.019	.861	.024	.922	.069
10	.788	.007	.810	.014	.824	.020	.833	.025	.884	.071
15	.752	.007	.770	.015	.781	.021	.788	.026	.824	.076
20	.703	.008	.715	.016	.723	.023	.727	.028	.740	.084
25	.642	.009	.648	.017	.650	.025	.651	.032	.633	.099
30	.571	.010	.569	.020	.566	.029	.562	.037	.500	.125
35	.493	.011	.481	.023	.470	.035	.460	.045	.294	.213
40	.409	.014	.386	.029	.365	.045	.346	.060		
45	.320	.018	.282	.040	.244	.067	.200	.103		
50	.228	.024	.159	.071						
55	.127	.044								
60										
θ max.	56.37		50.96		47.83		45.77		35.27	
E_1/E_T for θ max.	.075		.106		.128		.144		.250	

Table 23
(See Figs. 23a & 23b)

TABLE OF I (Ω)/ I (Θ) FOR D + D → n + He^3

$E_T = E_0 + 3.24$

E_0 / Θ	6 Fast	6 Slow	8 Fast	8 Slow	10 Fast	10 Slow	12 Fast	12 Slow	∞ Fast	∞ Slow
0	.206	24.8	.191	12.1	.181	8.20	.174	6.38	.134	1.87
5	.207	24.4	.192	11.9	.182	8.06	.175	6.27	.134	1.78
10	.209	23.4	.194	11.4	.184	7.65	.176	5.94	.135	1.69
15	.213	21.6	.197	10.4	.187	6.99	.179	5.40	.136	1.47
20	.219	19.4	.202	9.23	.191	6.12	.183	4.69	.136	1.19
25	.227	16.8	.209	7.81	.197	5.10	.188	3.86	.134	.863
30	.236	13.8	.216	6.26	.203	3.99	.193	2.95	.125	.500
35	.248	10.8	.226	4.66	.210	2.84	.197	2.02	.049	.067
40	.263	7.85	.234	3.11	.212	1.73	.194	1.12		
45	.279	5.06	.236	1.67	.191	.699	.122	.236		
50	.289	2.72	.168	.377						
55	.238	.692								
60										
Θ max.	56.37		50.96		47.83		45.77		35.27	
I (Ω)/ I (Θ) for Θ max.	.000		.000		.000		.000		.000	

TABLE OF E_2/E_T AND $I(\Omega)/I(\phi)$ FOR $D + D \rightarrow n + He^3$

Table 24
(See Figs. 24a & 24b)

$E_T = E_0 + 3.24$

E_2/E_T

ϕ \ E_0	6	8	10	12	∞
0	.993	.987	.981	.976	.933
10	.981	.974	.968	.963	.917
20	.946	.937	.929	.923	.870
30	.891	.878	.868	.860	.797
40	.821	.804	.791	.781	.705
50	.741	.719	.704	.692	.603
60	.656	.631	.613	.599	.500
70	.573	.545	.525	.509	.404
80	.495	.465	.443	.428	.319
90	.425	.394	.372	.356	.250
100	.366	.334	.313	.297	.196
110	.316	.285	.264	.249	.155
120	.276	.246	.226	.212	.125
130	.244	.216	.197	.184	.104
140	.220	.193	.175	.162	.089
150	.203	.177	.160	.148	.078
160	.191	.166	.149	.138	.072
170	.184	.160	.143	.132	.068
180	.182	.157	.141	.130	.067

$I(\Omega)/I(\phi)$

ϕ \ E_0	6	8	10	12	∞
0	.510	.490	.476	.466	.402
10	.515	.495	.481	.471	.407
20	.530	.510	.496	.487	.423
30	.557	.537	.524	.514	.451
40	.596	.578	.565	.556	.494
50	.651	.634	.623	.614	.558
60	.724	.711	.701	.695	.650
70	.819	.812	.806	.803	.780
80	.940	.942	.944	.945	.966
90	1.091	1.107	1.120	1.130	1.225
100	1.274	1.310	1.338	1.361	1.576
110	1.486	1.550	1.601	1.641	2.035
120	1.723	1.822	1.900	1.964	2.598
130	1.973	2.113	2.224	2.315	3.244
140	2.221	2.403	2.549	2.670	3.926
150	2.444	2.668	2.848	2.997	4.576
160	2.624	2.882	3.090	3.263	5.115
170	2.741	3.020	3.248	3.437	5.472
180	2.781	3.068	3.303	3.497	5.598

TABLE OF Θ AND Ω AS A FUNCTION OF ϕ FOR $D + D \rightarrow n + He^3$

Table 25
(See Figs. 25a & 25b)

Θ

ϕ \ E_o	6	8	10	12	∞
0	0.00	0.00	0.00	0.00	0.00
2	13.58	9.80	8.21	7.34	4.29
4	25.35	18.81	15.91	14.28	8.38
6	34.60	26.53	22.74	20.55	12.43
8	41.43	32.82	28.53	25.98	15.50
10	46.34	37.77	33.28	30.54	19.43
20	55.84	49.41	45.54	43.00	30.67
30	55.69	50.86	47.83	45.76	34.83
40	52.58	48.70	46.22	44.51	34.98
50	48.34	45.08	42.97	41.49	33.02
60	43.68	40.84	38.99	37.68	30.00
70	38.92	36.40	34.74	33.57	26.51
80	34.25	31.99	30.50	29.43	22.92
90	29.78	27.75	26.40	25.44	19.47
100	25.56	23.76	22.55	21.69	16.29
110	21.63	20.04	18.98	18.21	13.43
120	17.97	16.60	15.69	15.03	10.89
130	14.56	13.42	12.65	12.10	8.65
140	11.38	10.46	9.85	9.41	6.65
150	8.38	7.69	7.23	6.90	4.83
160	5.51	5.05	4.74	4.52	3.15
170	2.73	2.50	2.35	2.24	1.55
180	0.00	0.00	0.00	0.00	0.00

Ω

ϕ \ E_o	6	8	10	12	∞
0	180.00	180.00	180.00	180.00	180.00
10	166.01	165.73	165.52	165.37	164.25
20	152.13	151.56	151.15	150.84	148.61
30	138.45	137.61	137.01	136.55	133.22
40	125.09	123.99	123.20	122.60	118.21
50	112.17	110.81	109.85	109.12	103.76
60	99.71	98.19	97.09	96.24	90.00
70	87.89	86.19	84.99	84.08	77.15
80	76.78	75.00	73.71	72.73	65.35
90	66.40	64.58	63.27	62.27	54.73
100	56.78	55.00	53.71	52.73	45.35
110	47.90	46.22	45.00	44.08	37.14
120	39.72	38.19	37.08	36.24	30.00
130	32.14	30.81	29.85	29.12	23.75
140	25.09	23.99	23.20	22.60	18.22
150	18.45	17.61	17.00	16.55	13.22
160	12.13	11.56	11.15	10.84	8.61
170	6.01	5.73	5.52	5.37	4.25
180	0.00	0.00	0.00	0.00	0.00

TABLE OF Ω AS A FUNCTION OF θ FOR $D + D \rightarrow n + He^3$

Table 26
(See Fig. 26)

θ \ E_0	6		8		10		12		∞	
	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow
0	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00
5	11.01	178.99	11.44	178.56	11.75	178.25	11.99	178.01	13.68	176.32
10	22.04	177.96	22.92	177.08	23.55	176.45	24.05	175.97	27.51	172.50
15	33.11	[illegible]	34.46	175.54	35.44	174.56	[illegible].18	173.82	41.64	168.37
20	44.25	175.75	46.12	173.88	47.48	172.52	48.51	171.49	56.33	163.67
25	55.50	174.50	57.96	172.04	59.76	170.24	61.14	168.86	72.06	157.94
30	66.91	173.09	70.07	169.93	72.42	167.58	74.25	165.75	90.00	150.00
35	78.55	171.46	82.59	167.40	85.70	164.36	88.17	161.82	118.44	131.55
40	90.36	169.47	95.86	164.15	100.14	159.86	103.79	156.21		
45	103.12	166.87	110.56	159.45	127.56	152.44	125.73	144.28		
50	116.92	163.07	120.48	149.52						
55	134.66	155.33								
θ max.	56.37		50.96		47.83		45.76		35.26	
Ω for θ max.	146.37		140.96		137.83		135.76		125.27	

Fig. 22 (See Table 22)

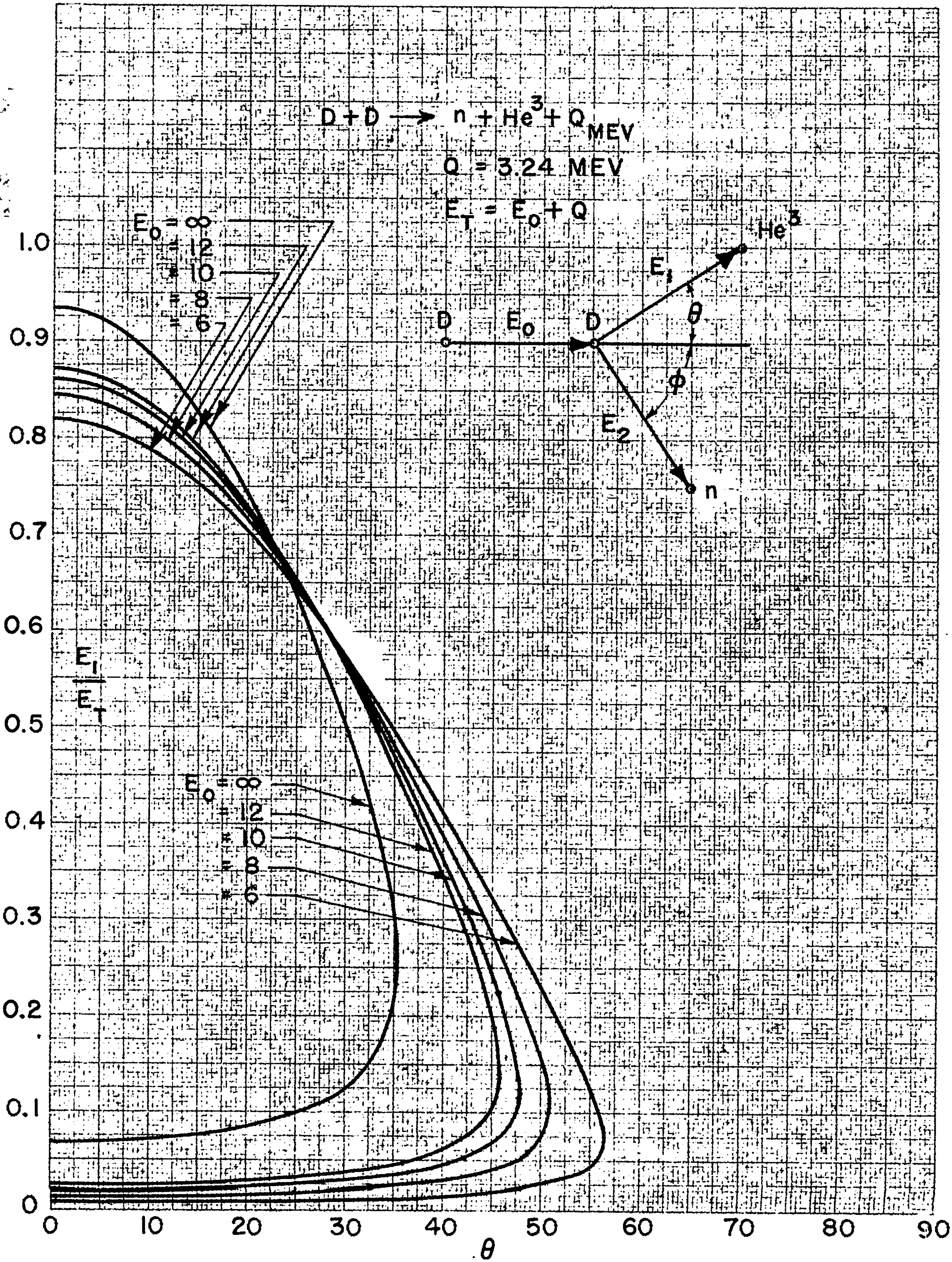


Fig. 23a (See Table 23)

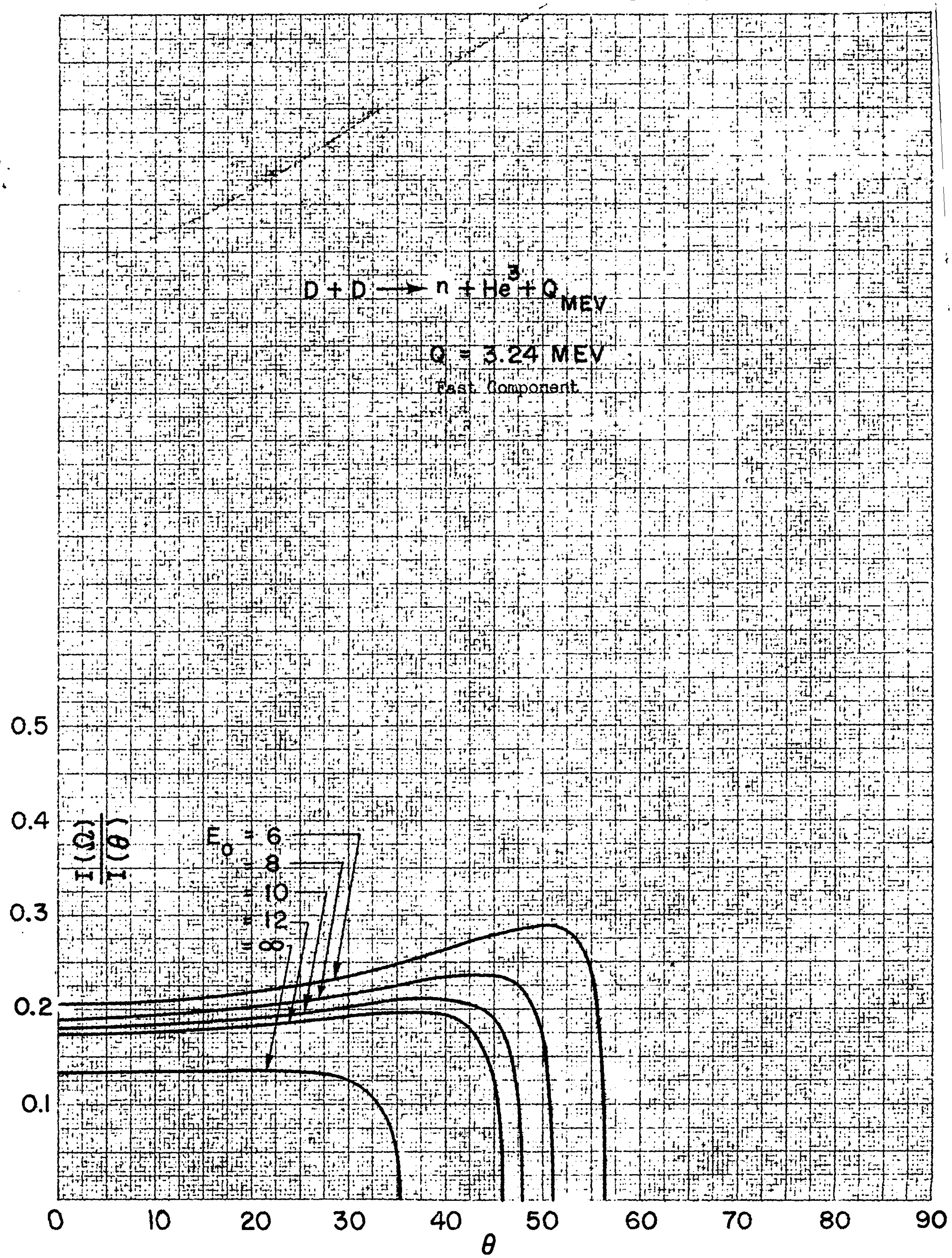


Fig. 23b (See Table 23)

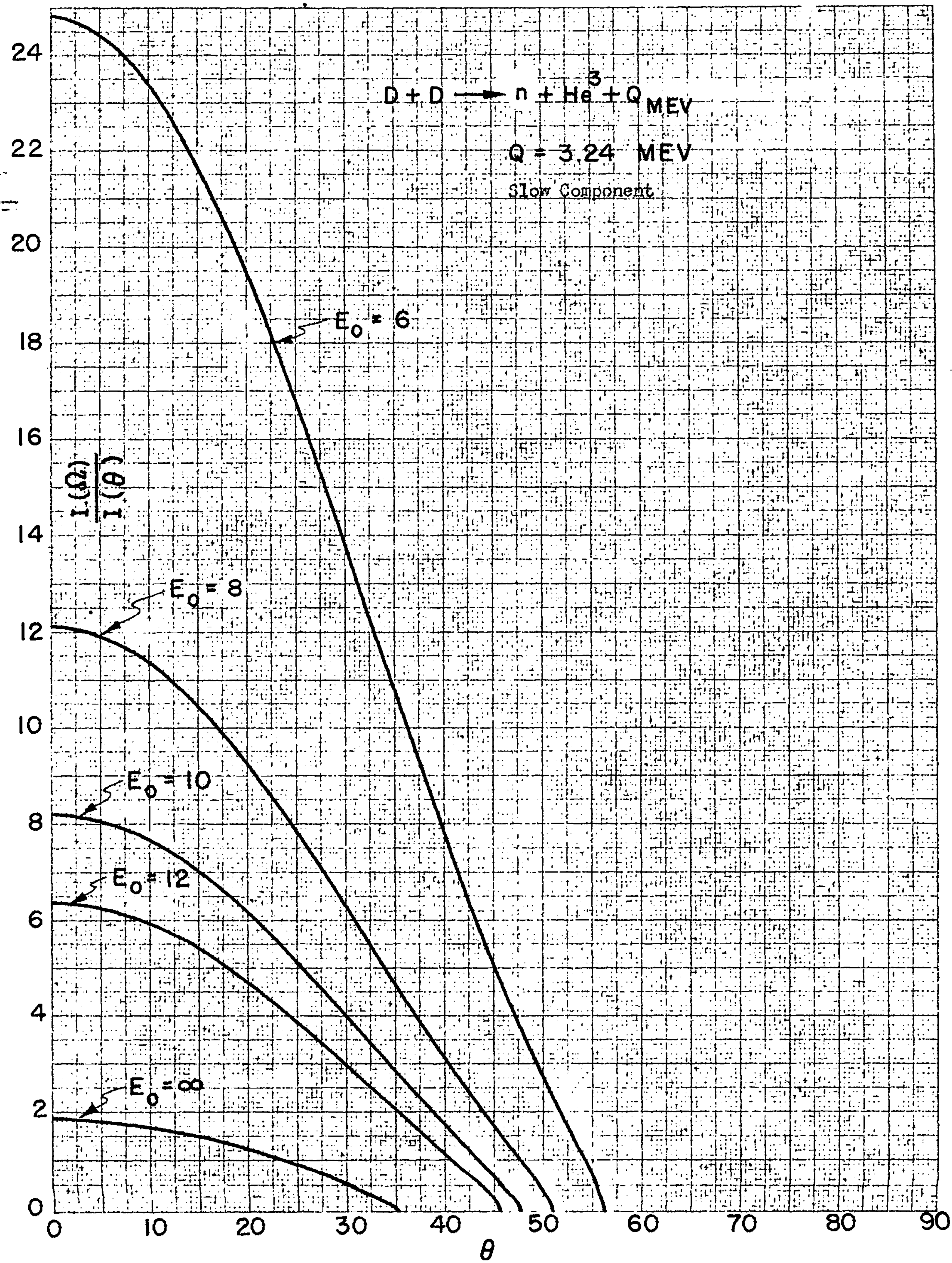


Fig. 24a (See Table 24)

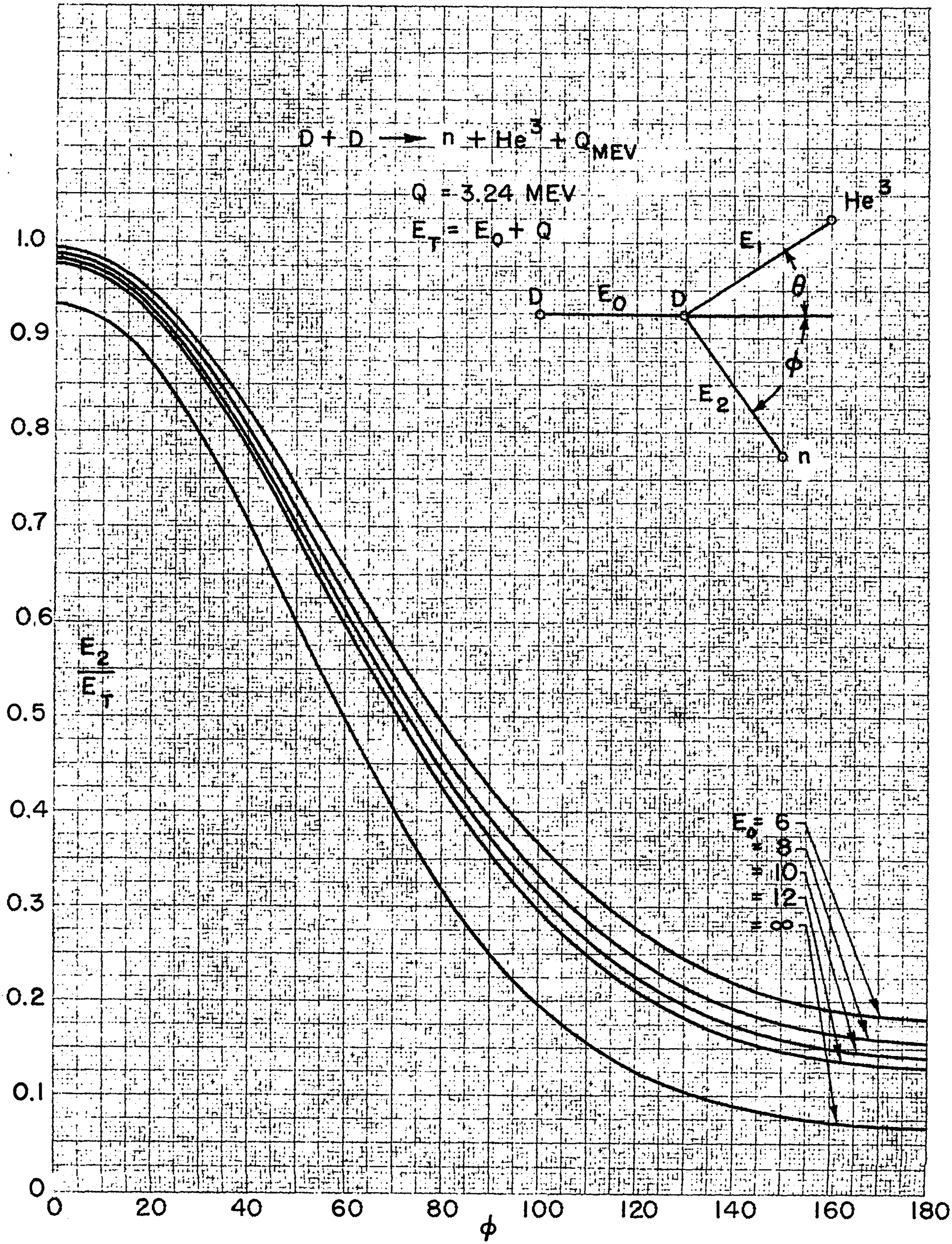


Fig. 24b (See Table 24)

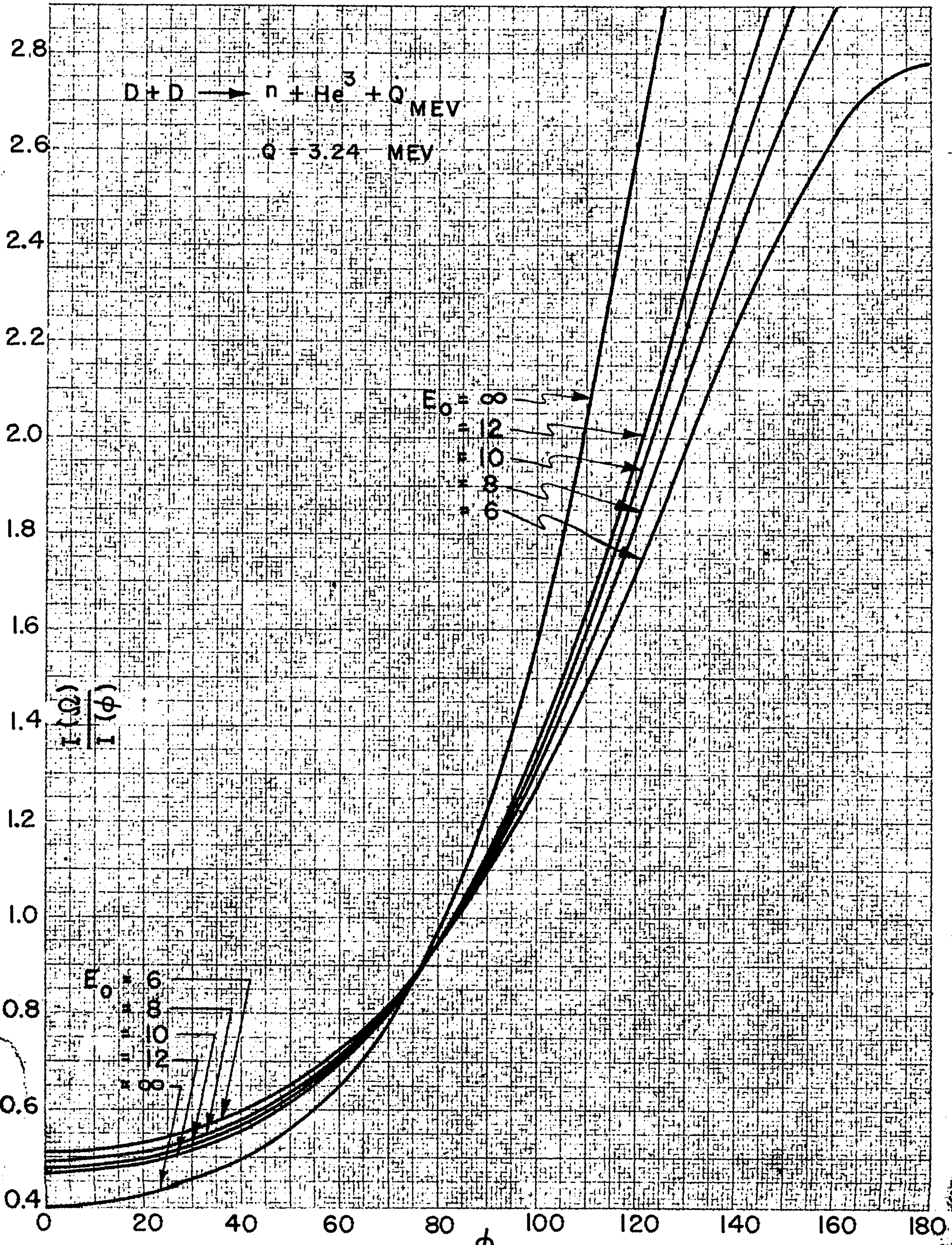


Fig. 25a(See Table 25)

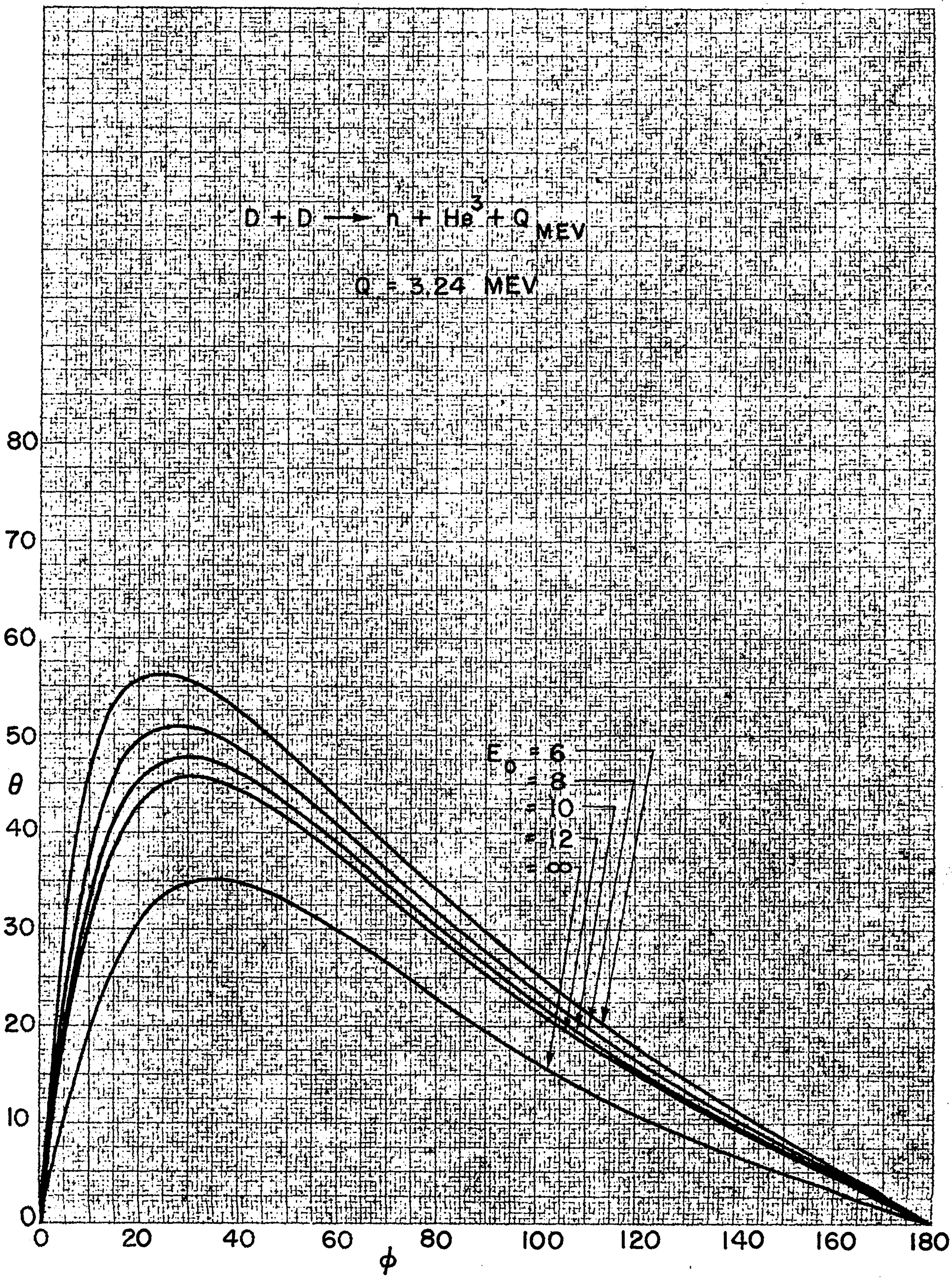


Fig. 25b (See Table 25)

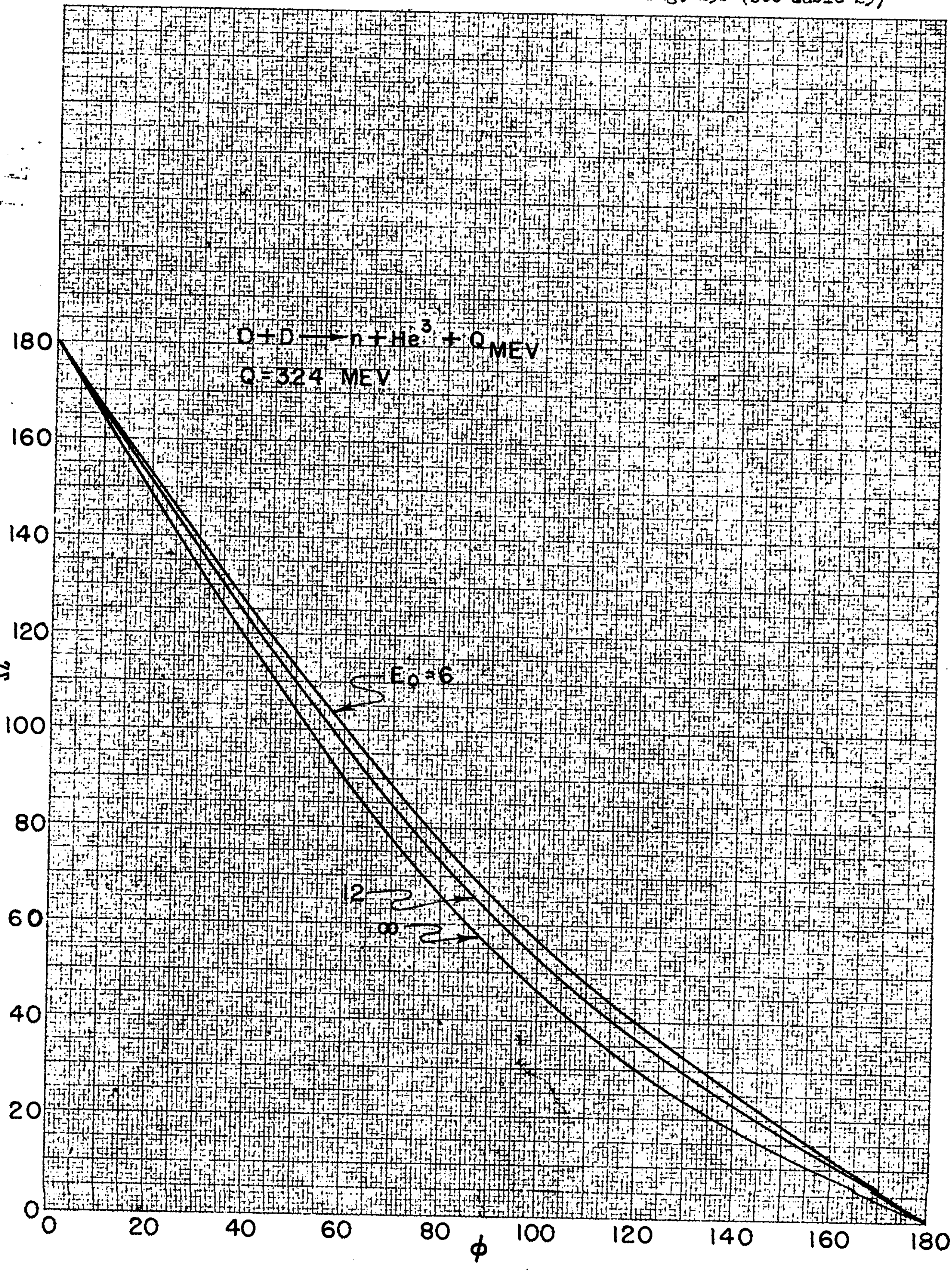


Fig. 26 (See Table 26)

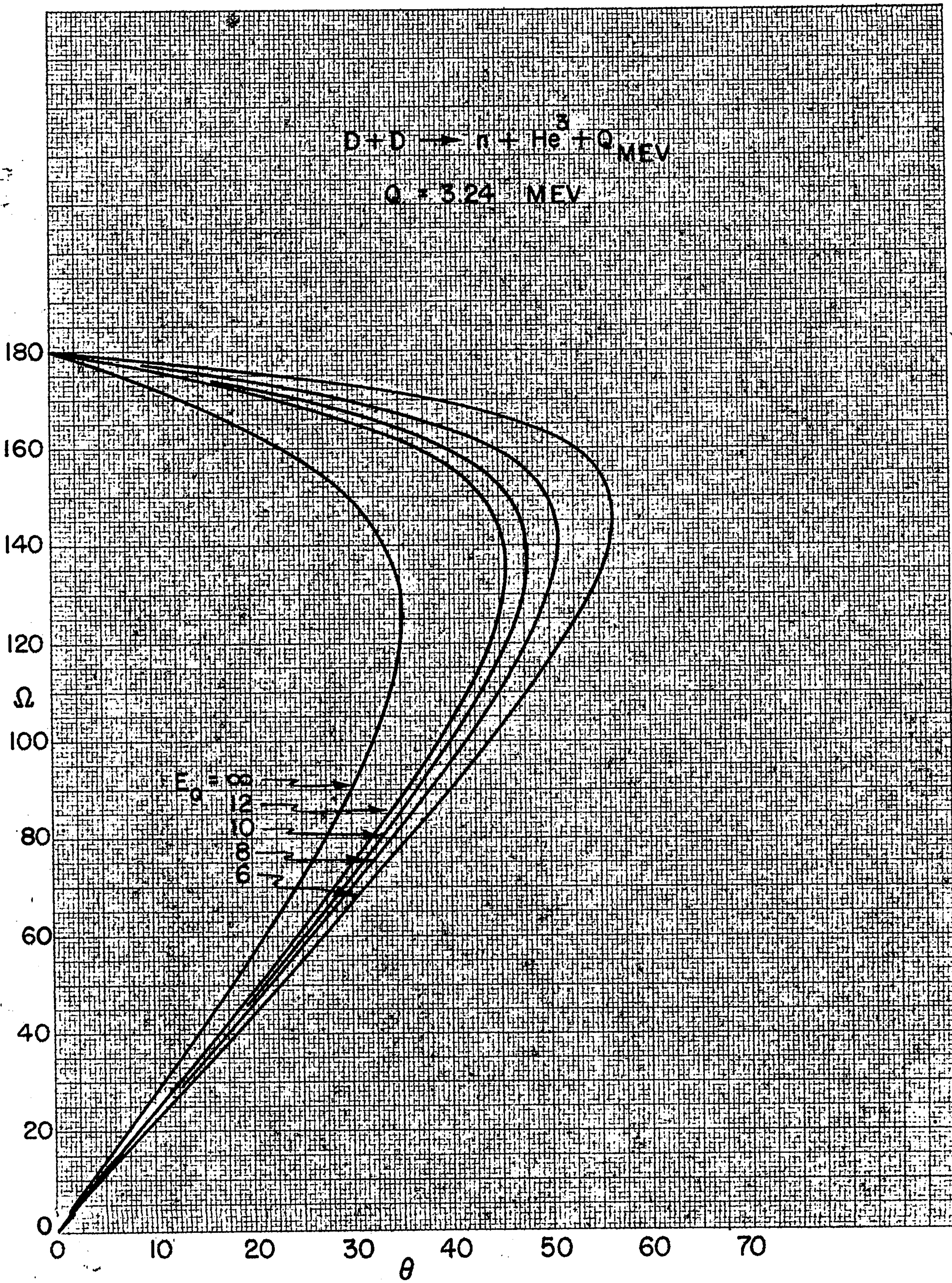


TABLE OF E_1/E_T AND $I(\Omega)/I(\Theta)$ FOR $D + He^3 \rightarrow p + He^4$

Table 27

E_1/E_T $\qquad$ $E_T = E_0 + 18.40$ $\qquad$ $I(\Omega) / I(\Theta)$ (See Figs. 27a & 27b)

Θ \ E_o	6	8	10	12	Θ \ E_o	6	8	10	12
0	.497	.534	.563	.586	0	.363	.329	.305	.287
10	.487	.522	.549	.571	10	.368	.334	.310	.292
20	.459	.487	.509	.527	20	.383	.349	.324	.305
30	.414	.434	.449	.459	30	.411	.376	.350	.331
40	.359	.368	.373	.376	40	.454	.419	.393	.372
50	.299	.297	.293	.287	50	.549	.487	.461	.439
60	.239	.227	.215	.202	60	.620	.592	.571	.552
70	.184	.165	.147	.130	70	.769	.761	.757	.755
80	.138	.115	.095	.076	80	.994	1.04	1.09	1.15
90	.102	.079	.059	.042	90	1.33	1.49	1.70	2.00
100	.075	.054	.037	.023	100	1.83	2.23	2.82	3.78
110	.056	.038	.024	.014	110	2.52	3.35	4.69	7.16
120	.043	.027	.016	.009	120	3.42	4.93	7.52	12.7
130	.035	.021	.012	.006	130	4.50	6.91	11.3	20.4
140	.029	.017	.009	.005	140	5.68	9.16	15.7	29.7
150	.025	.014	.008	.004	150	6.83	11.4	20.1	39.3
160	.023	.013	.007	.003	160	7.80	13.3	24.0	47.8
170	.021	.012	.006	.003	170	8.45	14.6	26.7	53.6
180	.021	.012	.006	.003	180	8.68	15.1	27.6	55.7

TABLE OF E_2/E_T AND $I(\Omega)/I(\phi)$ FOR $D + He^3 \rightarrow p + He^4$

Table 28

E_2/E_T — $E_T = E_0 + 18.40$

ϕ \ E_0	6	8	10	12	∞
0	.979	.988	.994	.997	.952
10	.974	.983	.988	.990	.940
20	.960	.967	.970	.971	.906
30	.937	.940	.941	.941	.852
40	.906	.906	.904	.900	.784
50	.870	.865	.859	.853	.705
60	.829	.820	.810	.801	.623
70	.787	.772	.759	.747	.542
80	.744	.725	.708	.693	.467
90	.702	.679	.659	.642	.400
100	.662	.636	.614	.594	.343
110	.626	.597	.572	.552	.295
120	.594	.562	.536	.515	.257
130	.566	.533	.506	.483	.227
140	.543	.509	.481	.458	.204
150	.526	.490	.462	.438	.188
160	.513	.477	.448	.425	.177
170	.505	.469	.440	.416	.170
180	.503	.466	.437	.414	.168

$I(\Omega)/I(\phi)$ (See Figs. 28a & 28b)

ϕ \ E_0	6	8	10	12	∞
0	.737	.711	.692	.676	.504
10	.740	.715	.695	.680	.509
20	.750	.726	.707	.692	.525
30	.767	.744	.727	.712	.551
40	.791	.771	.754	.741	.591
50	.823	.805	.790	.779	.646
60	.861	.846	.835	.826	.720
70	.906	.896	.889	.883	.817
80	.957	.954	.951	.949	.941
90	1.014	1.018	1.021	1.024	1.095
100	1.075	1.087	1.098	1.107	1.283
110	1.139	1.161	1.179	1.195	1.503
120	1.203	1.235	1.262	1.286	1.749
130	1.264	1.306	1.343	1.375	2.010
140	1.320	1.372	1.417	1.457	2.268
150	1.368	1.429	1.481	1.528	2.503
160	1.404	1.472	1.530	1.583	2.691
170	1.427	1.499	1.561	1.617	2.813
180	1.435	1.508	1.572	1.629	2.856

TABLE OF Θ AND Ω VS. ϕ FOR $D + He^3 \rightarrow p + He^4$

Table 29
(See Figs. 29a & 29b)

Θ

ϕ \ E_0	6	8	10	12	∞
0	180.00	180.00	180.00	180.00	0.00
2	173.15	170.82	167.50	162.26	4.43
4	166.41	161.95	155.82	147.07	8.75
6	159.88	153.61	145.49	134.77	12.84
8	153.61	145.90	136.49	125.32	16.67
10	147.68	138.89	128.95	117.96	20.15
20	123.20	113.29	104.33	96.40	32.07
30	105.82	97.14	90.00	84.18	36.90
40	92.61	85.54	79.67	75.14	37.70
50	81.90	75.76	71.08	67.37	36.35
60	72.69	67.44	63.47	60.36	33.85
70	64.48	59.95	56.54	53.87	30.77
80	57.00	53.05	50.10	47.78	27.45
90	50.06	46.62	44.05	42.04	24.09
100	43.56	40.57	38.34	36.60	20.82
110	37.41	34.84	32.92	31.42	17.69
120	31.56	29.38	27.75	26.48	14.74
130	25.94	24.14	22.79	21.74	11.97
140	20.52	19.09	18.02	17.18	9.37
150	15.25	14.18	13.35	12.76	6.90
160	10.11	9.40	8.86	8.45	4.54
170	5.03	4.68	4.41	4.20	2.25
180	0.00	0.00	0.00	0.00	0.00

Ω

ϕ \ E_0	6	8	10	12	∞
0	180.00	180.00	180.00	180.00	180.00
10	168.36	168.16	167.98	167.84	165.93
20	156.76	156.36	156.03	155.75	151.97
30	145.26	144.67	144.19	143.78	138.22
40	133.91	133.14	132.52	132.00	124.79
50	122.73	121.82	121.08	120.45	111.77
60	111.78	110.75	109.90	109.19	99.29
70	101.08	99.96	99.02	98.26	87.46
80	90.73	89.37	88.60	87.69	76.30
90	80.49	79.30	78.33	77.50	65.91
100	70.63	69.46	68.51	67.69	56.29
110	61.07	59.95	59.04	58.26	47.44
120	51.78	50.75	49.90	49.19	39.30
130	41.95	41.82	41.08	40.45	31.78
140	33.91	33.14	32.52	32.00	24.79
150	25.26	24.67	24.20	23.78	18.22
160	16.76	16.36	16.03	15.75	11.97
170	8.36	8.15	7.99	7.84	5.93
180	0.00	0.00	0.00	0.00	0.00

TABLE OF Ω VS. θ FOR $D + He^3 \rightarrow p + He^4$

Table 30
(See Fig. 30)

θ \ E_0	6	8	10	12
0	0.00	0.00	0.00	0.00
10	16.59	17.41	18.08	18.65
20	33.06	34.72	36.06	37.23
30	49.29	51.80	53.88	55.66
40	65.13	68.52	71.37	73.83
50	80.40	84.70	88.34	91.56
60	94.86	100.04	104.53	108.59
70	108.37	114.26	119.55	124.47
80	120.58	127.01	132.89	138.53
90	131.34	137.97	144.08	150.00
100	140.59	147.01	152.89	158.53
110	148.37	154.26	159.55	164.47
120	154.89	160.04	164.53	168.59
130	160.40	164.68	168.34	171.56
140	165.12	168.52	171.37	173.83
150	169.29	171.80	173.89	175.66
160	173.05	174.72	176.08	177.23
170	176.59	177.41	178.08	178.65
180	180.00	180.00	180.00	180.00

Fig. 27a (See Table 27)

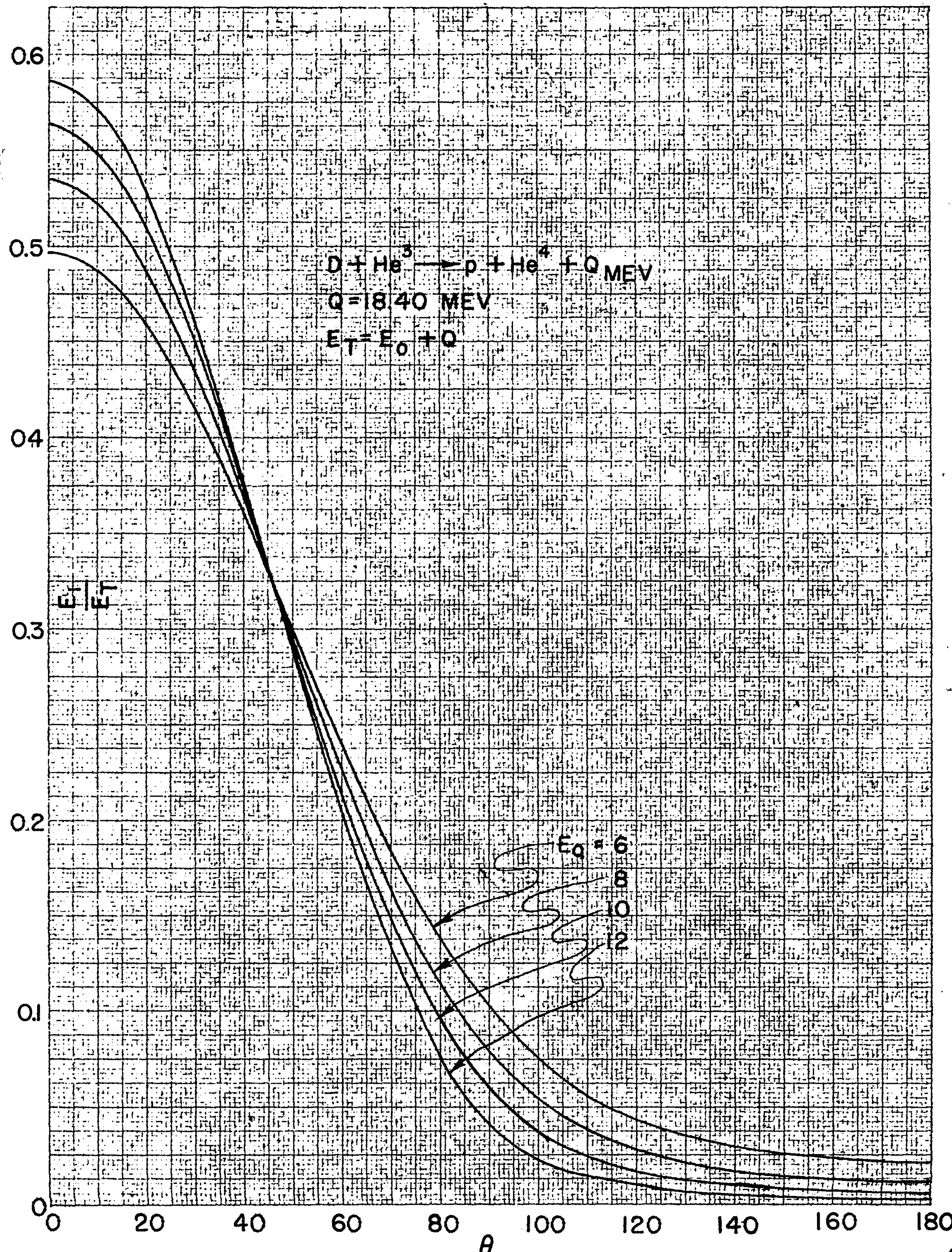


Fig. 27b (See Table 27)

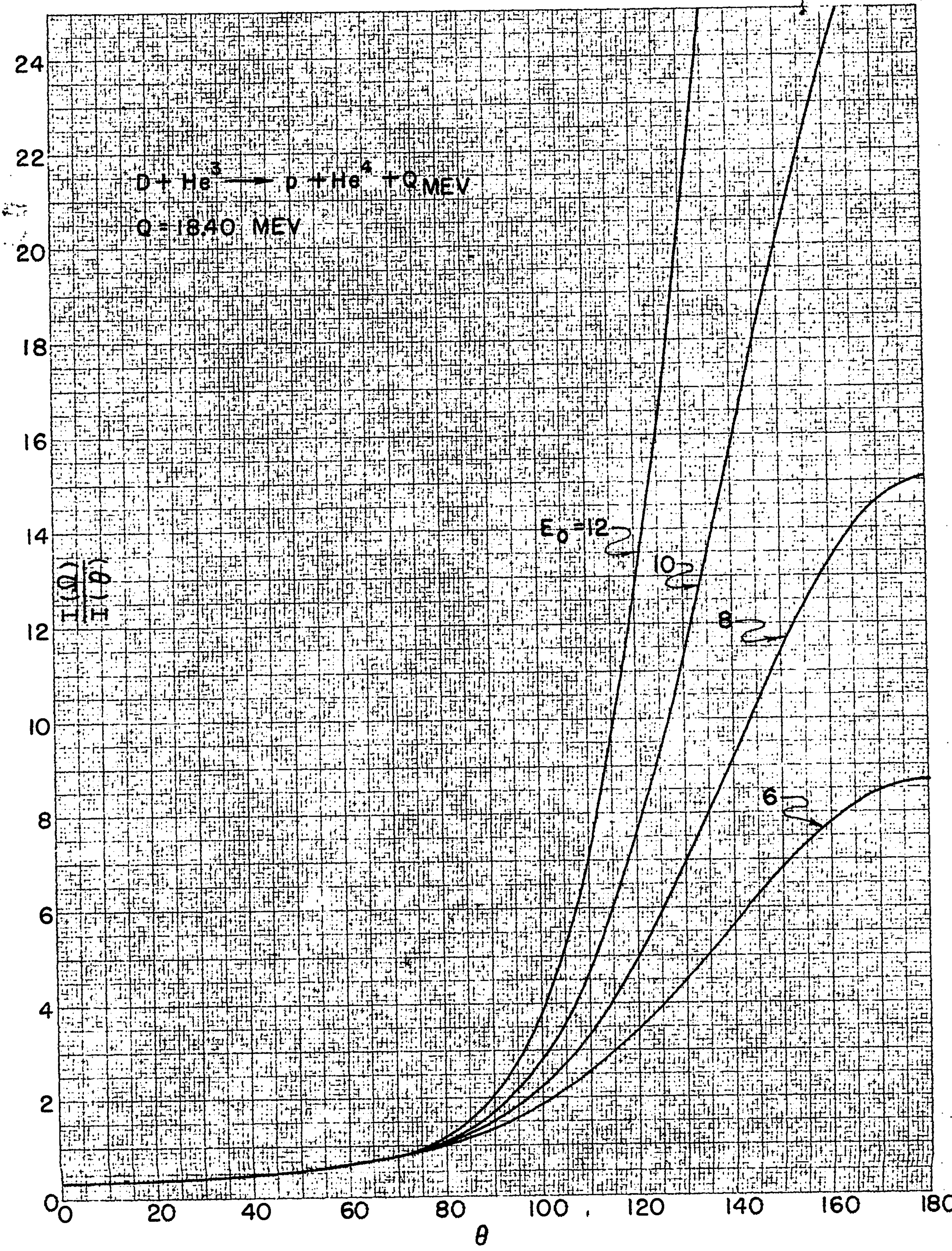


Fig 28a (See Table 28)

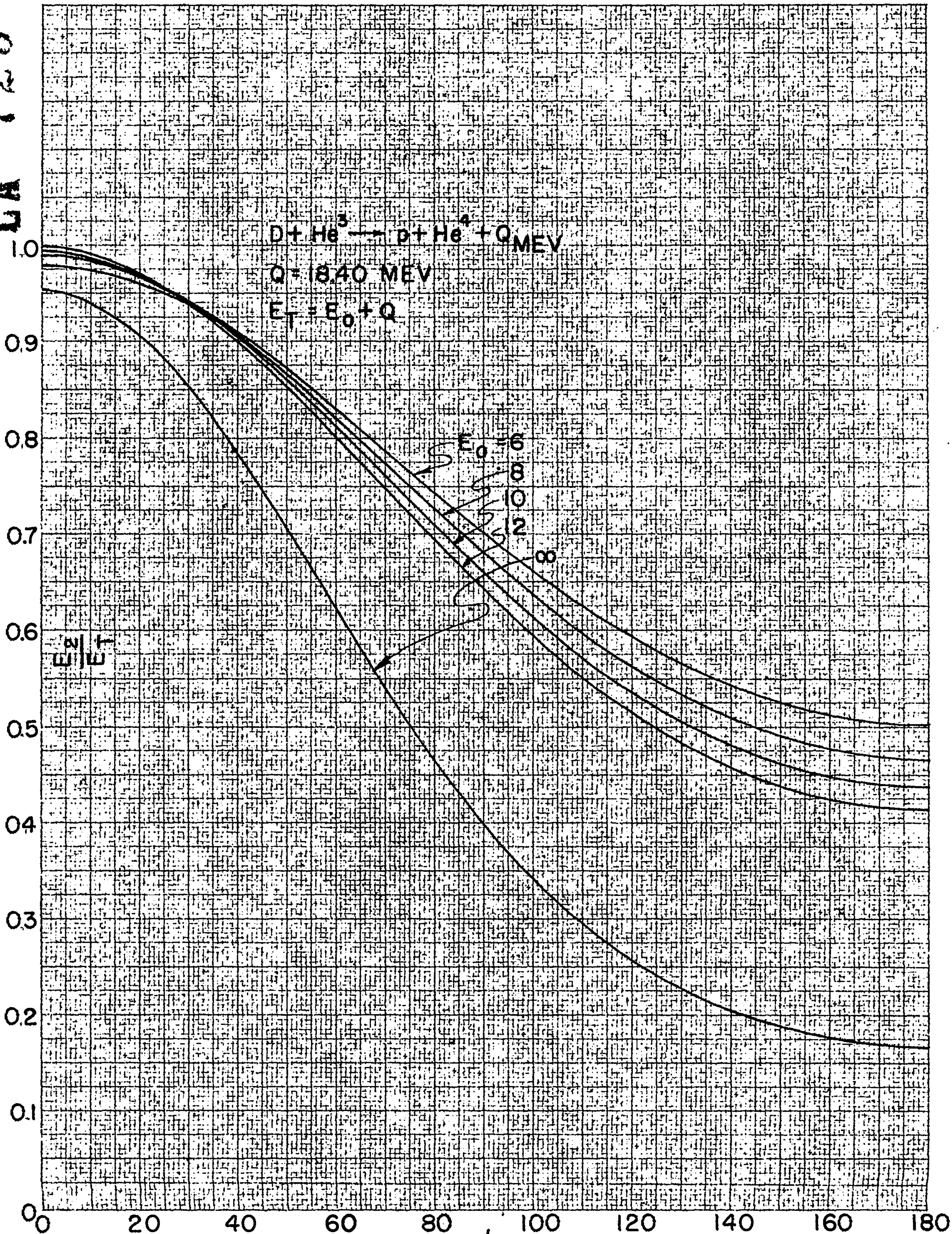


Fig. 28b (See Table 28)

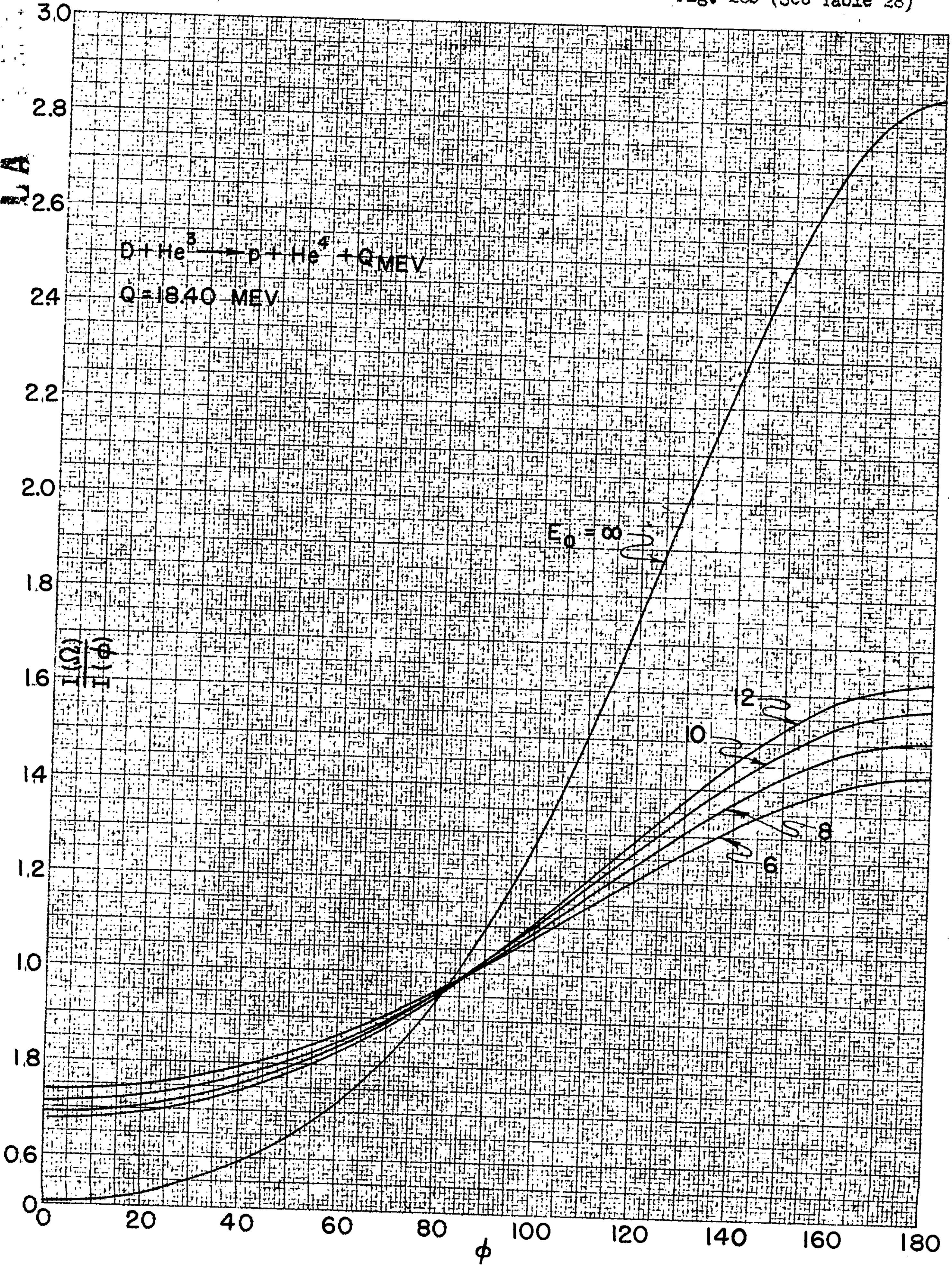


Fig 29a (See Table 29)

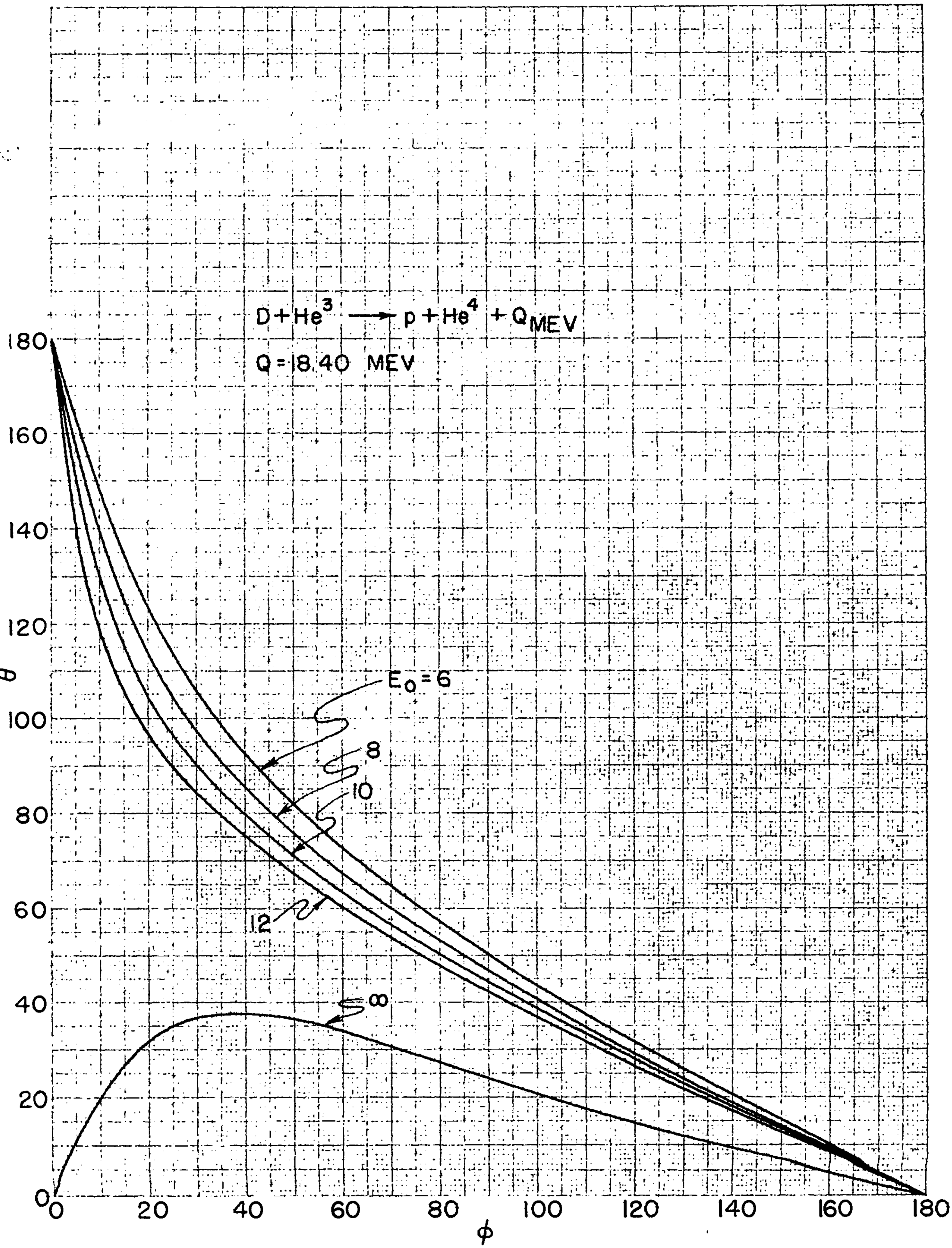


Fig. 29b (See Table 29)

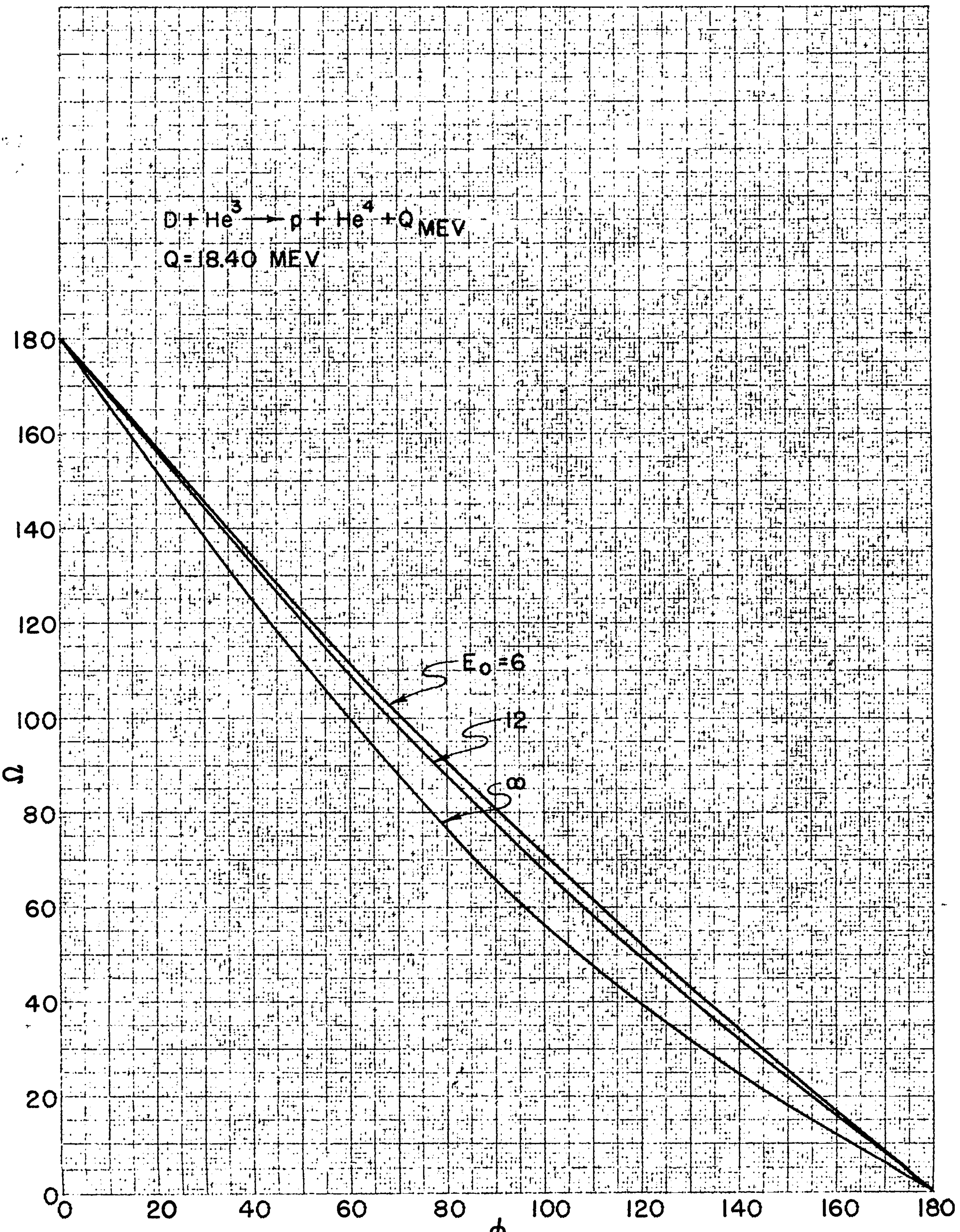


Fig. 30 (See Table 30)

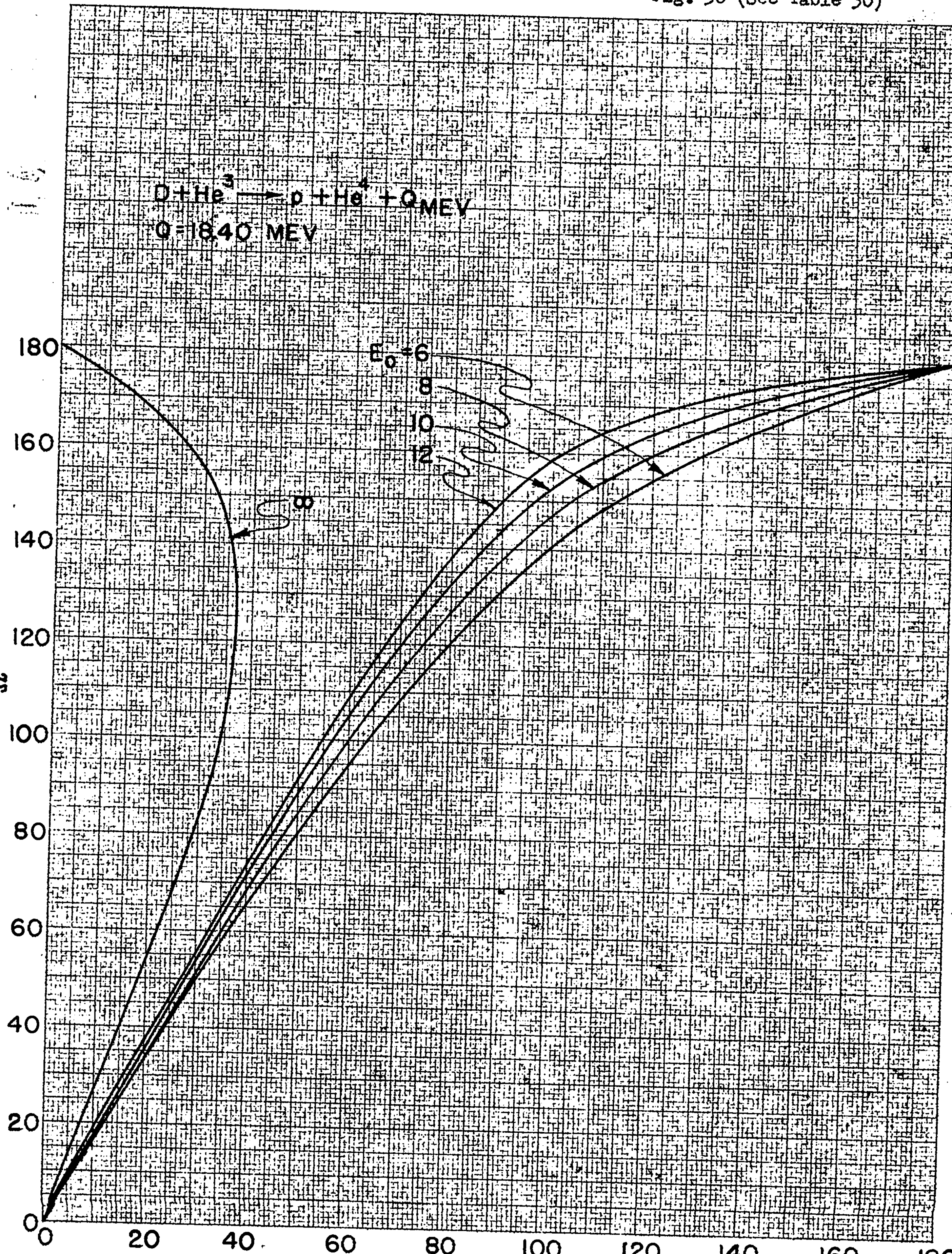


TABLE OF E_1/E_T AND I (Ω)/ I (θ) FOR D + T → n + He^4

Table 31
(See Figs. 31a & 31b)

E_1/E_T $E_T = E_0 + 17.60$ I (Ω)/ I (θ)

θ \ E_0	6	8	10	12	θ \ E_0	6	8	10	12
0	.503	.540	..569	.592	0	.357	.324	.301	.283
10	.493	.527	.554	.576	10	.362	.329	.305	.287
20	.463	.492	.514	.531	20	.378	.344	.319	.301
30	.418	.437	.451	.462	30	.405	.371	.345	.326
40	.361	.369	.374	.376	40	.449	.414	.388	.367
50	.299	.296	.291	.285	50	.515	.482	.455	.434
60	.237	.225	.212	.198	60	.615	.588	.566	.548
70	.181	.162	.143	.125	70	.767	.760	.757	.754
80	.135	.112	.091	.071	80	.999	1.05	1.10	1.17
90	.098	.075	.055	.038	90	1.35	1.53	1.76	2.10
100	.072	.050	.033	.020	100	1.87	2.32	2.99	4.16
110	.053	.035	.021	.011	110	2.61	3.55	5.12	8.22
120	.041	.025	.014	.007	120	3.58	5.29	8.37	15.0
130	.032	.019	.010	.005	130	4.76	7.52	12.7	24.7
140	.027	.015	.008	.004	140	6.05	10.0	17.9	36.4
150	.023	.013	.007	.003	150	7.31	12.6	23.2	48.5
160	.021	.011	.006	.003	160	8.38	14.8	27.8	59.4
170	.020	.011	.005	.002	170	9.09	16.3	30.9	66.8
180	.019	.010	.005	.002	180	9.35	16.8	32.1	69.2

TABLE OF E_2/E_T AND I (Ω)/ I (φ) FOR D + T → n + He^4

Table 32
(See Figs. 32a & 32b)

E_2/E_T — $E_T = E_0 + 17.60$ — I (Ω)/ I (φ)

φ \ E_0	6	8	10	12	∞	φ \ E_0	6	8	10	12	∞
0	.981	.990	.995	.998	.952	0	.733	.707	.688	.672	.504
2	.981	.989	.994	.997	.952	2	.733	.708	.688	.672	.504
4	.980	.989	.994	.996	.950	4	.733	.708	.688	.673	.505
6	.979	.988	.992	.995	.948	6	.734	.709	.689	.673	.506
8	.978	.986	.991	.993	.944	8	.735	.710	.690	.674	.507
10	.976	.984	.988	.991	.940	10	.736	.711	.692	.676	.509
20	.961	.967	.970	.971	.906	20	.747	.722	.703	.688	.525
30	.937	.941	.941	.940	.852	30	.764	.741	.723	.708	.551
40	.906	.906	.903	.899	.784	40	.788	.767	.751	.738	.591
50	.869	.864	.858	.851	.705	50	.820	.802	.787	.776	.646
60	.828	.818	.808	.799	.623	60	.859	.844	.833	.824	.720
70	.785	.770	.756	.744	.542	70	.904	.895	.887	.881	.817
80	.741	.722	.705	.690	.467	80	.957	.953	.951	.949	.941
90	.698	.675	.655	.638	.400	90	1.015	1.018	1.022	1.025	1.095
100	.658	.631	.609	.590	.343	100	1.077	1.089	1.100	1.109	1.283
110	.621	.592	.567	.547	.295	110	1.142	1.164	1.183	1.199	1.503
120	.589	.557	.531	.509	.257	120	1.207	1.240	1.268	1.292	1.749
130	.561	.527	.500	.478	.227	130	1.270	1.313	1.350	1.383	2.010
140	.538	.503	.475	.452	.204	140	1.328	1.381	1.427	1.467	2.268
150	.520	.484	.456	.433	.188	150	1.377	1.439	1.492	1.540	2.503
160	.507	.471	.442	.419	.177	160	1.414	1.483	1.543	1.596	2.691
170	.500	.463	.434	.411	.170	170	1.438	1.511	1.575	1.631	2.813
180	.497	.460	.431	.408	.168	180	1.445	1.520	1.586	1.644	2.856

TABLE OF Θ AND Ω AS A FUNCTION OF ϕ FOR $D + T \rightarrow n + He^4$

Table 33
(See Figs. 33a & 33b)

Θ

ϕ \ E_o	6	8	10	12	∞
0	180.00	180.00	180.00	180.00	0.00
2	172.88	170.32	166.49	160.37	4.43
4	165.88	161.00	154.02	143.95	8.75
6	159.11	152.30	143.18	131.39	12.84
8	152.64	144.34	134.06	121.88	16.67
10	146.57	137.22	126.46	115.50	20.15
20	121.83	111.66	102.42	94.32	32.07
30	104.53	95.85	88.72	82.82	36.90
40	91.62	84.18	78.59	74.01	37.70
50	80.96	74.81	70.18	66.50	36.35
60	71.86	66.65	62.72	59.62	33.85
70	63.76	59.25	55.88	53.24	30.77
80	56.38	52.45	49.53	47.24	27.45
90	49.52	46.10	43.56	41.57	24.09
100	43.09	40.12	37.91	36.19	20.82
110	37.08	34.45	32.55	31.07	17.69
120	31.21	29.05	27.44	26.18	14.74
130	25.66	23.87	22.53	21.49	11.97
140	20.30	18.87	17.81	16.98	9.37
150	15.09	14.02	13.23	12.61	6.90
160	9.99	9.29	8.76	8.35	4.54
170	4.98	4.63	4.36	4.16	2.25
180	0.00	0.00	0.00	0.00	0.00

Ω

ϕ \ E_o	6	8	10	12	∞
0	180.00	180.00	180.00	180.00	180.00
10	168.33	168.12	167.95	167.81	165.93
20	156.70	156.29	155.96	155.69	151.97
30	145.18	144.58	144.09	143.69	138.22
40	133.79	133.02	132.40	131.87	124.79
50	122.60	121.68	120.93	120.30	111.78
60	111.62	110.58	109.73	109.02	99.29
70	100.91	99.78	98.85	98.07	87.44
80	90.51	89.23	88.30	87.49	76.30
90	80.31	79.10	78.12	77.29	65.91
100	70.46	69.27	68.30	67.52	56.29
110	60.92	59.77	58.85	58.07	47.44
120	51.62	50.58	49.73	49.02	39.30
130	42.60	41.68	40.93	40.30	31.78
140	33.79	33.02	32.39	31.87	24.79
150	25.17	24.58	24.09	23.69	18.22
160	16.70	16.29	15.96	15.69	11.97
170	8.33	8.12	7.95	7.81	5.93
180	0.00	0.00	0.00	0.00	0.00

TABLE OF Ω FOR $D + T \rightarrow n + He^4$

Table 34
(See Fig. 34)

θ \ E_0	6	8	10	12
0	0.00	0.00	0.00	0.00
10	16.71	17.54	18.22	18.79
20	33.31	34.98	36.36	37.51
30	49.66	52.21	54.31	56.10
40	65.62	69.08	71.96	74.44
50	81.02	85.38	89.11	92.38
60	95.65	100.89	105.48	109.64
70	109.23	115.26	120.69	125.77
80	121.51	128.11	134.18	140.06
90	132.30	139.11	145.43	151.63
100	141.51	148.11	154.18	160.06
110	149.26	155.26	160.69	165.77
120	155.65	160.89	165.49	169.64
130	161.03	165.39	169.11	172.38
140	165.63	169.07	171.96	174.44
150	169.66	172.21	174.31	176.10
160	173.31	174.98	176.36	177.51
170	176.71	177.54	178.22	178.79
180	180.00	180.00	180.00	180.00

Fig. 31a (See Table 31)

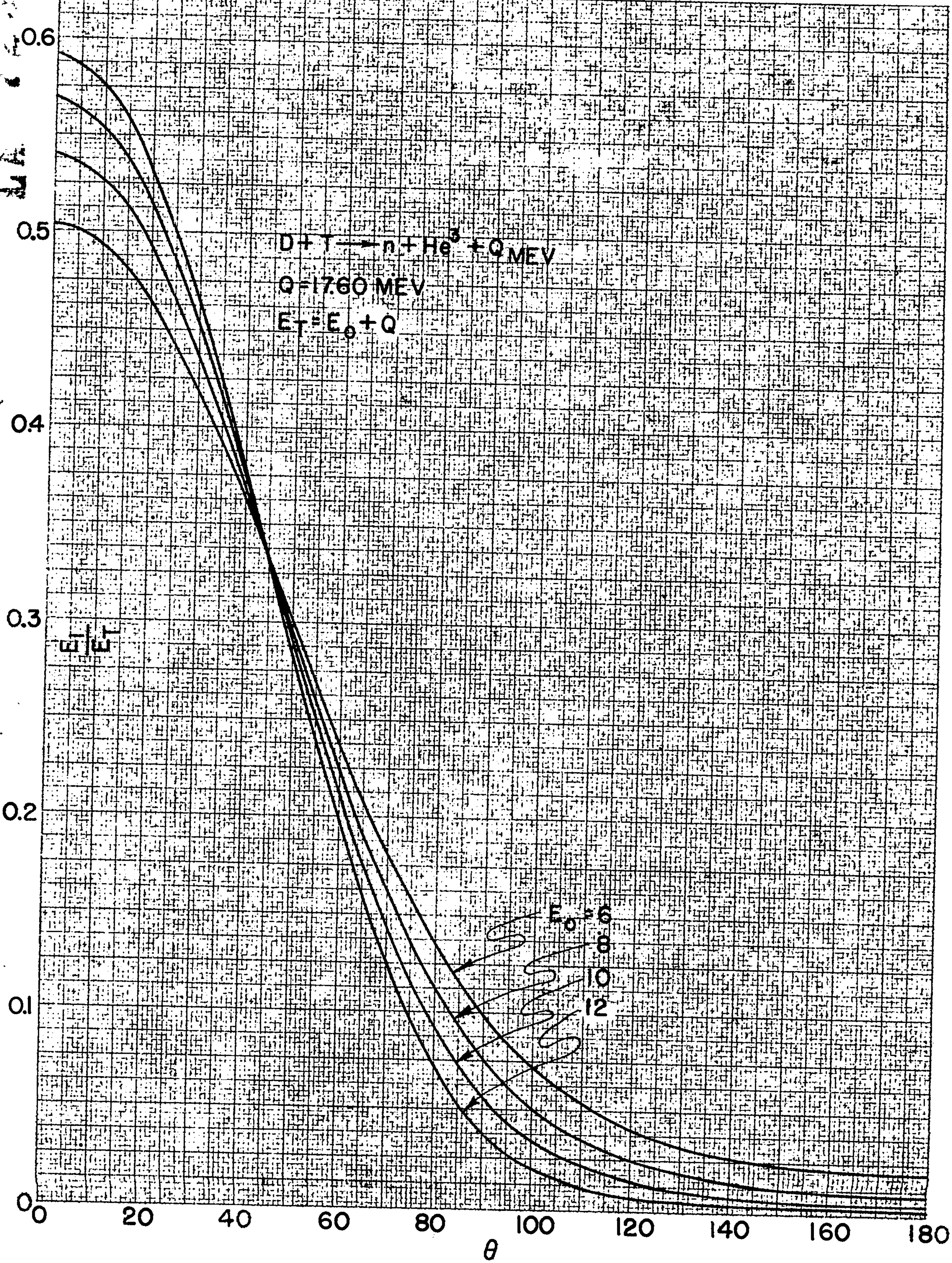


Fig. 31b (See Table 31)

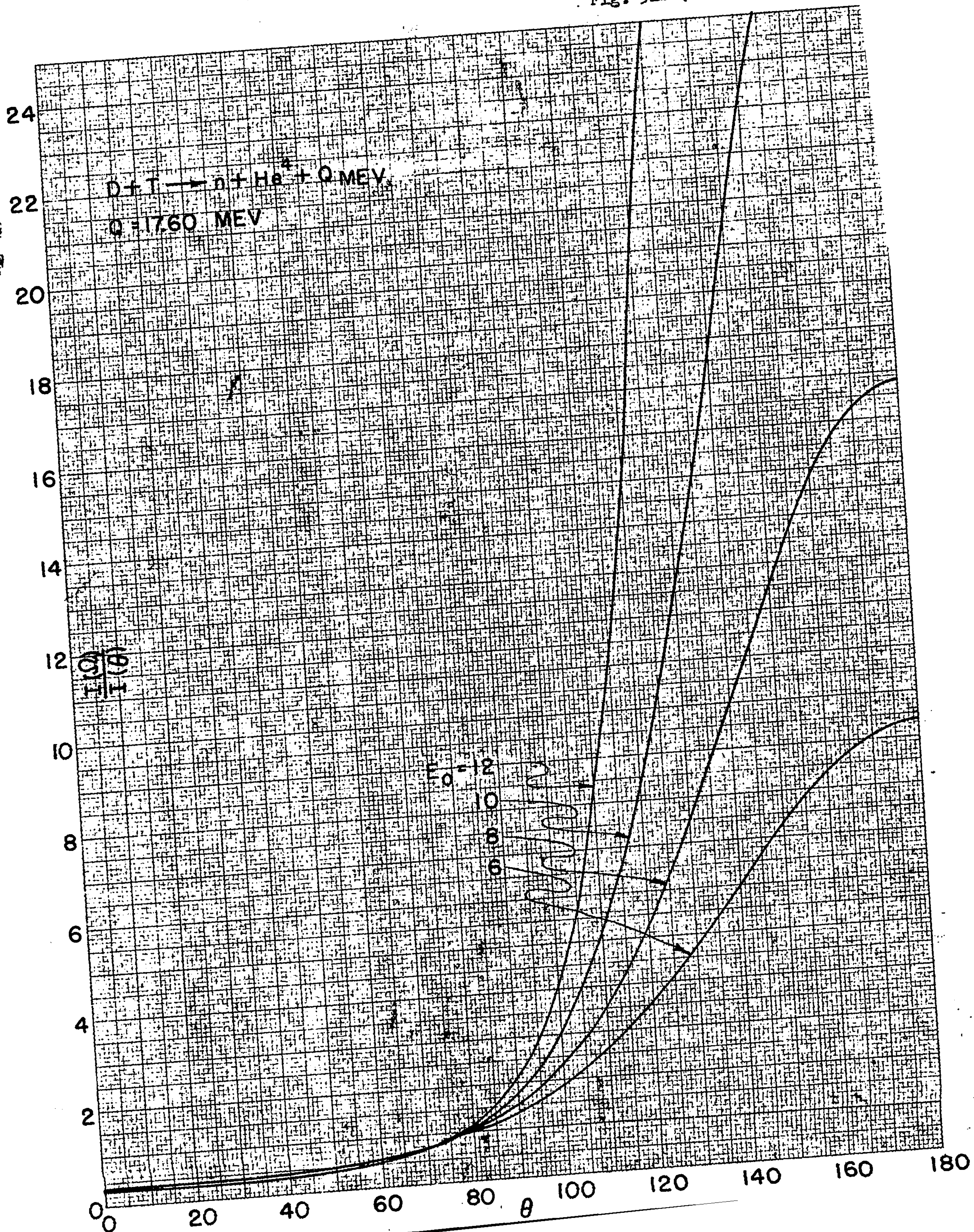


Fig. 32a (See Table 32)

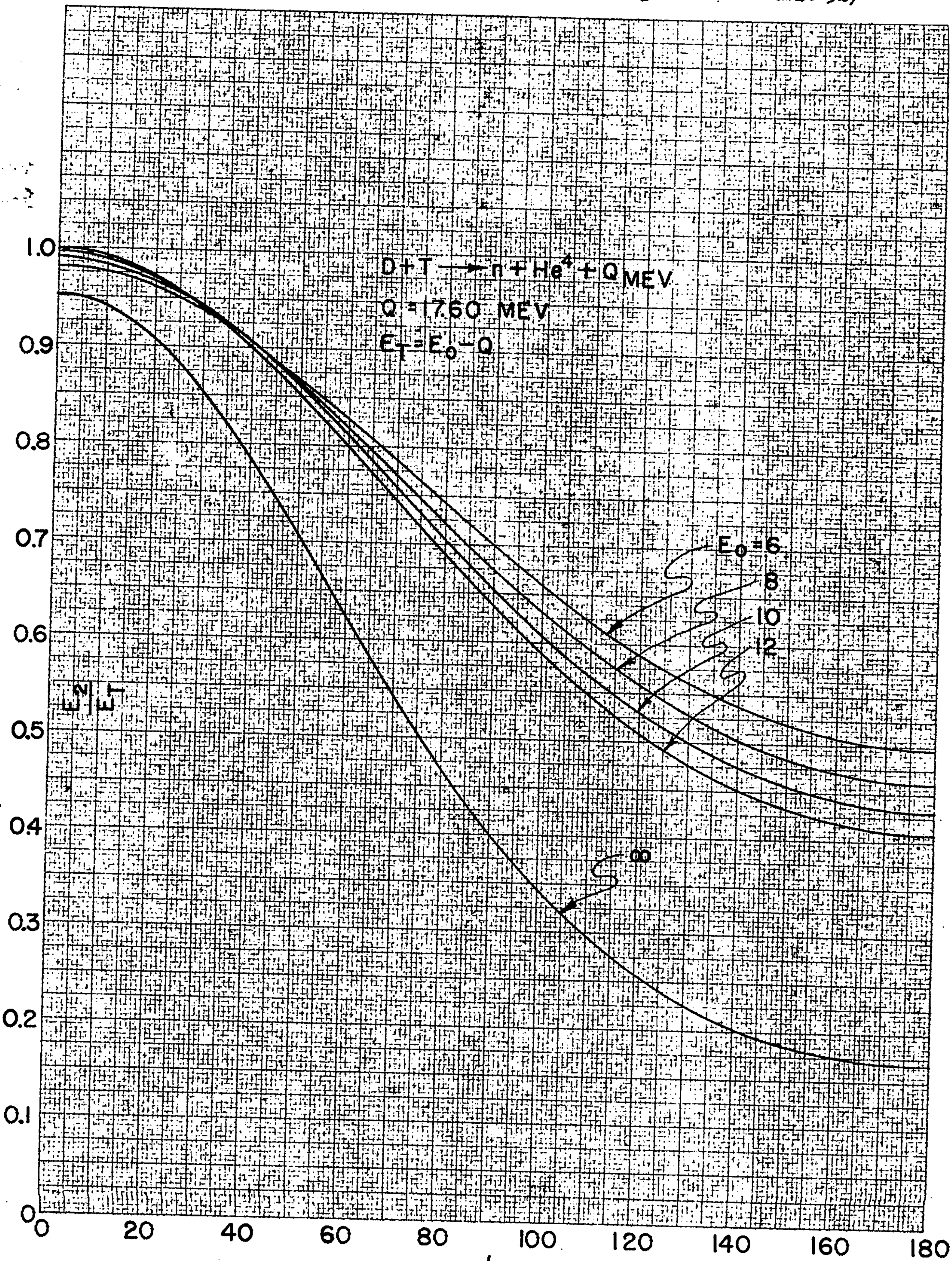


Fig. 32b (See Table 32)

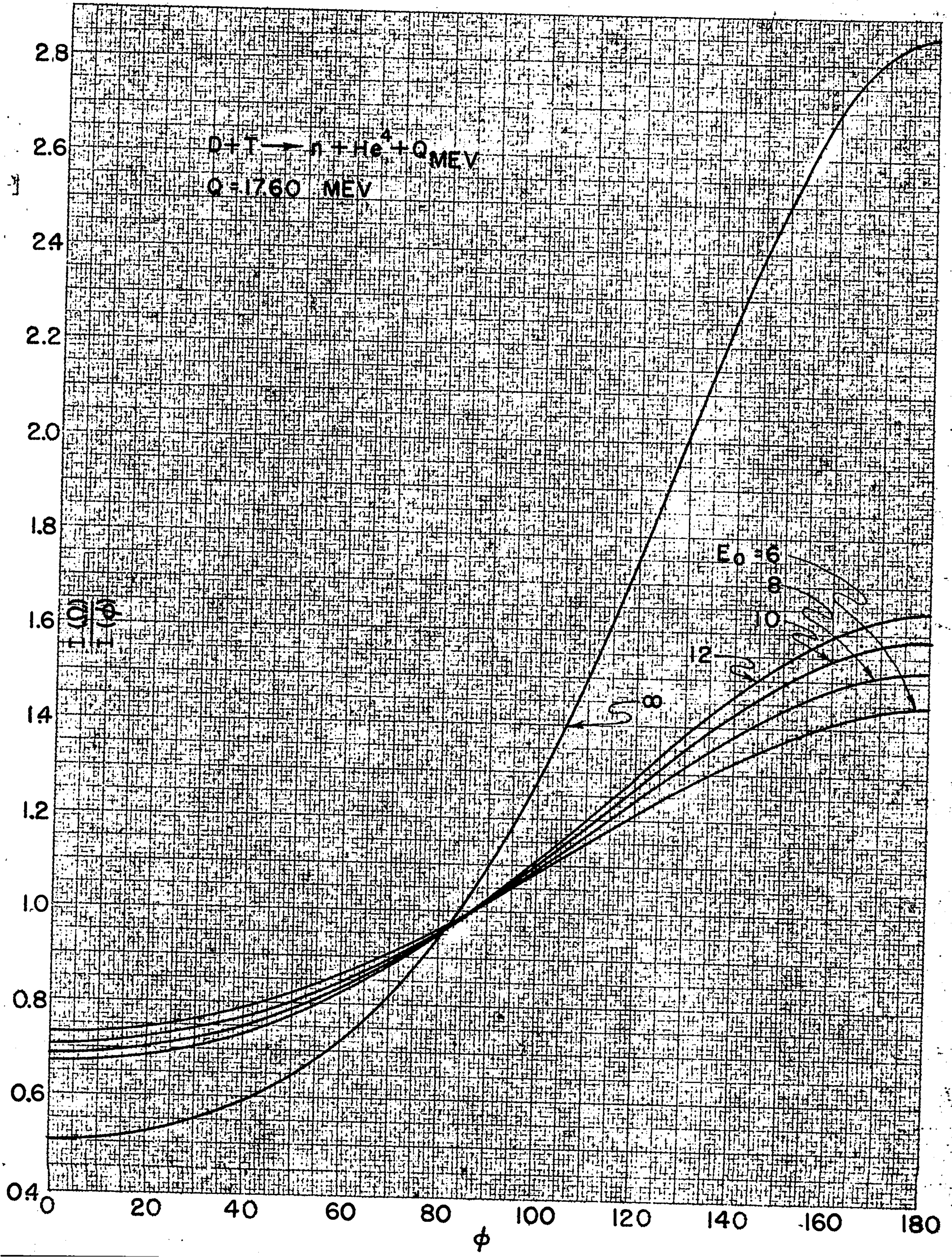


Fig. 33a (See Table 33)

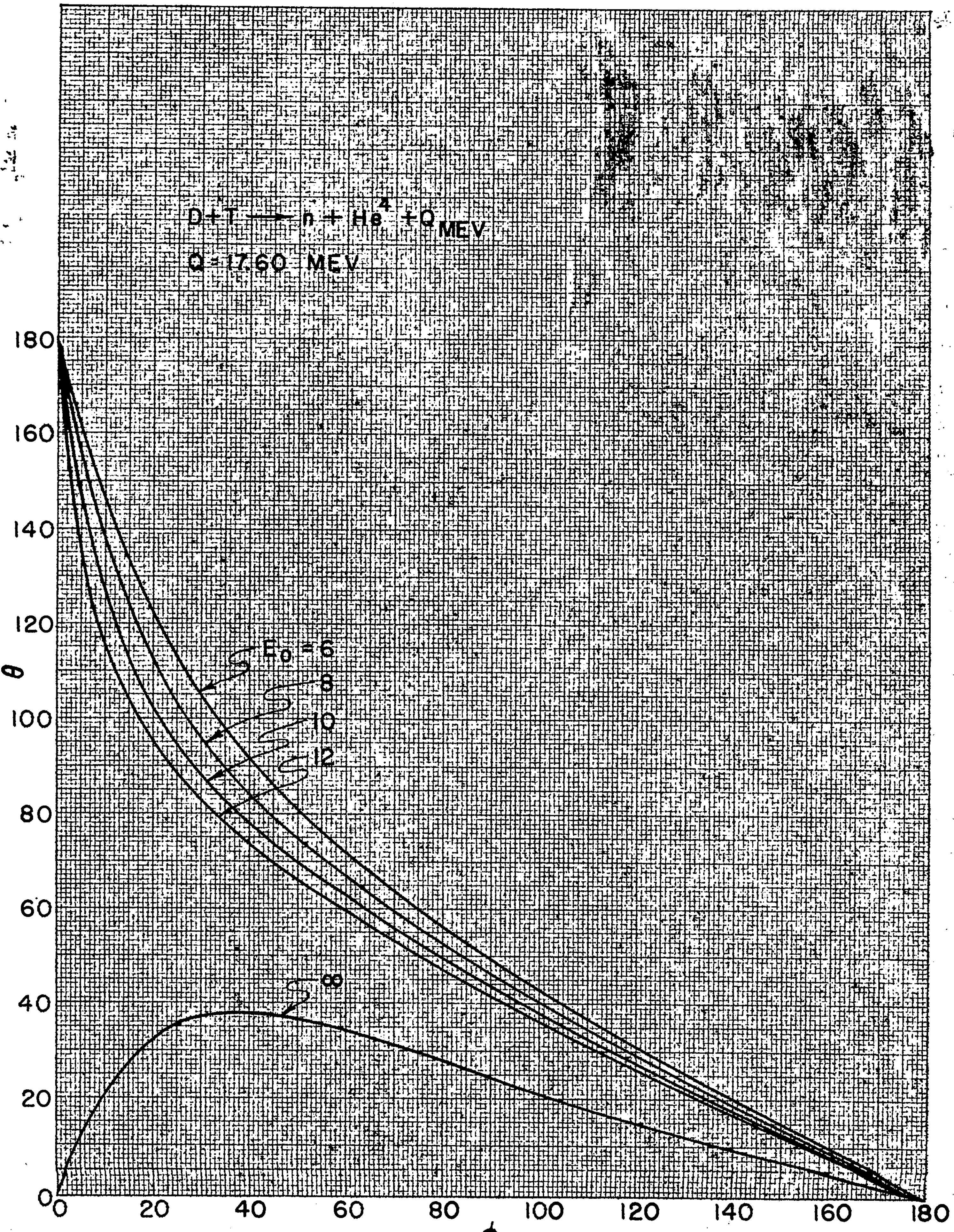


Fig. 33b (See Table 33)

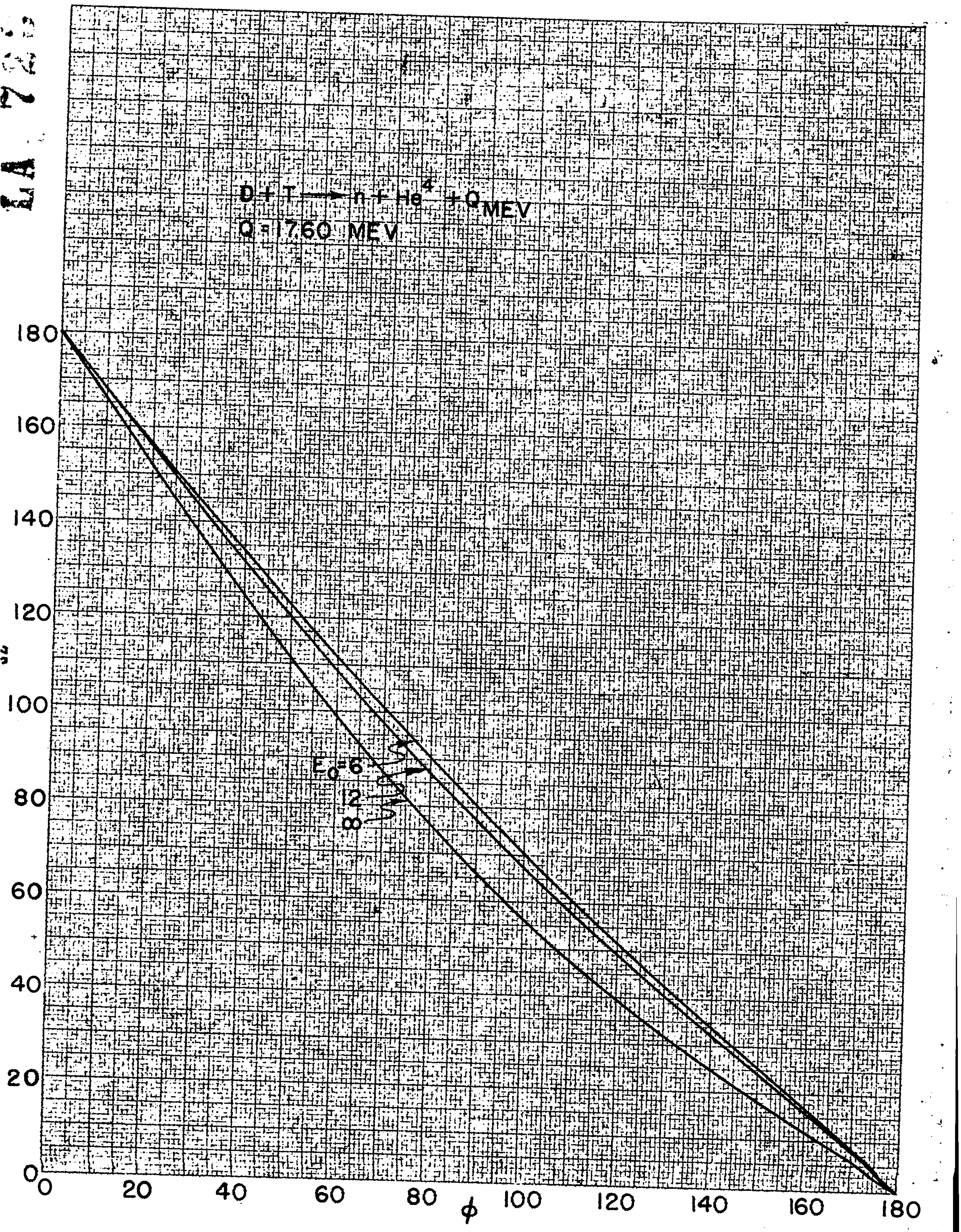


Fig. 34 (See Table 34)

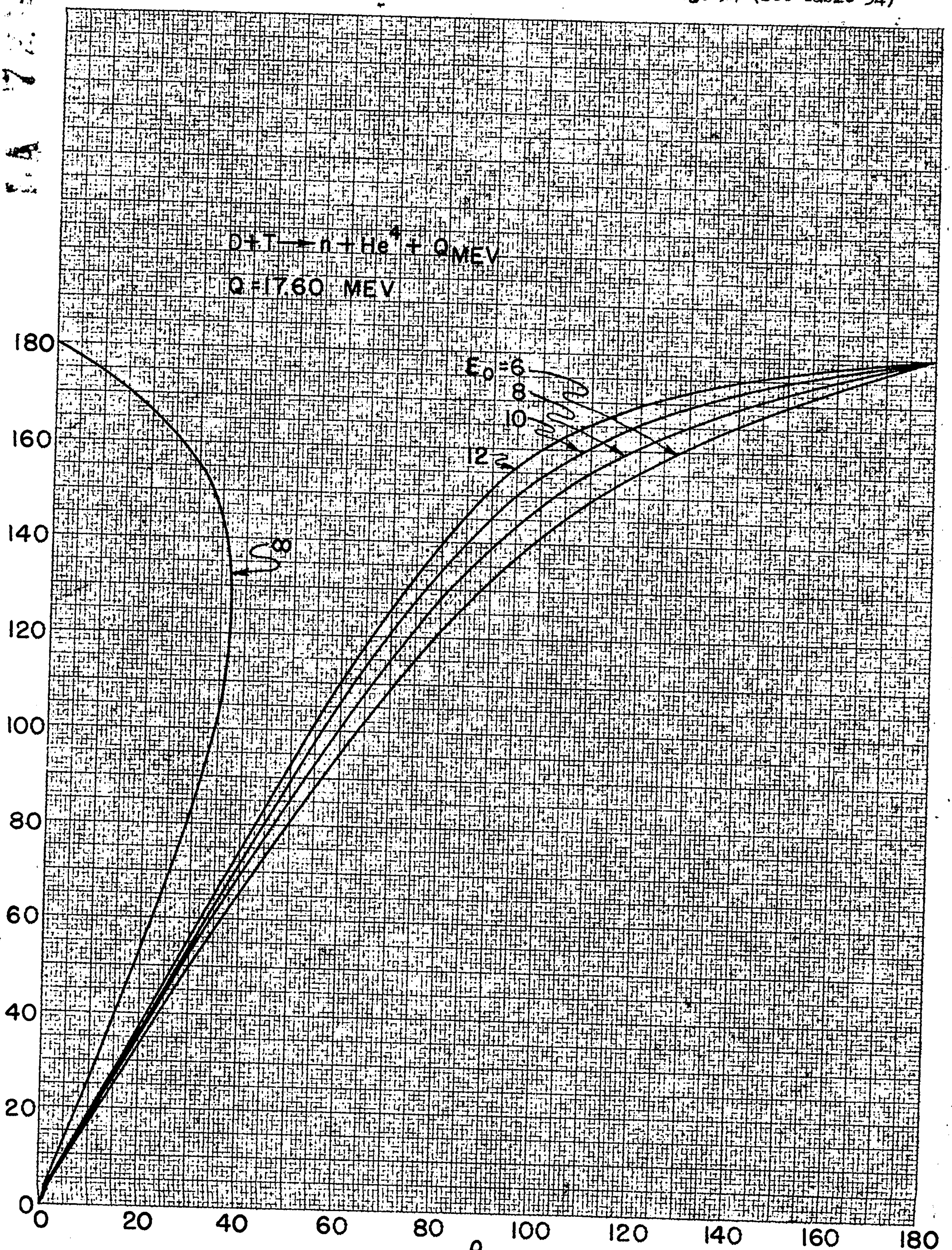


TABLE OF E_1/E_T FOR $p + T \rightarrow n + He^3$

Table 35
(See Fig. 35)

$E_T = E_o - 0.76$

E_o / θ	6		8		10		12		∞
	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow	
0	.785	.002	.775	.001	.770	.001	.767	.000	.750
5	.778	.002	.769	.001	.764	.001	.760	.000	.744
10	.759	.002	.750	.001	.746	.001	.742	.000	.727
15	.727	.002	.720	.001	.716	.001	.713	.000	.700
20	.684	.002	.678	.001	.675	.001	.673	.000	.662
25	.631	.002	.627	.001	.625	.001	.623	.000	.616
30	.569	.002	.568	.001	.567	.001	.566	.001	.563
35	.501	.003	.502	.001	.503	.001	.503	.001	.503
40	.428	.003	.432	.002	.434	.001	.435	.001	.440
45	.353	.004	.360	.002	.364	.001	.366	.001	.375
50	.278	.005	.288	.002	.293	.001	.296	.001	.310
55	.204	.006	.217	.003	.224	.002	.228	.001	.247
60	.132	.010	.150	.005	.159	.003	.165	.002	.188
65	.058	.023	.088	.008	.010	.004	.107	.003	.134
70					.044	.010	.055	.005	.088
75									.050
80									.023
85									.006
90									0.000
θ max.	65.74		69.15		71.44		73.10		
E_1/E_T for θ max.	.036		.026		.021		.017		

Table 36
(See Figs. 36a & 36b)

TABLE OF $I(\Omega)/I(\theta)$ FOR $p + T \rightarrow n + He^3$

$E_T = E_0 - 0.76$

θ \ E_0	6 Fast	6 Slow	8 Fast	8 Slow	10 Fast	10 Slow	12 Fast	12 Slow	∞
0	.227	106.5	.233	203.7	.237	332.1	.239	491.6	.250
5	.228	105.1	.234	201.2	.238	328.0	.240	485.7	.251
10	.231	101.1	.237	193.7	.240	316.1	.243	468.3	.254
15	.235	94.5	.242	181.7	.245	296.9	.248	440.6	.259
20	.242	86.2	.248	165.8	.252	270.0	.254	403.0	.266
25	.251	76.0	.257	146.7	.261	240.1	.264	357.4	.276
30	.262	64.6	.269	126.3	.273	206.6	.276	306.4	.289
35	.277	52.9	.284	104.3	.289	172.9	.292	257.4	.305
40	.295	41.2	.304	82.6	.309	138.2	.312	205.7	.326
45	.319	30.3	.329	61.9	.334	104.7	.338	158.3	.354
50	.349	20.5	.360	43.4	.367	74.6	.371	113.2	.389
55	.385	12.1	.401	27.5	.410	48.6	.415	75.8	.436
60	.422	5.61	.453	14.8	.466	27.9	.473	44.8	.500
65	.331	.858	.503	5.62	.537	12.6	.552	21.9	.592
70					.544	2.52	.632	6.60	.731
75									.966
80									1.439
85									2.867
90									
θ max.	65.74		69.15		71.44		73.10		
$I(\Omega)/I(\theta)$ for θ max.	0.00		0.00		0.00		0.00		

TABLE OF E_2/E_T AND I (Ω)/I (φ) FOR $P + T \rightarrow N + He^3$

Table 37
(See Figs. 37a & 37b)

$E_T = E_o - 0.76$

E_2/E_T

φ \ E_o	6	8	10	12	∞
0	.998	.999	.999	1.000	1.000
10	.987	.988	.989	.989	.990
20	.955	.957	.958	.958	.960
30	.904	.907	.909	.910	.914
40	.839	.844	.846	.847	.854
50	.764	.770	.773	.776	.785
60	.685	.692	.696	.699	.711
70	.606	.615	.619	.623	.636
80	.531	.541	.546	.550	.565
90	.464	.474	.479	.483	.500
100	.405	.415	.421	.425	.442
110	.355	.365	.371	.375	.393
120	.314	.324	.330	.334	.352
130	.281	.291	.297	.301	.319
140	.256	.266	.272	.275	.293
150	.238	.247	.253	.256	.274
160	.225	.235	.240	.244	.260
170	.218	.227	.232	.236	.253
180	.215	.225	.230	.233	.250

I (Ω)/I (φ)

φ \ E_o	6	8	10	12	∞
0	.536	.543	.547	.550	.562
10	.541	.548	.552	.555	.567
20	.556	.563	.567	.570	.582
30	.582	.589	.593	.595	.607
40	.620	.626	.630	.632	.643
50	.672	.678	.681	.683	.693
60	.741	.746	.748	.750	.758
70	.829	.832	.834	.835	.839
80	.940	.940	.940	.940	.940
90	1.074	1.070	1.068	1.067	1.061
100	1.234	1.225	1.220	1.216	1.201
110	1.417	1.401	1.392	1.386	1.360
120	1.618	1.593	1.579	1.570	1.531
130	1.827	1.792	1.773	1.761	1.707
140	2.030	1.986	1.961	1.946	1.877
150	2.213	2.159	2.130	2.111	2.028
160	2.359	2.297	2.263	2.242	2.147
170	2.453	2.386	2.349	2.326	2.224
180	2.485	2.416	2.379	2.355	2.250

TABLE OF Θ AND Ω AS A FUNCTION OF ϕ FOR $p + T \rightarrow n + He^3$

Table 38
(See Figs. 38a & 38b)

ϕ \ E_0	Θ: 6	Θ: 8	Θ: 10	Θ: 12	Θ: ∞	Ω: 6	Ω: 8	Ω: 10	Ω: 12	Ω: ∞
0	0.00	0.00	0.00	0.00	90.00	180.00	180.00	180.00	180.00	180.00
2	25.73	33.80	39.56	45.40	88.51					
4	43.20	51.52	57.81	62.43	87.36					
6	53.12	60.24	65.05	69.39	86.00					
8	58.62	64.83	68.52	71.84	84.67					
10	61.91	67.32	70.69	72.84	83.34	166.36	166.45	166.50	166.53	166.68
20	65.58	68.43	70.16	71.32	76.65	152.82	152.99	153.09	153.16	153.45
30	62.60	64.58	65.77	66.54	70.19	139.47	139.73	139.87	139.97	140.40
40	57.98	59.51	60.41	61.01	63.81	126.40	126.75	126.94	127.06	127.63
50	52.82	54.08	54.81	55.30	57.01	113.74	114.14	114.38	114.52	115.20
60	47.53	48.61	49.24	49.65	51.61	101.54	102.00	102.28	102.44	103.22
70	42.31	43.26	43.80	44.16	45.87	90.00	90.42	90.70	90.89	91.74
80	37.27	38.11	38.59	38.91	40.42	78.89	79.44	79.74	79.94	80.84
90	32.47	33.22	33.65	33.93	35.26	68.55	69.10	69.41	69.61	70.53
100	27.95	28.61	28.99	29.24	30.42	58.89	59.44	59.74	59.94	60.84
110	23.72	24.30	24.63	24.84	25.87	50.00	50.42	50.70	50.89	51.74
120	19.77	20.26	20.54	20.73	21.61	41.54	42.01	42.27	42.44	43.22
130	16.06	16.48	16.71	16.87	17.61	33.74	34.14	34.37	34.52	35.21
140	12.58	12.91	13.10	13.23	13.81	26.41	26.74	26.94	27.06	27.63
150	9.28	9.53	9.67	9.76	10.20	19.47	19.73	19.87	19.97	20.41
160	6.11	6.28	6.37	6.43	6.73	12.82	12.99	13.09	13.16	13.45
170	3.09	3.12	3.16	3.19	3.34	6.36	6.45	6.50	6.53	6.68
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE OF Ω AS A FUNCTION OF θ FOR $p + T \rightarrow n + He^3$

Table 39
(See Fig. 39)

θ \ E_o	6		8		10		12		∞
	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow	
0	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00
5	10.49	179.51	10.35	179.65	10.28	179.72	10.23	179.77	10.00
10	20.98	179.02	20.71	179.29	20.56	179.44	20.46	179.54	20.00
15	31.49	178.51	31.08	178.92	30.84	179.16	30.69	179.31	30.00
20	42.04	177.97	41.47	178.53	41.15	178.85	40.94	179.06	40.00
25	52.62	177.38	51.89	178.11	51.48	178.52	51.21	178.79	50.00
30	63.26	176.74	62.35	177.65	61.83	178.17	61.50	178.50	60.00
35	73.99	176.01	72.86	177.14	72.23	177.77	71.83	178.17	70.00
40	84.84	175.16	83.46	176.54	82.69	177.31	82.20	177.80	80.00
45	95.85	174.14	94.16	175.83	93.24	176.76	92.64	177.35	90.00
50	107.17	172.83	105.05	174.94	103.91	176.09	103.19	176.81	100.00
55	118.96	171.04	116.23	173.77	114.78	175.22	113.88	176.12	110.00
60	131.79	168.21	127.93	172.07	126.00	174.00	124.84	175.16	120.00
65	148.78	161.22	140.88	169.12	137.95	172.05	136.30	173.70	130.00
70					152.42	167.59	149.14	170.86	140.00
75									150.00
80									160.00
85									170.00
90									180.00
θ max.	65.74		69.15		71.44		73.10		
Ω for θ max.	155.74		159.15		161.44		163.10		

Fig. 35 (See Table 35)

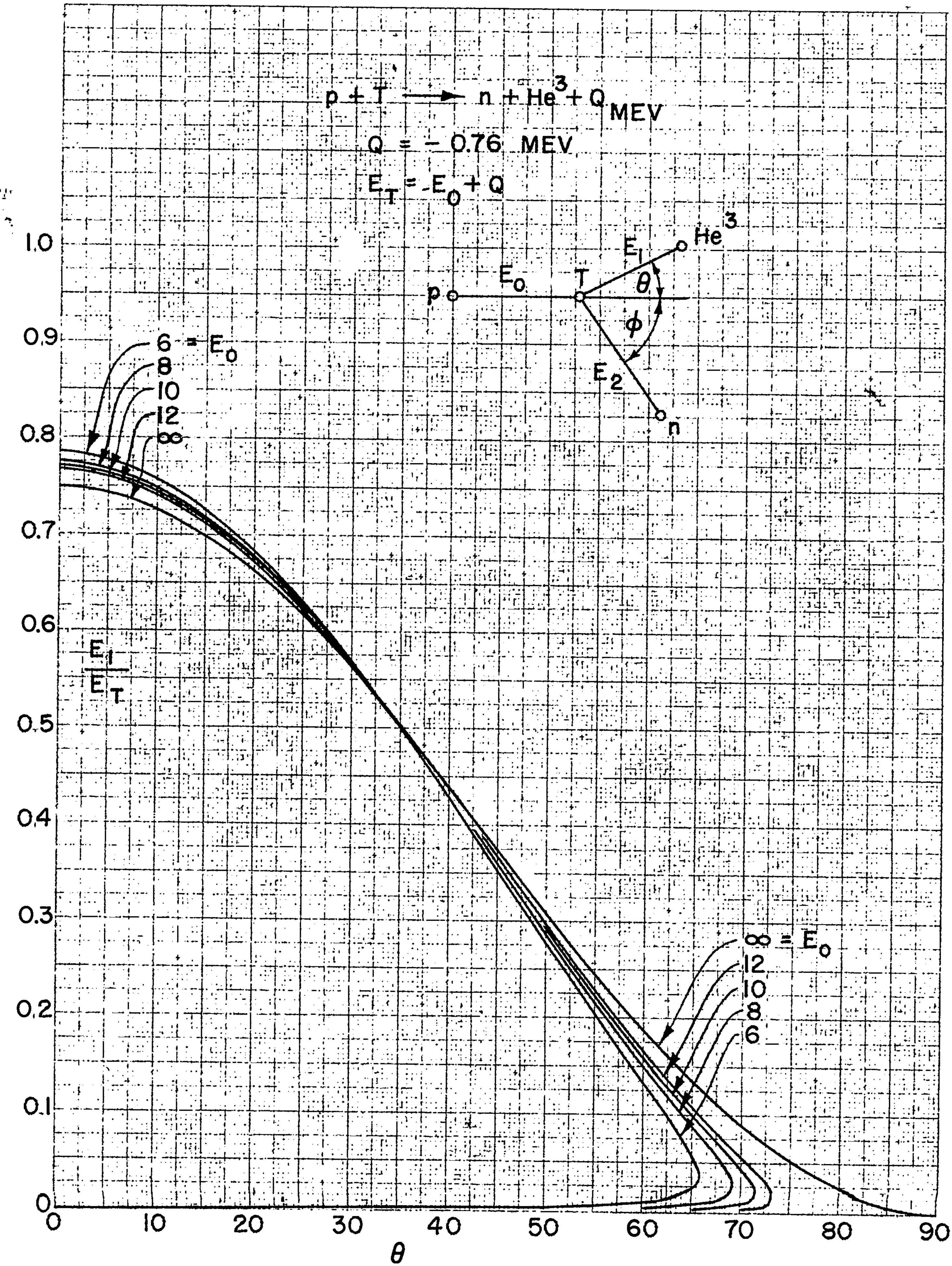


Fig. 36a (See Table 36)

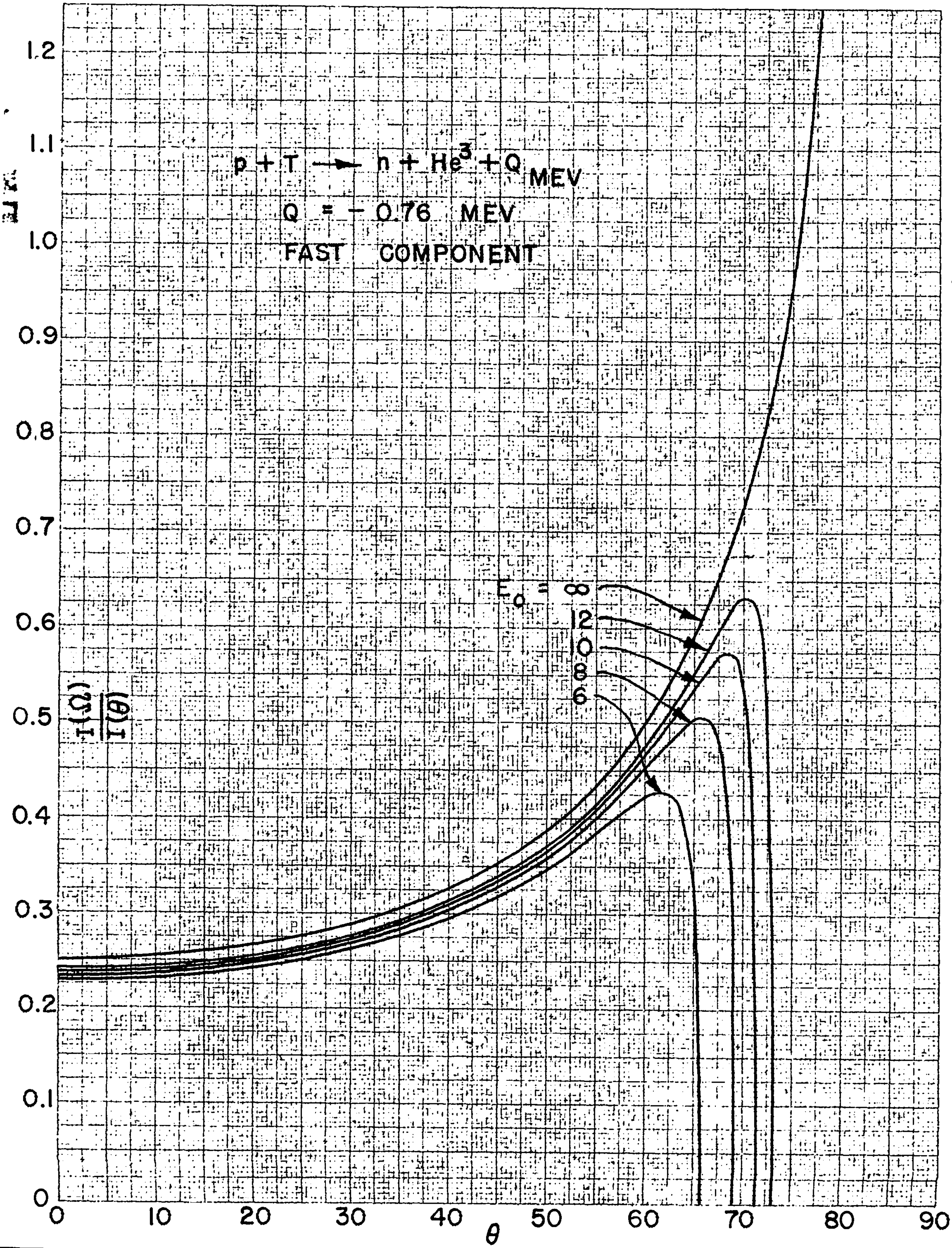


Fig. 36b (See Table 36)

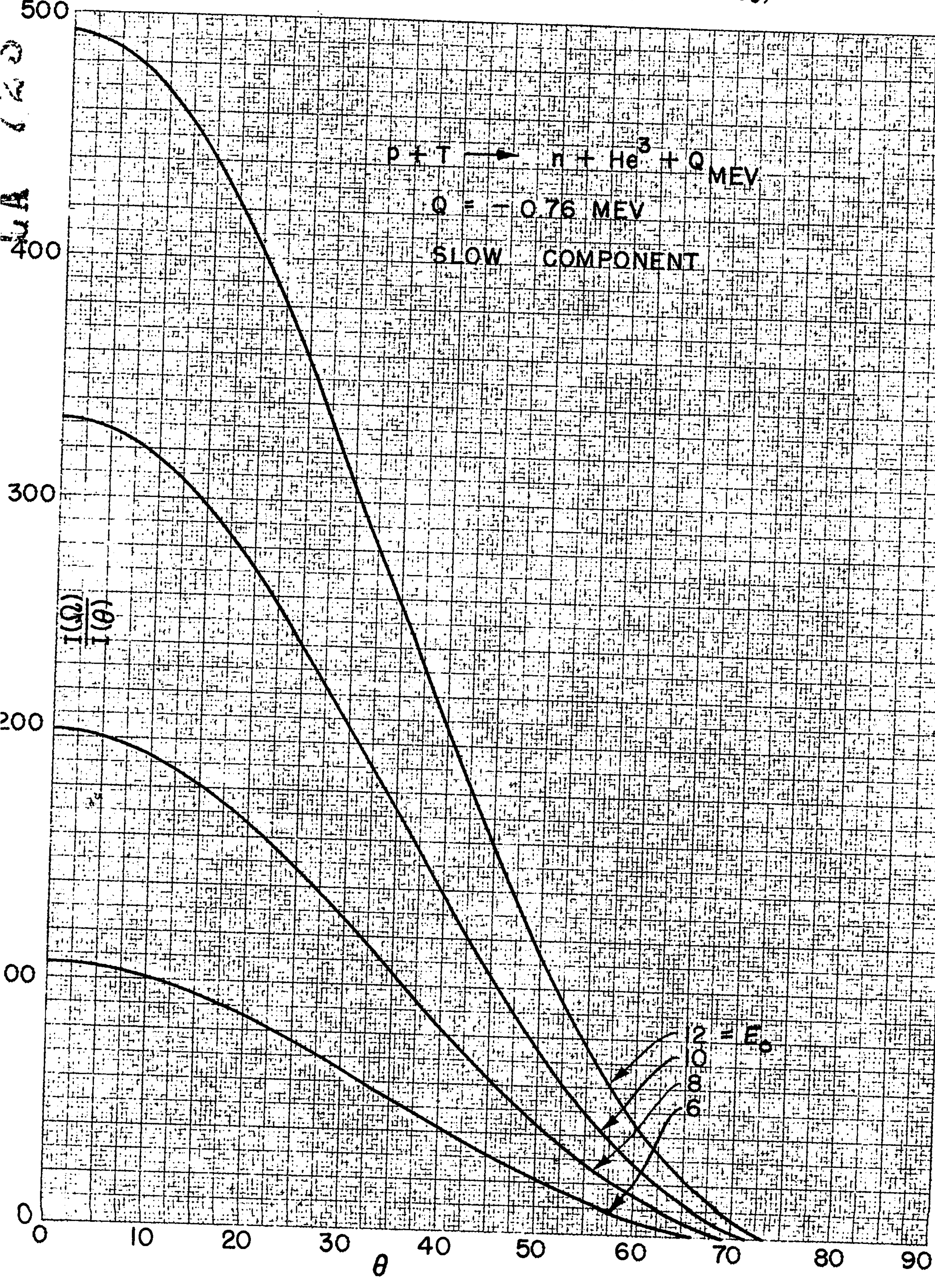


Fig. 37a (See Table 37)

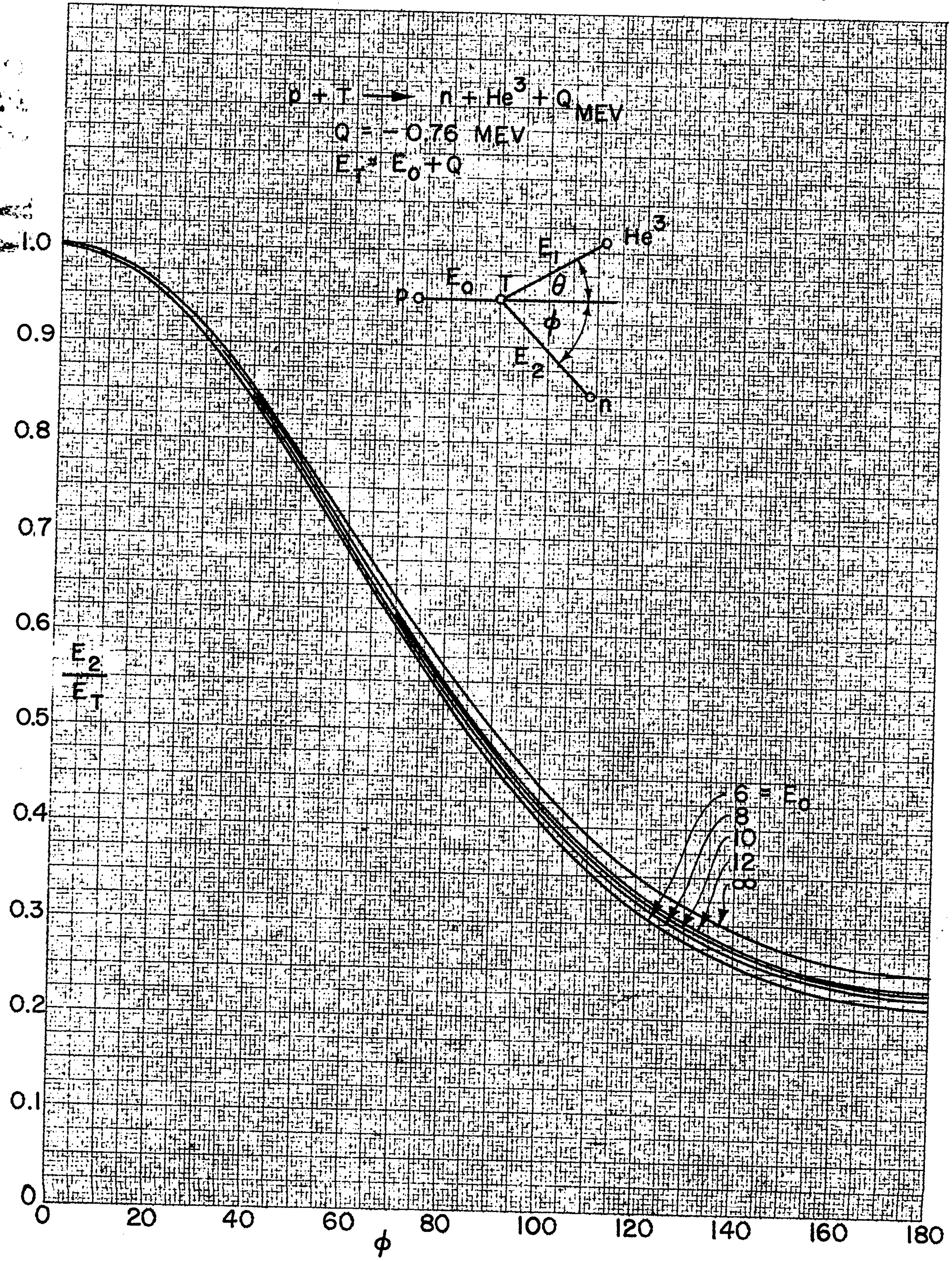


Fig. 37b (See Table 37)

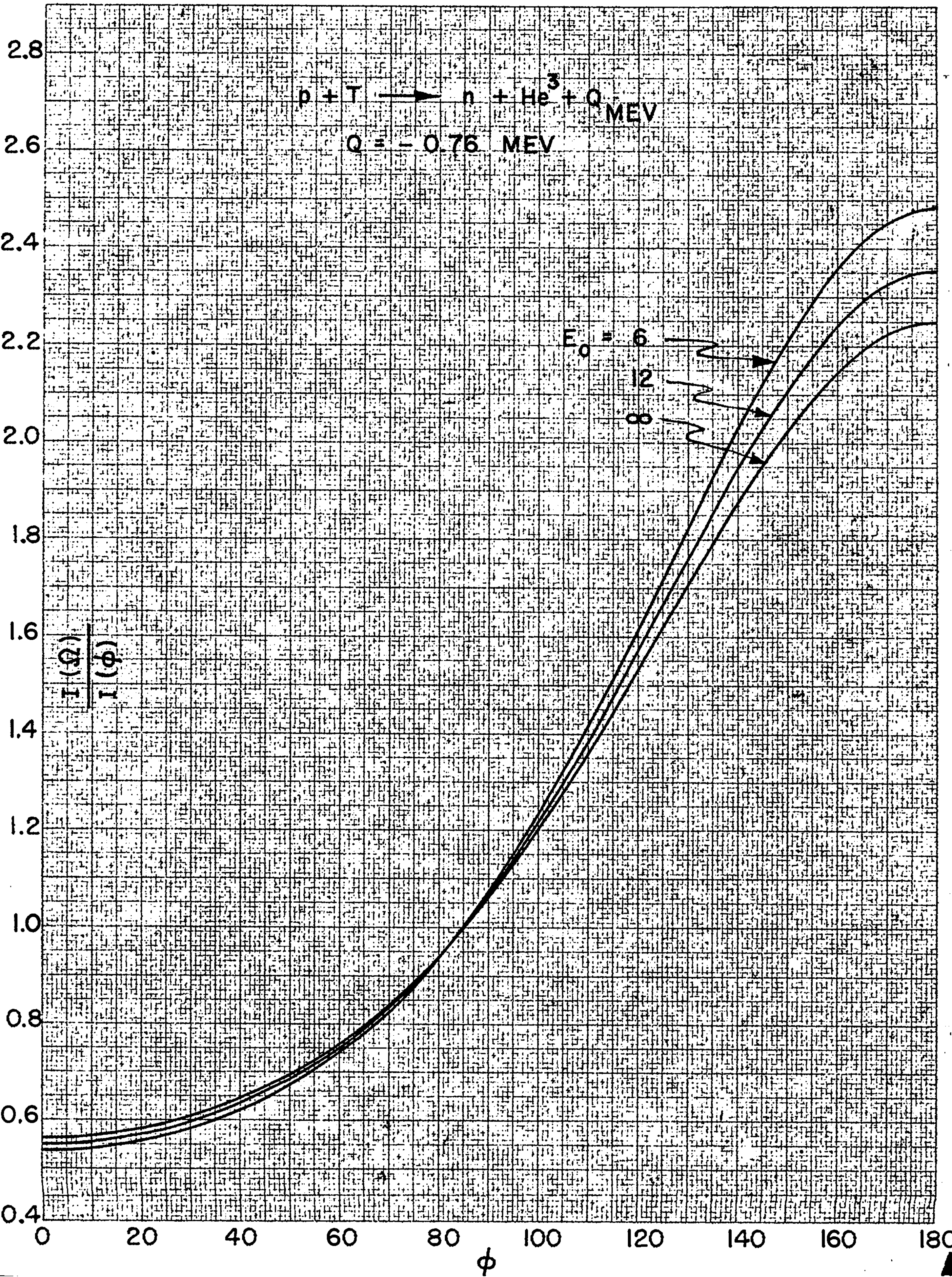
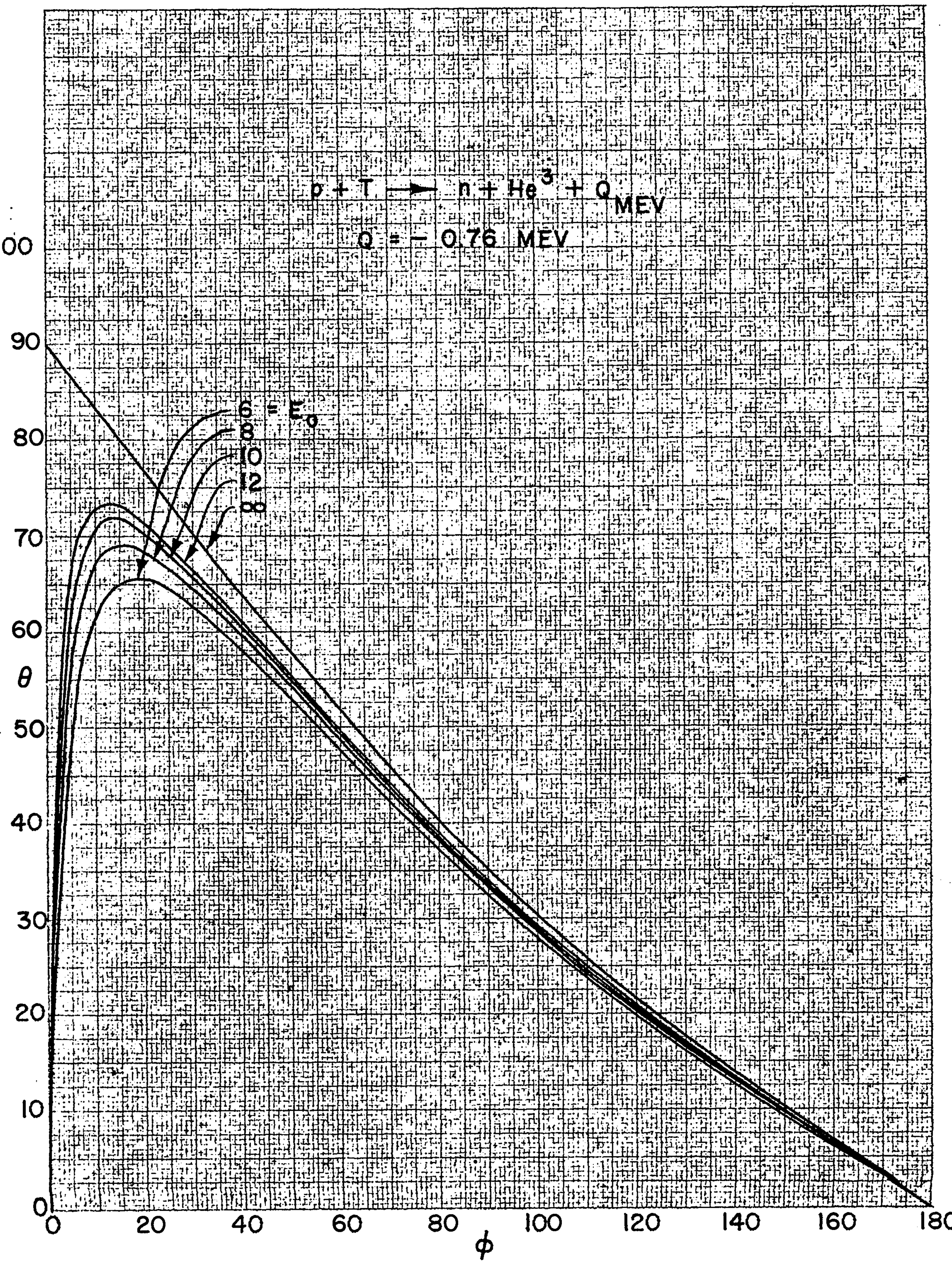


Fig. 38a (See Table 38)



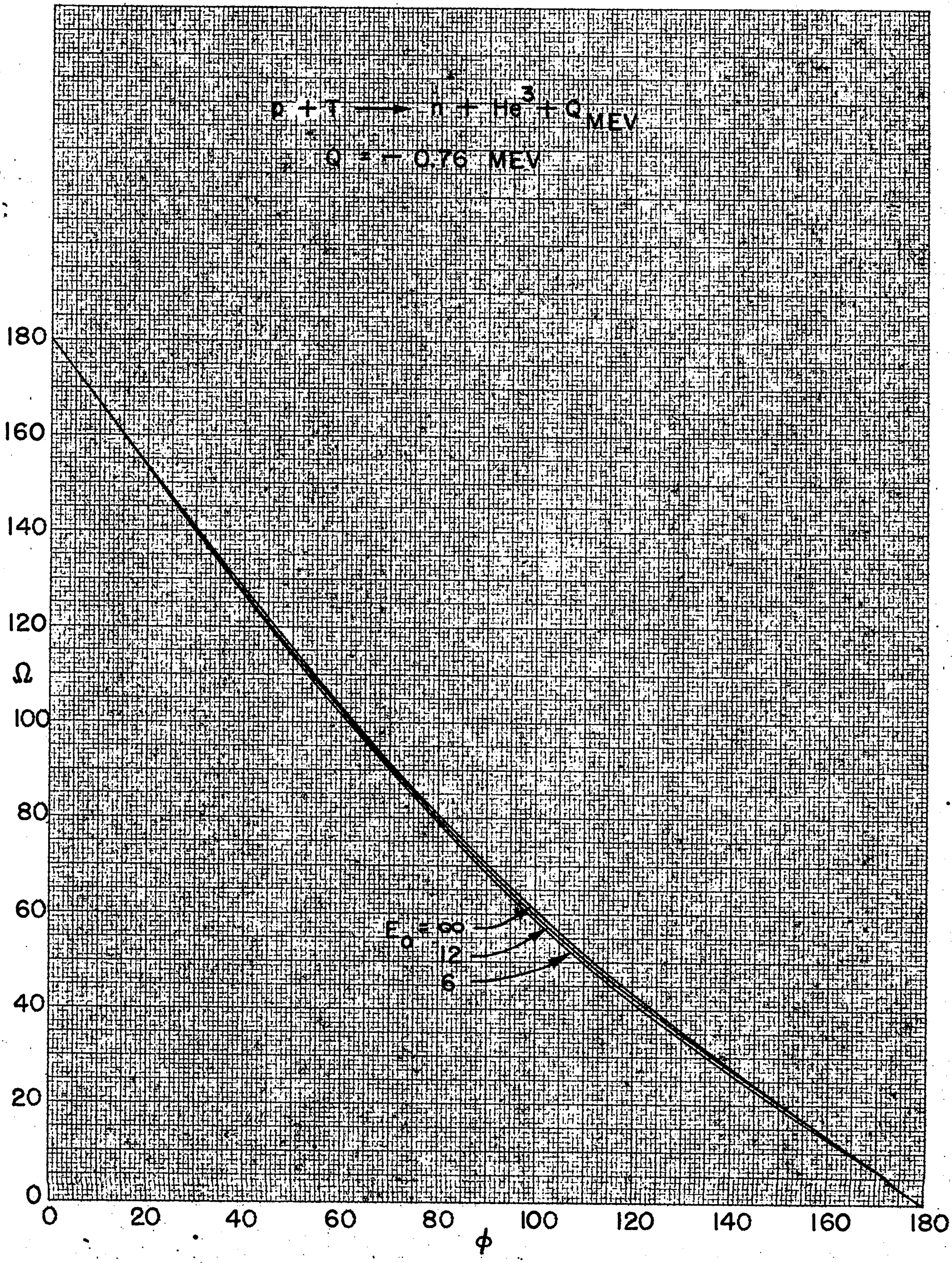
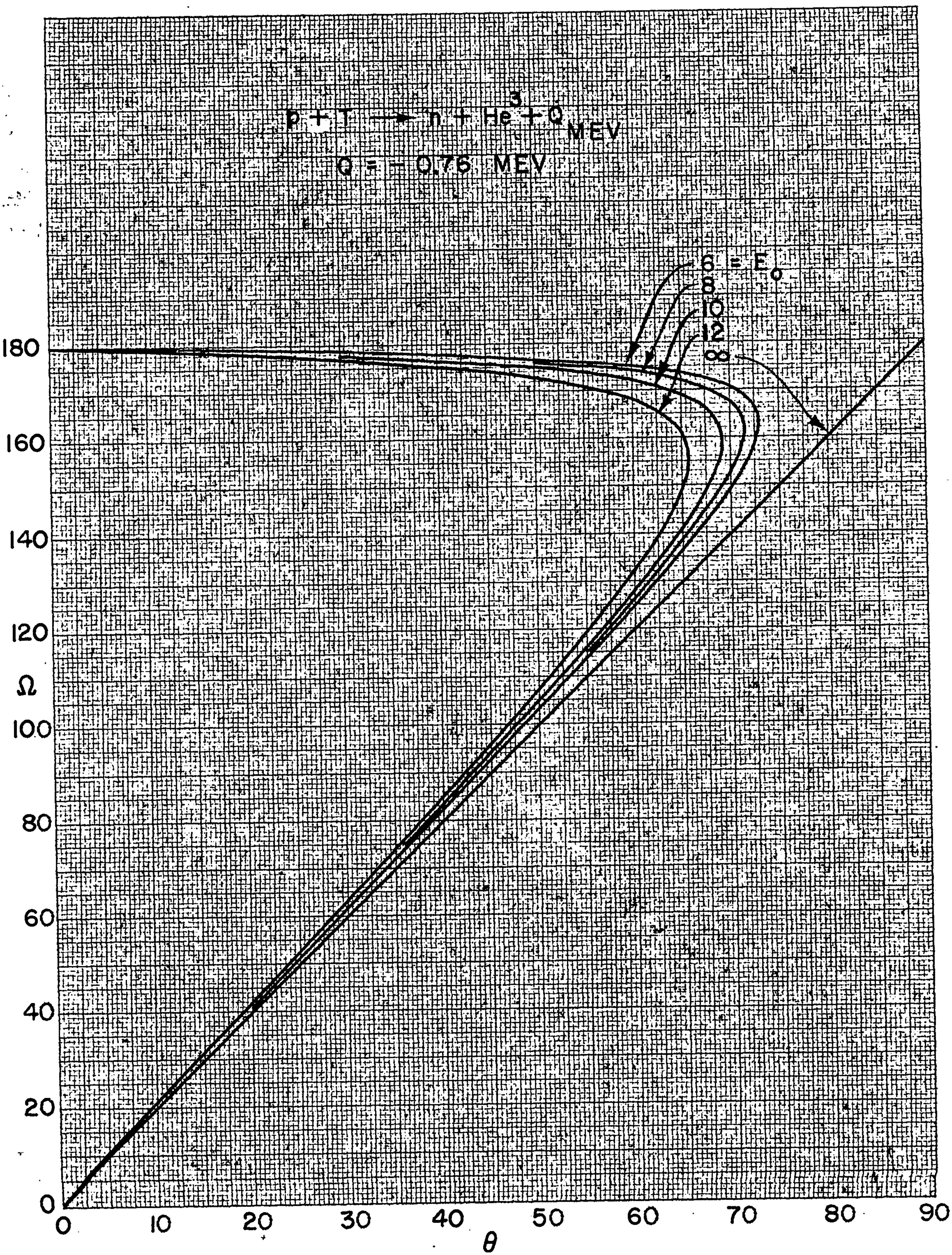

p + T ⟶ n + He^3 + Q$_{MEV}$
Q = − 0.76 MEV
Ω
φ
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
E$_a$ = ∞
12
6

Fig. 39 (See Table 39)



RUTHERFORD SCATTERING, RELATIVE PARTIAL CROSS-SECTIONS

Table 40
(See Figs. 40a & 40b)

M_1/M_2 / θ-Interval	2/∞	2/27	2/4	2/3	2/2	2/1
0.5 - 1.0	1.970×10^4	1.970×10^4	1.970×10^4	1.970×10^4	1.970×10^4	1.970×10^4
1.0 - 2.0	4.924×10^3	4.924×10^3	4.924×10^3	4.924×10^3	4.924×10^3	4.924×10^3
2.0 - 3.0	9.119×10^2	9.119×10^2	9.119×10^2	9.119×10^2	9.119×10^2	9.119×10^2
3.0 - 4.0	3.192×10^2	3.192×10^2	3.192×10^2	3.192×10^2	3.192×10^2	3.192×10^2
4.0 - 5.0	1.477×10^2	1.477×10^2	1.477×10^2	1.477×10^2	1.477×10^2	1.477×10^2
5 - 10	197.0	197.0	197.0	197.0	197.0	197.0
10 - 15	36.48	36.48	36.48	36.48	36.47	36.58
15 - 20	12.77	12.77	12.76	12.76	12.76	12.96
20 - 25	5.908	5.908	5.904	5.902	5.899	6.296
25 - 30	3.209	3.209	3.205	3.202	3.198	5.423
30 - 35	1.935	1.934	1.929	1.926	1.921	
35 - 40	1.255	1.255	1.249	1.245	1.239	
40 - 45	.8601	.8599	.8530	.8482	.8405	
45 - 50	.6148	.6146	.6070	.6014	.5918	
50 - 55	.4544	.4542	.4458	.4395	.4276	
55 - 60	.3451	.3449	.3358	.3287	.3139	
60 - 65	.2680	.2678	.2582	.2503	.2318	
65 - 70	.2122	.2119	.2017	.1930	.1699	
70 - 75	.1706	.1704	.1597	.1504	.1214	
75 - 80	.1391	.1388	.1278	.1179	.0814	
80 - 85	.1147	.1144	.1031	.0928	.0469	
85 - 90	.0955	.0952	.0838	.0733	.0153	
90 - 100	.1480	.1475	.1248	.1040		
100 - 110	.1069	.1064	.0843	.0655		
110 - 120	.0785	.0780	.0585	.0416		
120 - 130	.0579	.0576	.0402	.0267		
130 - 140	.0425	.0422	.0277	.0172		
140 - 150	.0303	.0301	.0187	.0111		
150 - 160	.0204	.0202	.0120	.0069		
160 - 170	.0117	.0116	.0067	.0038		
170 - 180	.0038	.0038	.0022	.0011		

To obtain actual partial cross-sections, multiply entries in table by $0.03256\left[\frac{ZZ'}{E_0}\right]^2$ barns

RUTHERFORD SCATTERING, RELATIVE PARTIAL CROSS-SECTIONS

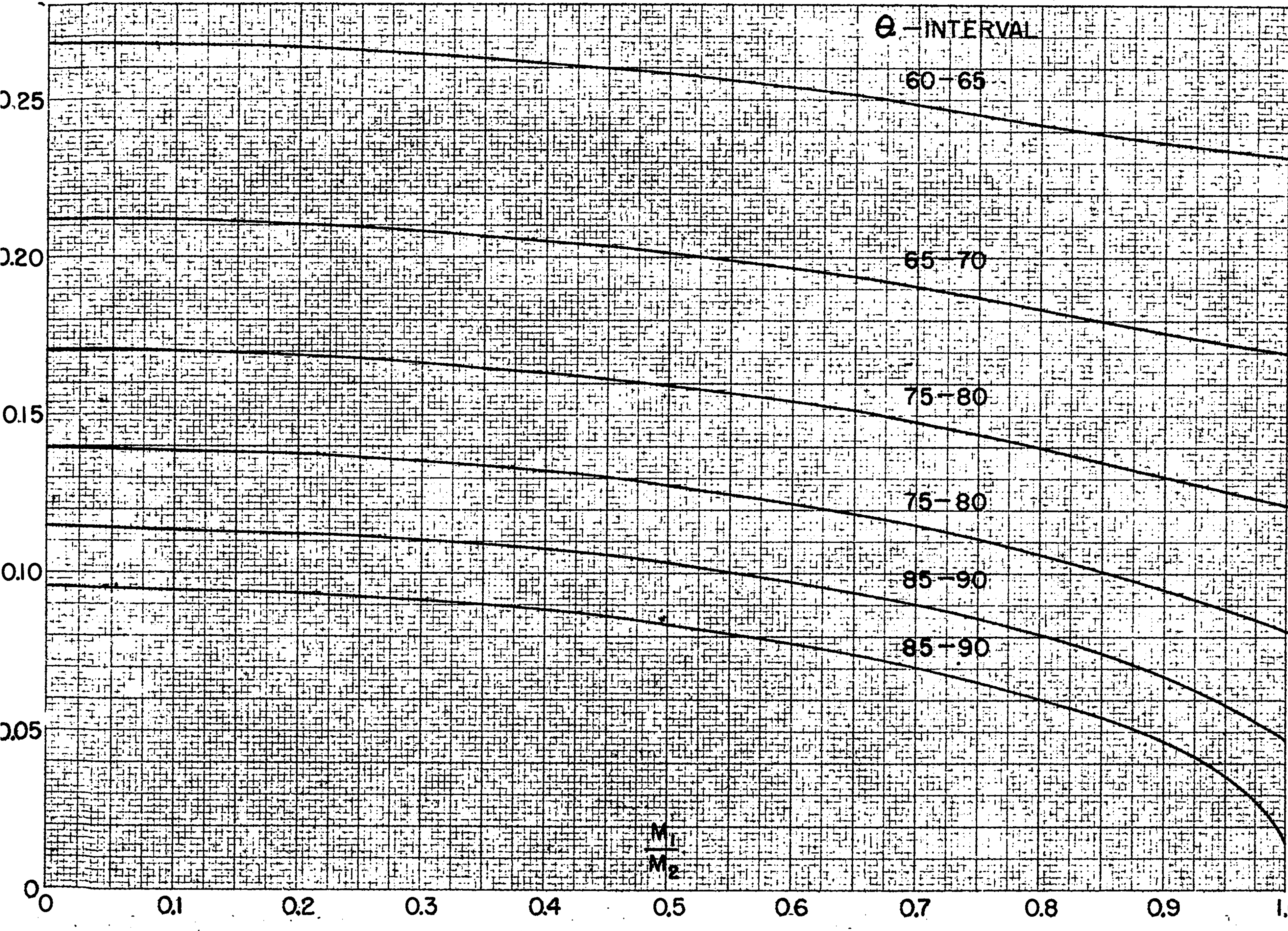


Fig. 40a (See Table 40)

RUTHERFORD SCATTERING, RELATIVE PARTIAL CROSS-SECTIONS

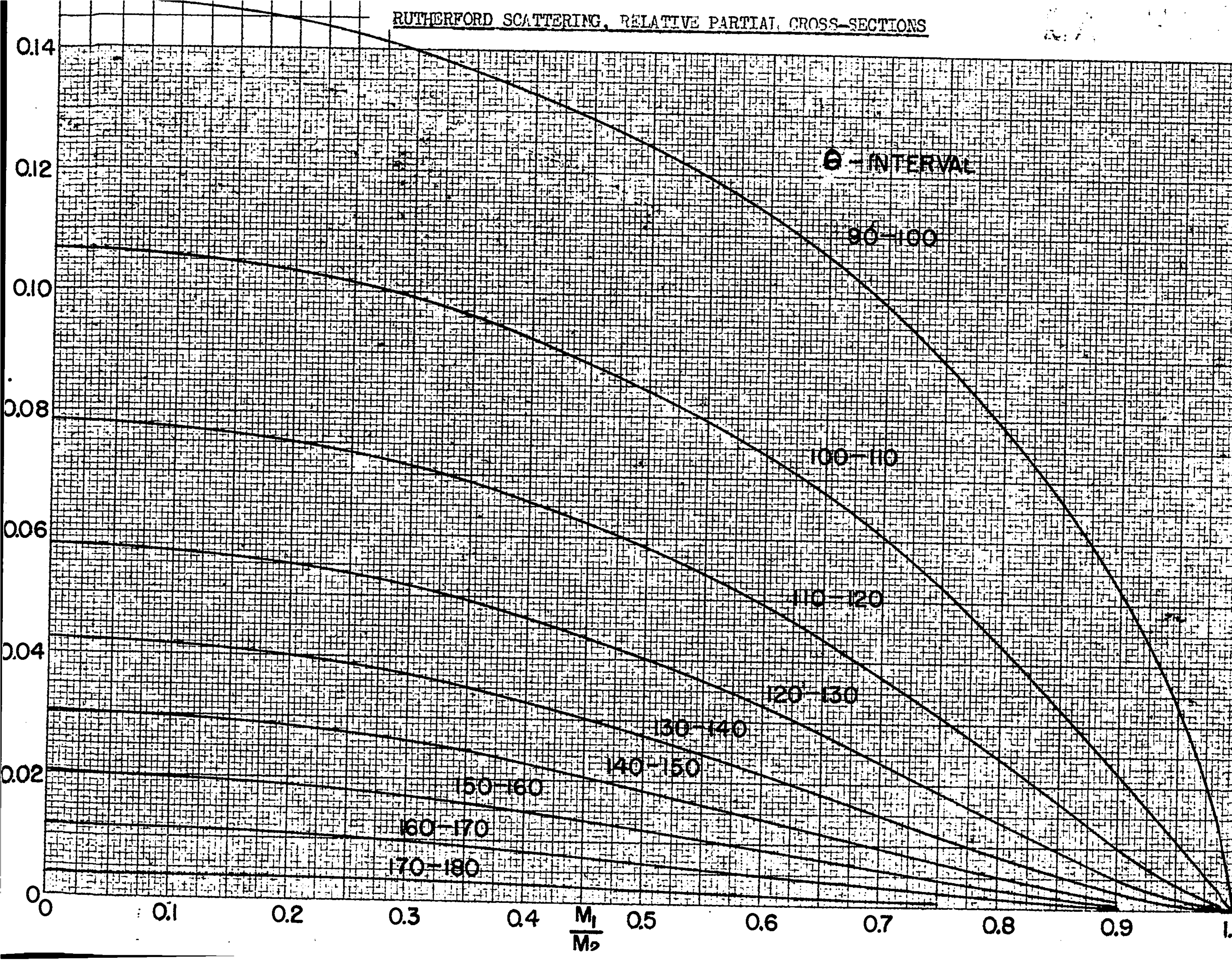


Fig. 40b (See Table 40)

Table 41
(See Fig. 41a & 41b)

We are indebted to Dr. C. F. Powell and his colleagues of the H. H. Wills Physical Laboratory, University of Bristol for the following data:

RANGE-ENERGY RELATION FOR PROTONS AND α-PARTICLES IN THE NUCLEAR RESEARCH EMULSIONS. TYPE B. 1.

C. M. G. Lattes, P. H. Fowler and P. Cuer
Bristol, January 1947.

Energy (MEV)	Range of protons (microns)	Range of α-particles (microns)
0.5	5.5	2.1
1.0	14.5	3.52
1.5	26.0	4.96
2.0	40.0	6.54
2.5	56.5	8.34
3.0	75.0	10.38
3.5	97.0	12.60
4.0	120.5	15.0
4.5	146.0	17.65
5.0	173.0	20.5
5.5	202.0	23.6
6.0	234.0	26.7
6.5	269.0	30.0
7.0	306.0	33.6
7.5	345.0	37.5
8.0	385.0	41.4
8.5	426.0	45.3
9.0	469.0	49.5
9.5	515.0	53.7
10.0	564.0	58.0
10.5	614.0	62.6
11.0	666.0	67.7
11.5	720.0	72.7
12.0	776.0	77.8
12.5	834.0	83.4
13.0	895.0	89.0*
15.0	1135.0*	113.5*

Precision in the range from 2 to 13 MEV, ± 2%. Extrapolated ± 8%

These figures apply also to B.2, C.1 and C.2 types. For E.1 the range for a given energy is about 3% less than the value stated.

* Extrapolated values.

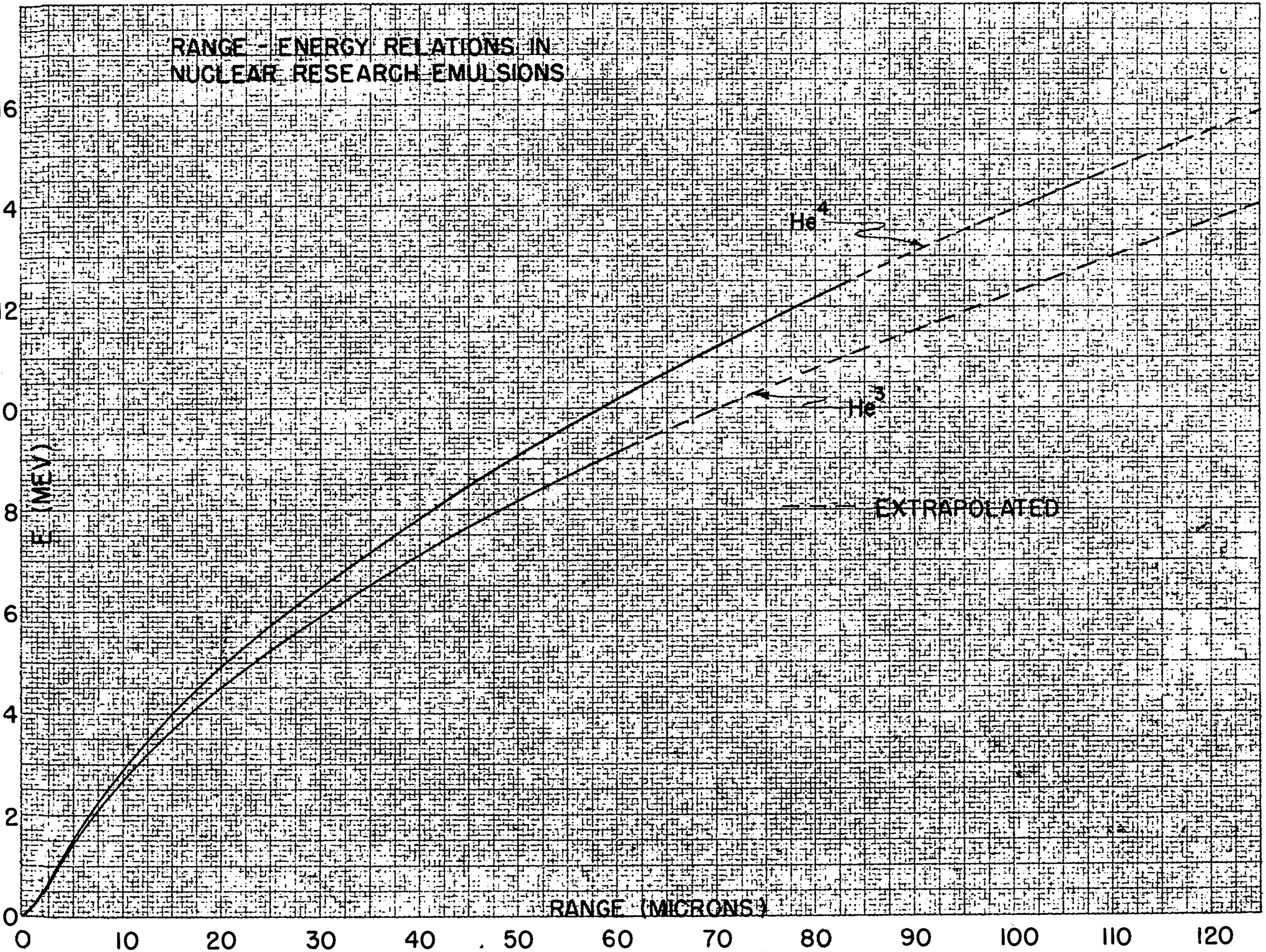


Fig. 41a (See Table 41)

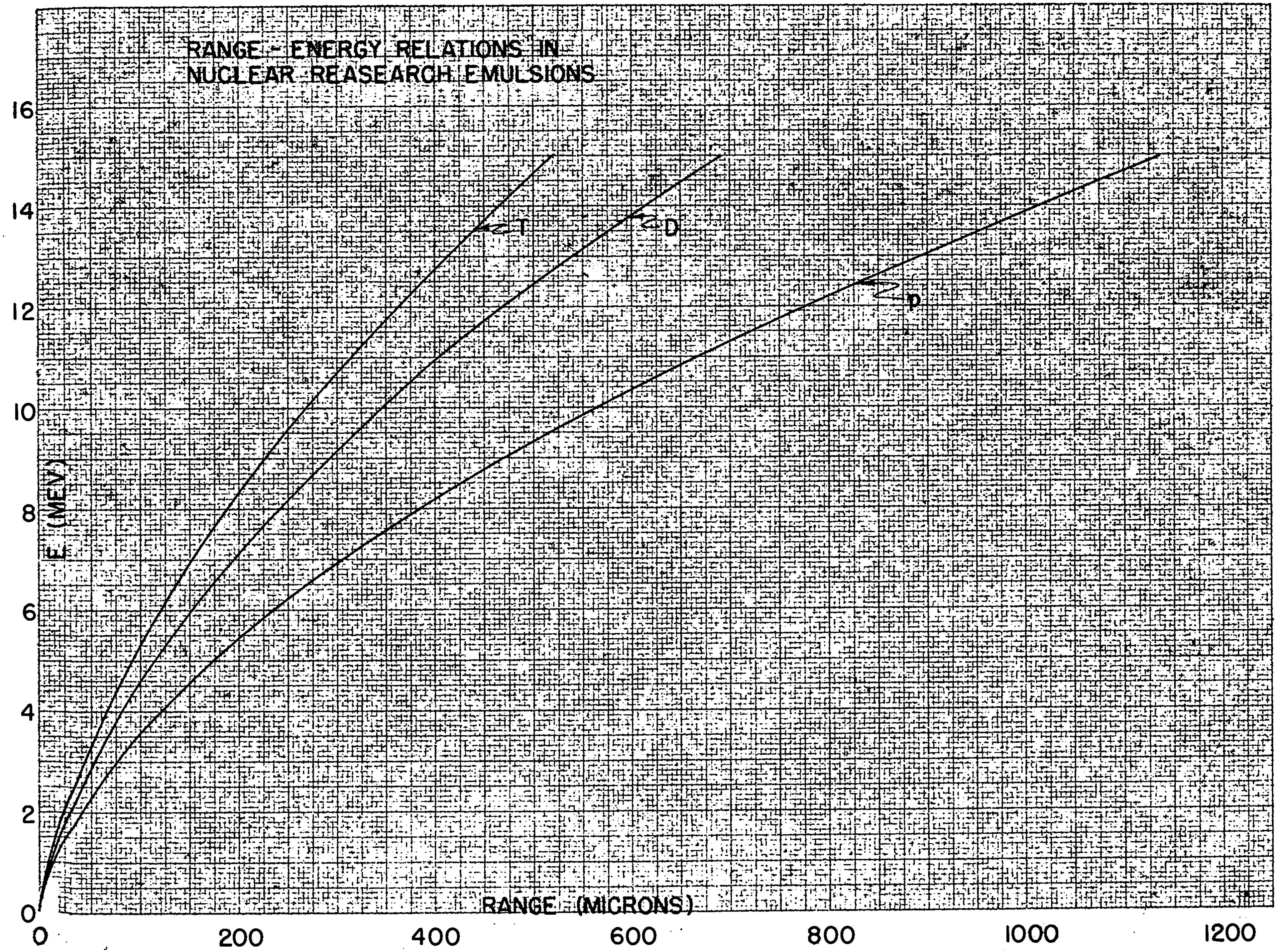


Fig. 41b (See Table 41)

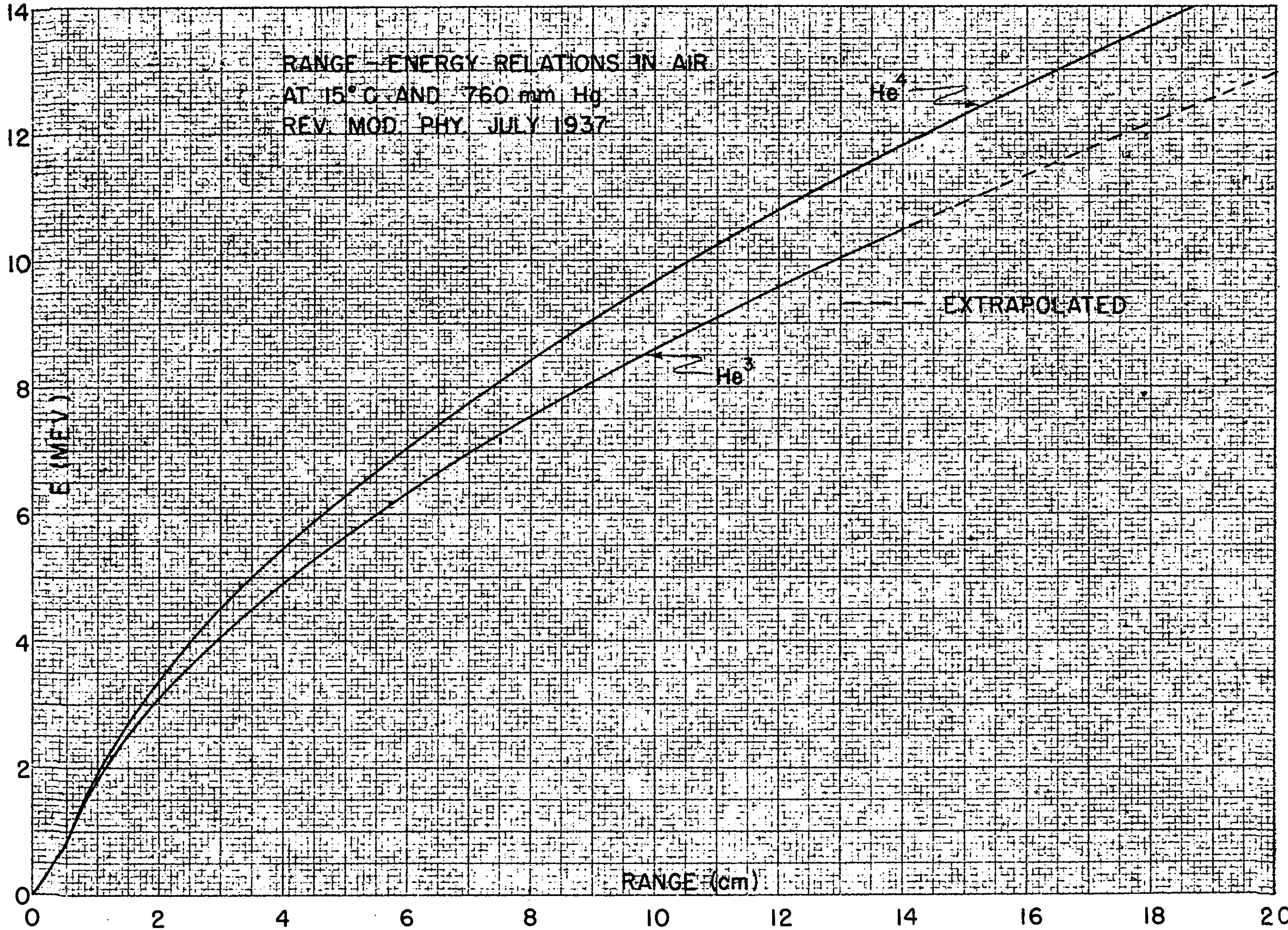

RANGE - ENERGY RELATIONS IN AIR
AT 15° C AND 760 mm Hg
REV. MOD. PHY. JULY 1937
He4
He3
EXTRAPOLATED
E (MEV)
RANGE (cm)
0
2
4
6
8
10
12
14
16
18
20

Fig. 42

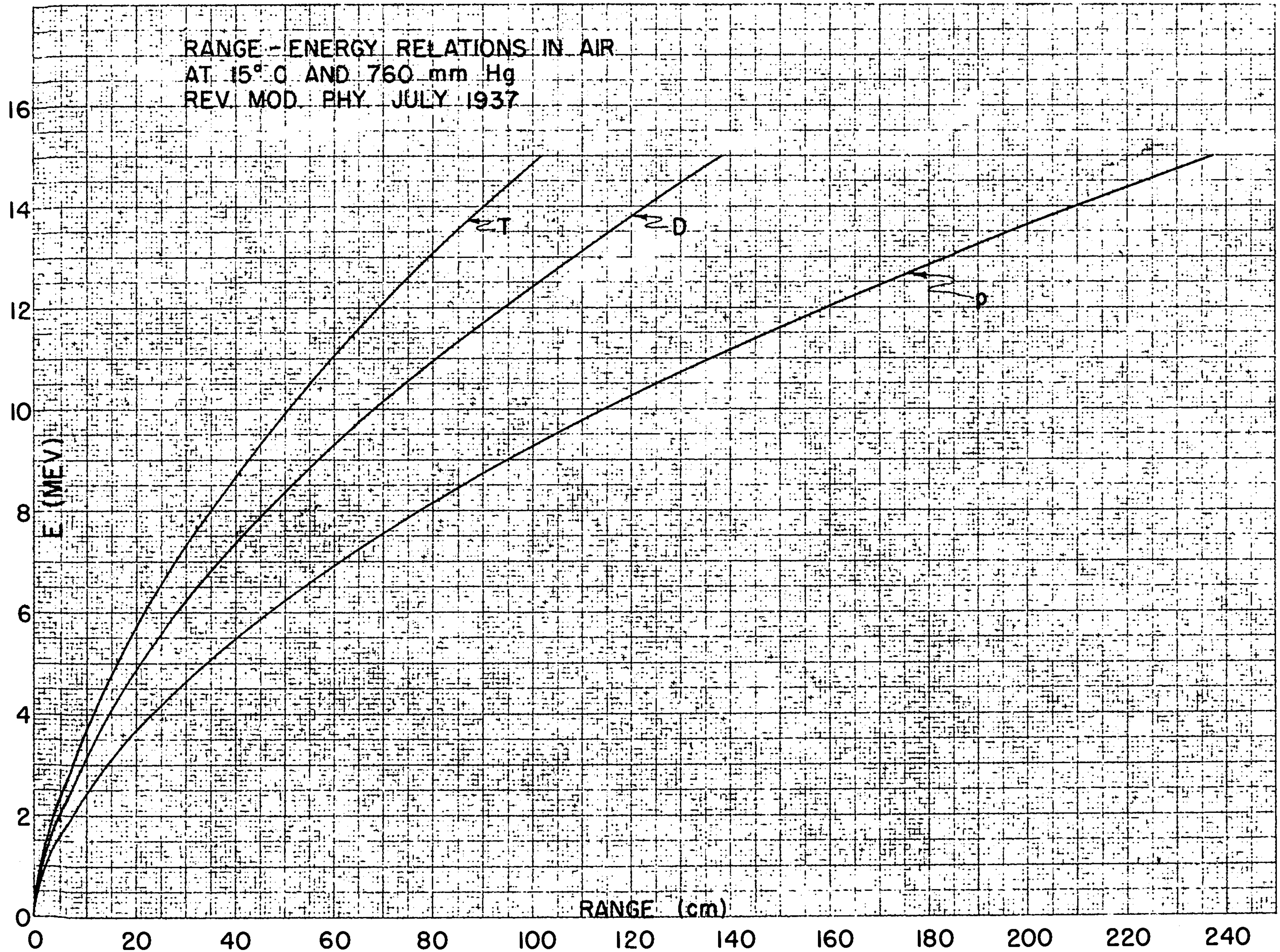

RANGE - ENERGY RELATIONS IN AIR
AT 15° C AND 760 mm Hg
REV. MOD. PHY. JULY 1937
E (MEV)
RANGE (cm)
T
D
p
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120
140
160
180
200
220
240

Fig. 43

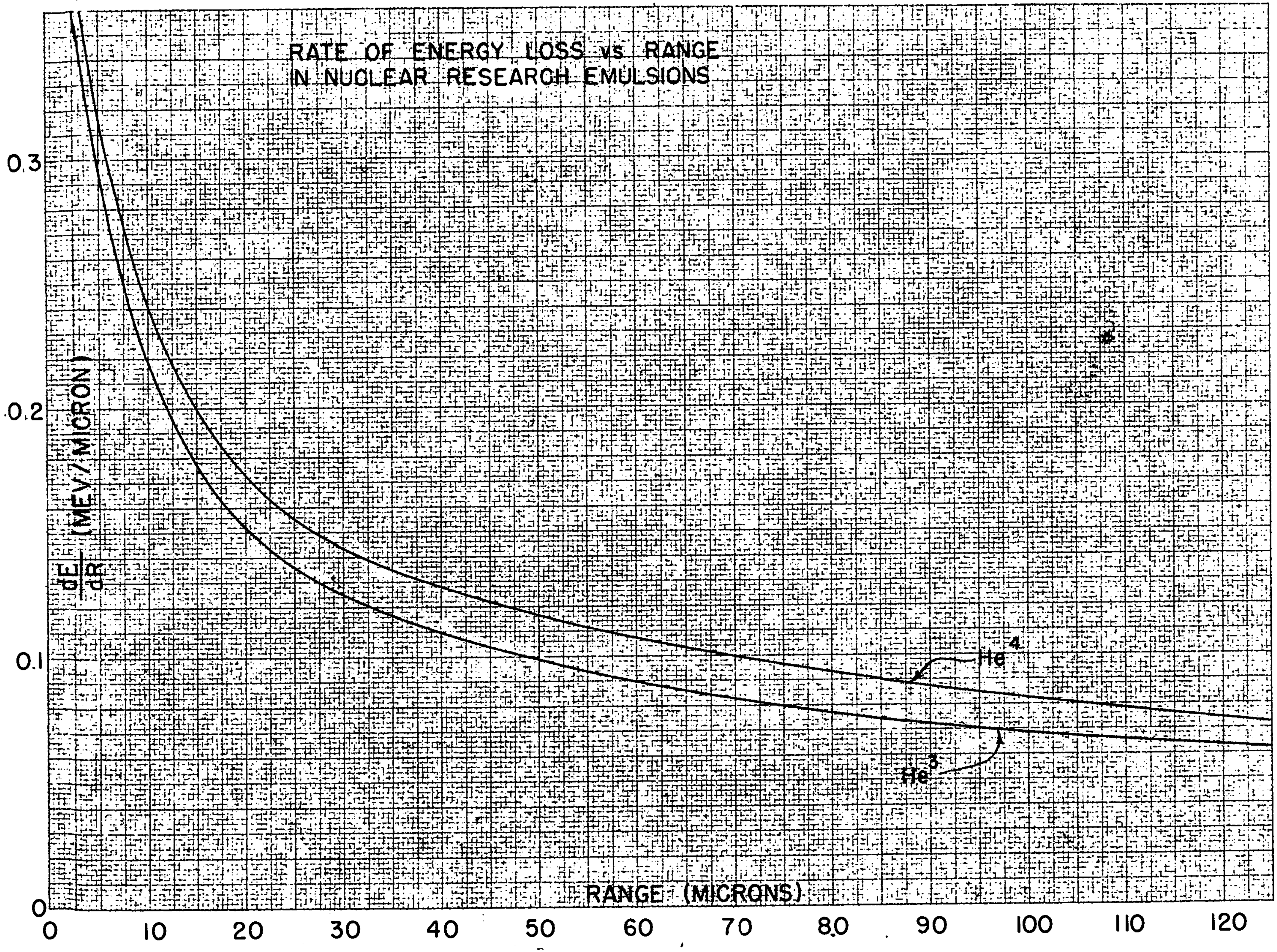

RATE OF ENERGY LOSS vs RANGE
IN NUCLEAR RESEARCH EMULSIONS
dE/dR (MEV/MICRON)
0.3
0.2
0.1
0
RANGE (MICRONS)
0
10
20
30
40
50
60
70
80
90
100
110
120
He4
He3

Fig. 44

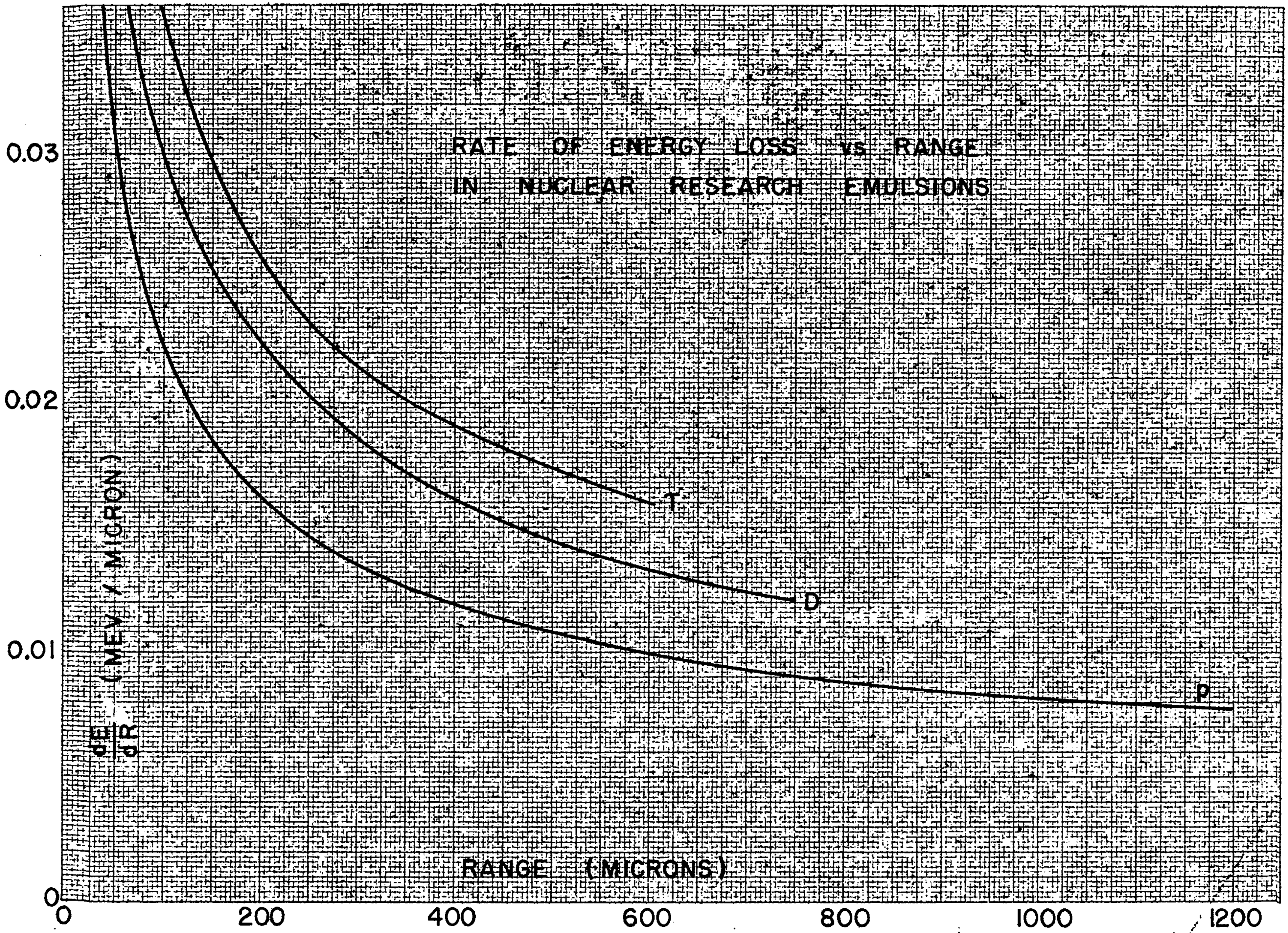

RATE OF ENERGY LOSS vs RANGE
IN NUCLEAR RESEARCH EMULSIONS
dE/dR (MEV / MICRON)
RANGE (MICRONS)
0.03
0.02
0.01
0
0
200
400
600
800
1000
1200
T
D
P

Fig. 45

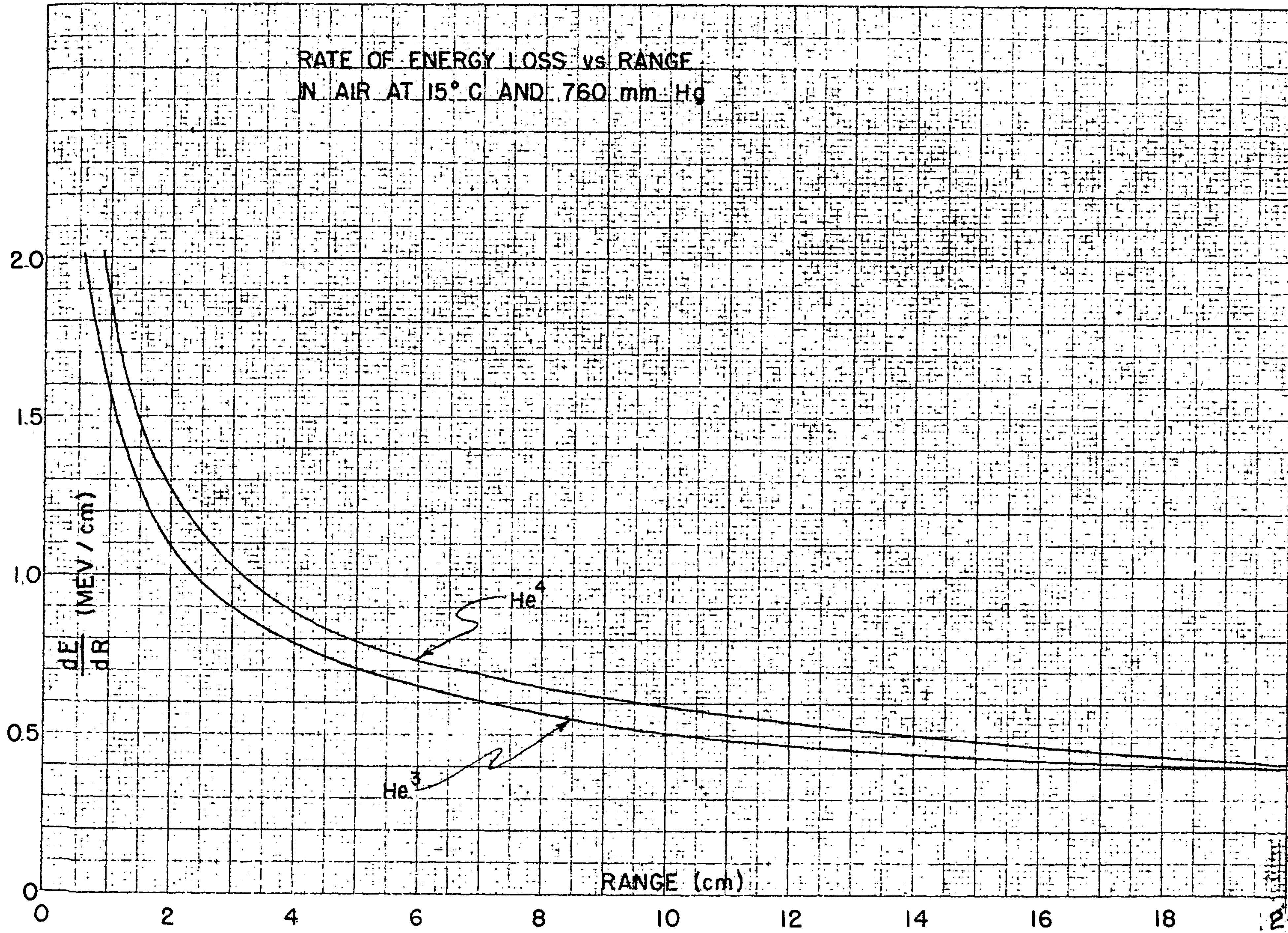

RATE OF ENERGY LOSS vs RANGE
IN AIR AT 15° C AND 760 mm Hg
dE/dR (MEV / cm)
2.0
1.5
1.0
0.5
0
He4
He3
RANGE (cm)
0
2
4
6
8
10
12
14
16
18
20

Fig. 46

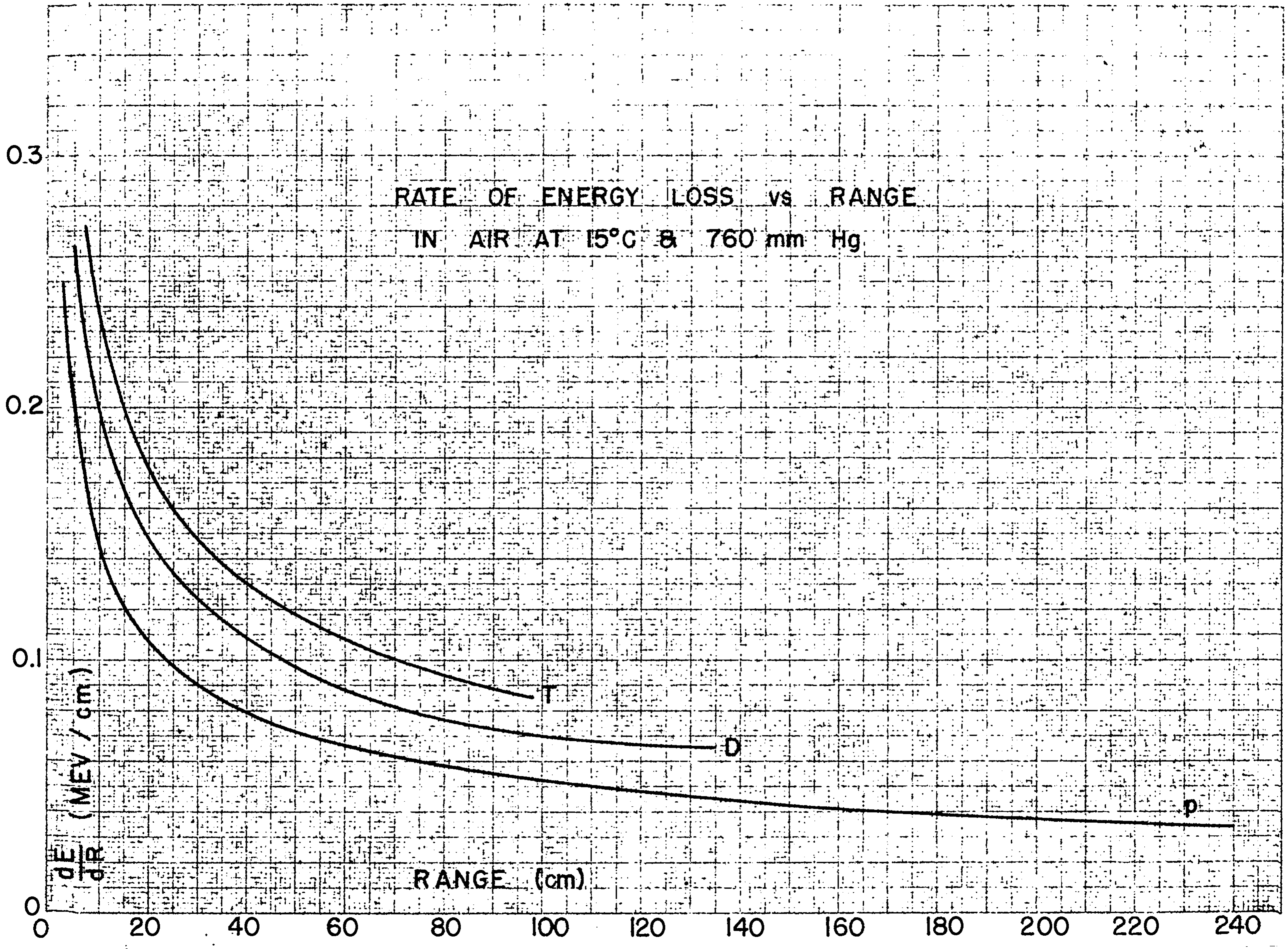

RATE OF ENERGY LOSS vs RANGE
IN AIR AT 15°C & 760 mm Hg
$\frac{dE}{dR}$ (MEV / cm)
RANGE (cm)
0
0.1
0.2
0.3
0
20
40
60
80
100
120
140
160
180
200
220
240
T
D
p

Fig. 47