

CHAPTER IV

TEST RESULTS

Consider the eddy current torque with the metal disk. Although in this case, the exact calculation of the eddy current is a matter of considerable difficulty, simple method of calculating, the approximate values of such currents, and of their braking effect may be obtained by the following method.

Suppose a large sheet of metal is moving across a magnet pole with a velocity u , as in Fig. 4. 1. If B is the flux density in the gap, and b_1 and b_2 the dimensions of the pole as shown, then an E. M. F. $V = b_1 B u / 10^8$ volts is induced in the portion of the plate passing through the field, producing a belt of current flowing in the direction of the arrow and of breadth b_2 . If x is the thickness of the disk, and ρ its specific resistance in ohm per centimetre cube, the resistance of the portion of the disk immediately in front of the pole is $b_1 \rho / b_2 x$ ohm. Obviously the whole resistance of the circuit in which the current flows is greater than this; let us suppose k times as great, where k is a coefficient difficult to calculate, but should not be very large compared with unity for a wide plate.

$$\text{Then } R = \frac{k b_1 \rho}{b_2 x}$$

$$\begin{aligned} \text{and the current } I &= \frac{V}{R} \\ &= \frac{b_1 B u}{10^8} \times \frac{b_2 x}{k b_1 \rho} \\ &= \frac{b_2 x B u}{10^8 k \rho} \quad \text{amps.} \end{aligned}$$

But the force produced by the reaction of this current on the field

$$\begin{aligned}
 F &= \frac{b_1 BI}{10} \\
 &= \frac{b_1 b_2 x B u^2}{10^9 k \rho} \\
 &= \frac{x \Phi^2 u}{10^9 A k \rho} \quad \text{dynes} \quad (4.1)
 \end{aligned}$$

Where Φ is the total flux of the magnet, and $A = b_1 b_2$, its polar area.

If the plate is a circular disk as shown in Fig. 4.2, r is the radius from the axis to the centre of the magnet pole, $u = rw$, and the torque Fr

$$\begin{aligned}
 \text{Hence } T &= Fr \\
 &= \frac{\Phi^2 r^2 x}{10^9 A k \rho} w \quad \text{dyne-em} \quad (4.2)
 \end{aligned}$$

The braking constant

$$\begin{aligned}
 K &= \frac{T}{w} \\
 &= \frac{\Phi^2 r^2 x}{10^9 A k \rho} \quad \text{dyne-em. per rad. per sec.} \quad (4.3)
 \end{aligned}$$

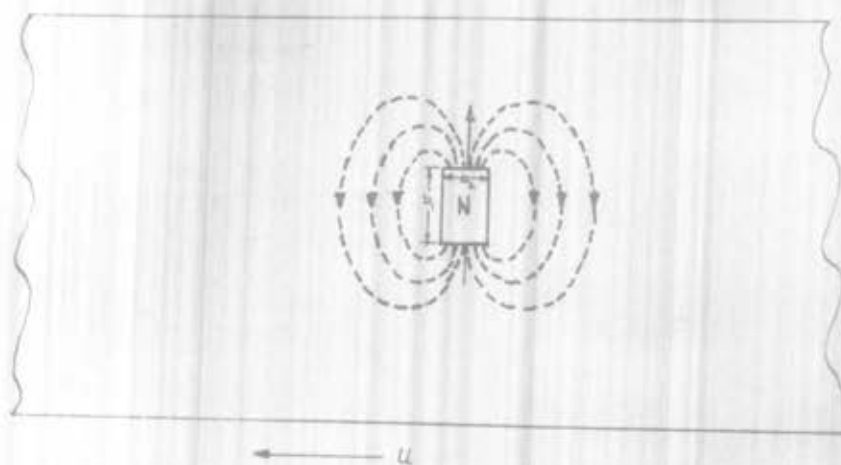


FIG. 4.1 STREAM LINES OF CURRENT IN CONDUCTING PLATE MOVING UNDER MAGNET POLE

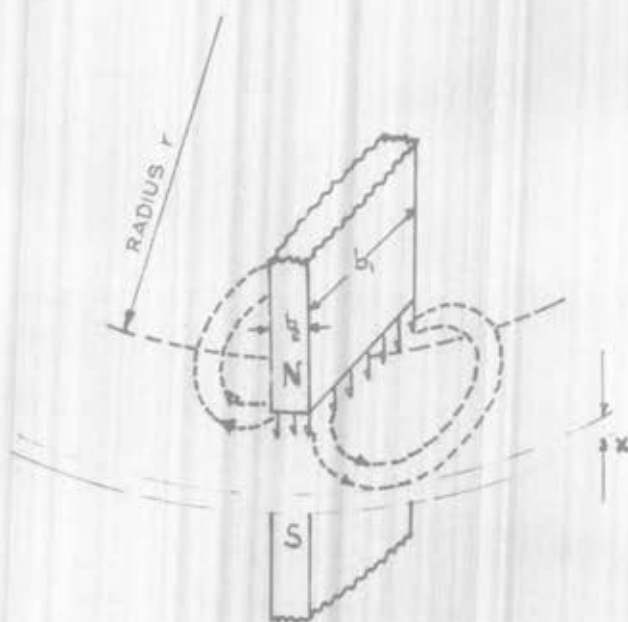


FIG. 4.2 EDDY CURRENT BRAKING WITH A METAL DISK

The assembly of the "eddy current brake" is shown in Fig. 3.1(a). The brake was coupled to a series motor of 1/15 hp. The balance supported the end of the horizontal arm, the weight of the braking torque was found by the scale reading. The length from the centre of the spindle to the end of the arm is 27.5 cm.

It was more convenient to run the disk at different speeds when the laminated cores were excited by a dc voltage at a constant value. The weight W at the balance was read at various speeds of the motor.

Then the torque

$$\begin{aligned} T &= Wa && \text{gm.-cm.} \\ &= Wa \times 980 && \text{dyne-cm.} \end{aligned}$$

and the braking constant

$$K = \frac{Wa \times 980 \times 60}{2 \pi n}$$

dyne-cm. per rad. per sec.

Where n is the speed of the motor in rpm., the arm length a in cm., and the balancing weight W in gm.

Then the coefficient

$$k = \frac{\Phi^2 r^2 \times}{10^9 A \rho} \times \frac{2 \pi n}{Wa \times 980 \times 60}$$

For these calculations, the torque-speed curves were obtained as in Fig. 4.3, 4.4, 4.5, 4.6, 4.7 and 4.8, and the variation of k with the excited current is shown in Fig. 4.18.

TABLE I VALUES OF BALANCED WEIGHT AT VARIOUS
SPEEDS OF MOTOR AND 1 AMP. EXCITING CURRENT

SPEED OF MOTOR (rpm.)	VOLTAGES	AMPERES	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
28	60	0.98	12.00	330.00
47	65	0.90	20.20	550.00
68	70	0.83	27.10	742.50
89	75	0.78	32.00	880.00
110	80	0.73	44.00	1,210.00
135	85	0.68	49.00	1,347.50
168	90	0.65	59.00	1,622.50
194	95	0.62	70.00	1,925.00
230	100	0.59	89.00	2,365.00
264	105	0.56	94.00	2,585.00

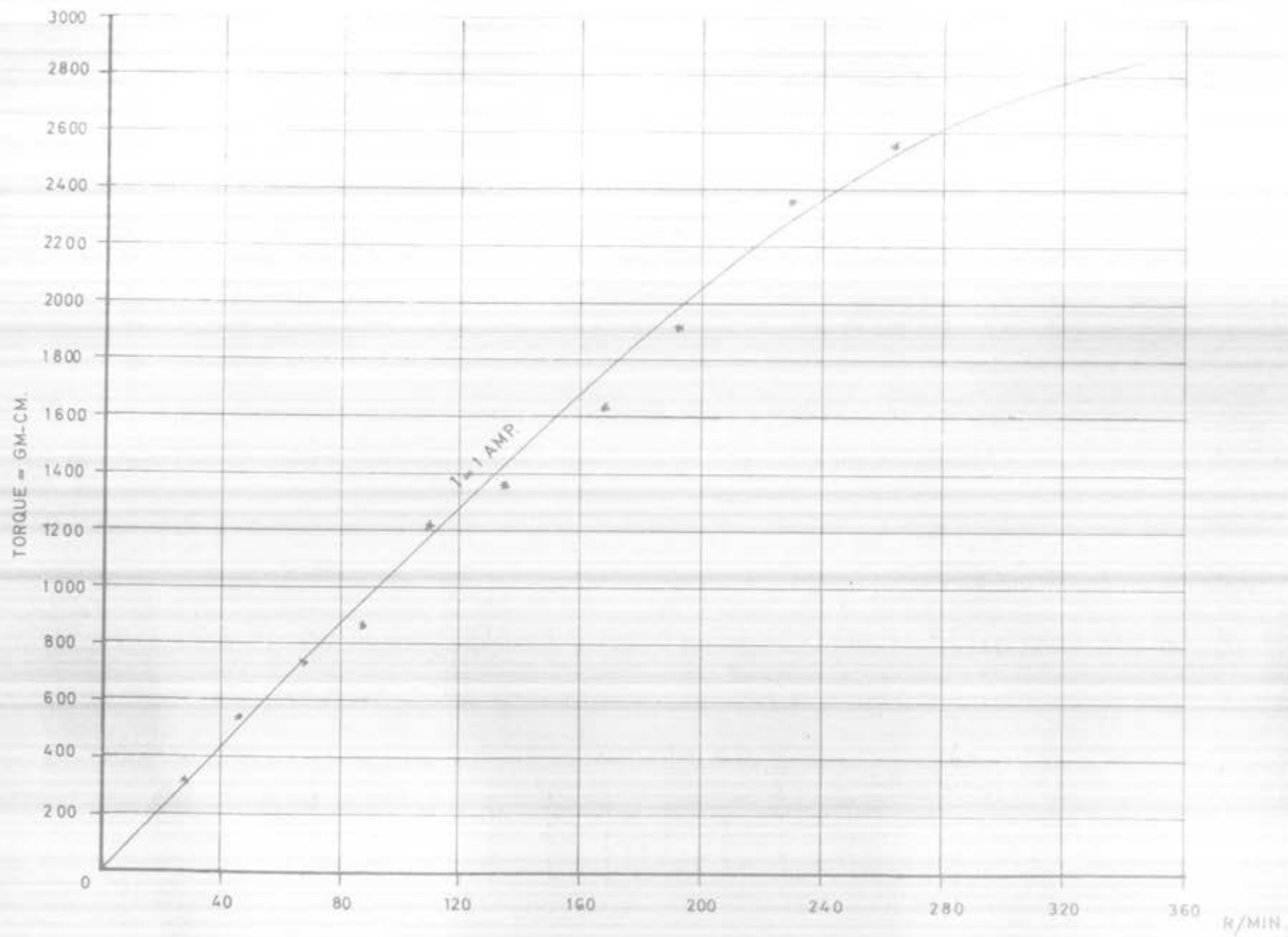


FIG. 4-3 TORQUE VS. SPEED CURVE FOR 1 AMP EXCITING CURRENT

TABLE II VALUES OF BALANCED WEIGHT AT VARIOUS
SPEEDS OF MOTOR AND 0.8 AMP. EXCITING CURRENT

SPEED OF MOTOR (rpm.)	VOLTAGES	AMPERES	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
53	60	0.98	14.00	385.00
80	65	0.90	18.00	495.00
98	70	0.83	24.00	660.00
110	75	0.78	32.00	880.00
150	80	0.73	40.10	1,100.00
178	85	0.69	50.30	1,375.00
238	90	0.65	61.50	1,677.50
278	95	0.62	66.00	1,815.00
382	100	0.58	78.00	2,145.00
420	105	0.56	86.00	2,365.00

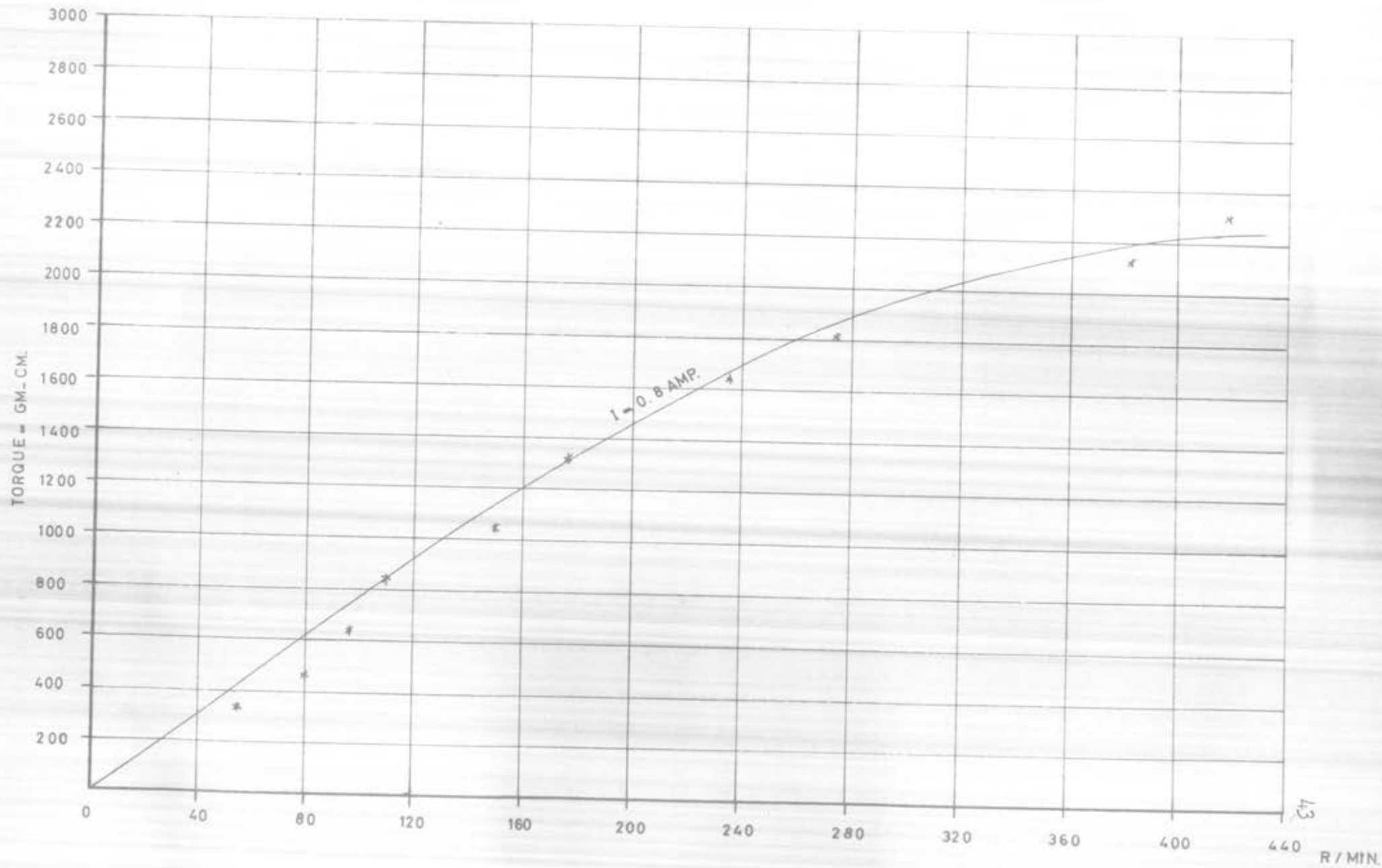


FIG. 4.4 TORQUE VS. SPEED CURVE FOR 0.8 AMP EXCITING CURRENT

TABLE III VALUES OF BALANCED WEIGHT AT VARIOUS
SPEEDS OF MOTOR AND 0.6 AMP. EXCITING CURRENT

SPEED OF MOTOR (rpm.)	VOLTAGES	AMPERES	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
104	60	0.98	17.40	467.50
134	65	0.90	20.00	550.00
150	70	0.83	26.00	715.00
184	75	0.78	36.30	990.00
260	80	0.73	44.10	1,210.00
490	85	0.68	52.00	1,430.00
620	86	0.68	56.00	1,540.00
740	88	0.67	58.00	1,595.00
1,200	89	0.67	55.90	1,550.00
1,600	90	0.65	51.20	1,400.00
2,660	92	0.64	30.00	825.00
3,220	95	0.62	28.00	770.00
3,480	100	0.59	26.00	715.00

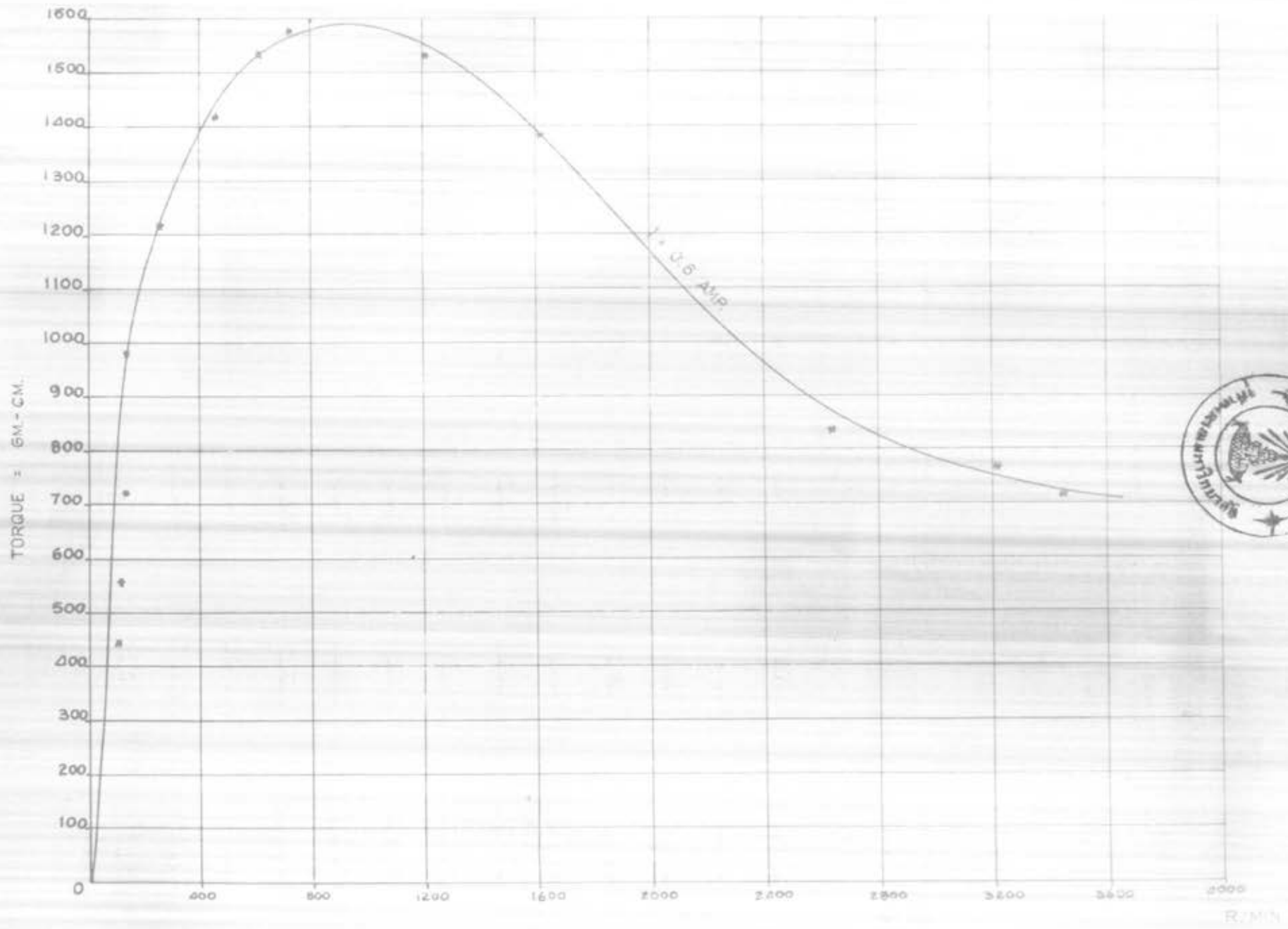


FIG. 4.5. TORQUE VS SPEED CURVE FOR 0.6 AMP. EXCITING CURRENT

TABLE IV VALUES OF BALANCED WEIGHT AT VARIOUS
SPEEDS OF MOTOR AND 0.4 AMP. EXCITING CURRENT

SPEED OF MOTOR (rpm.)	VOLTAGES	AMPERES	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
66	50	1.17	6.00	165.00
128	55	1.07	12.10	330.00
140	60	0.98	16.00	440.00
180	65	0.90	22.00	580.00
380	70	0.83	26.00	715.00
800	72	0.81	27.10	750.00
1,360	75	0.78	24.00	660.00
1,800	77	0.76	21.00	575.00
2,240	80	0.73	18.10	500.00
2,760	85	0.68	16.00	440.00
3,500	90	0.65	14.00	385.00

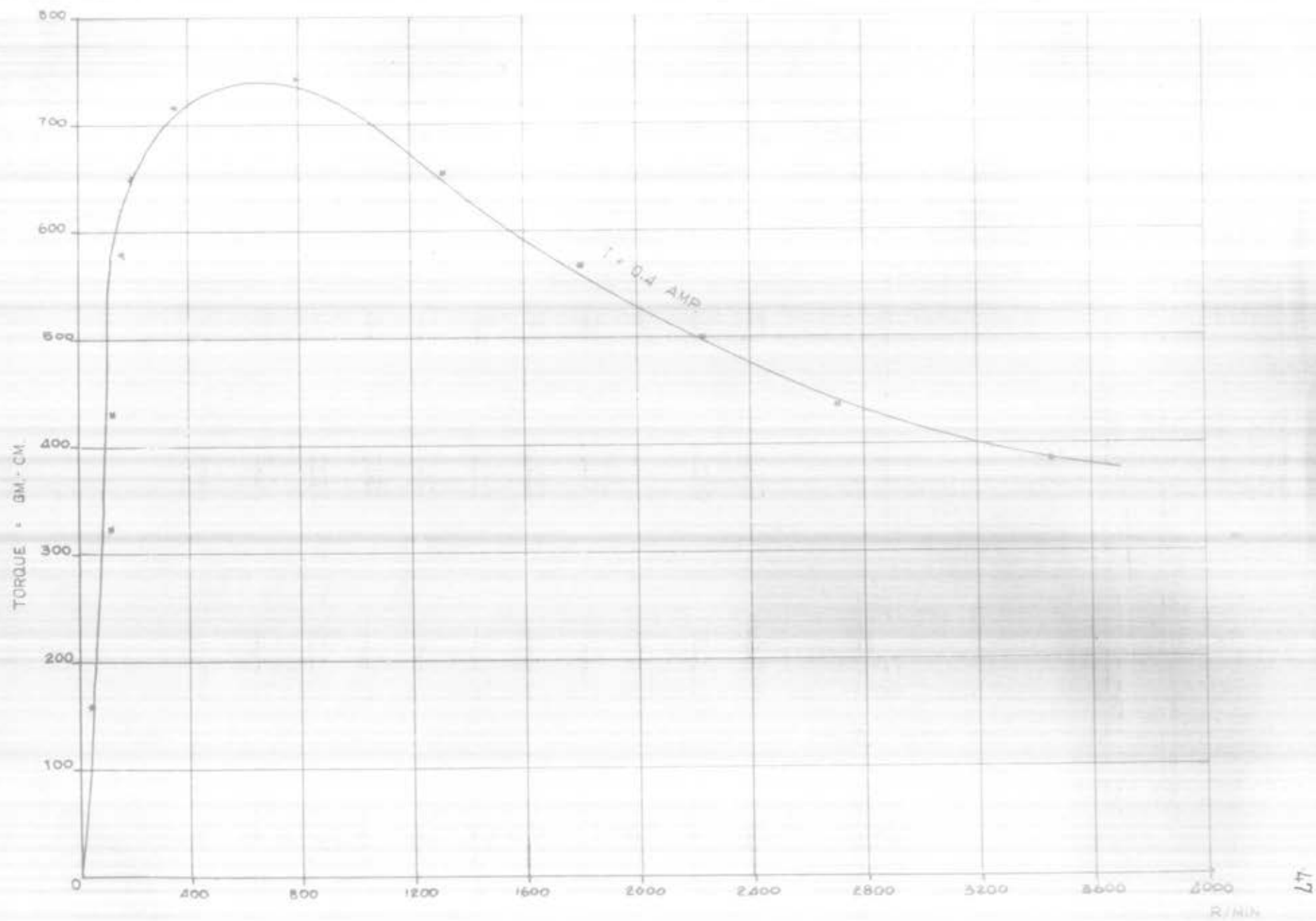


FIG. 4.6 TORQUE VS. SPEED CURVE FOR 0.4 AMP EXCITING CURRENT.

TABLE V VALUES OF BALANCED WEIGHT AT VARIOUS
SPEEDS OF MOTOR AND 0.2 AMP. EXCITING CURRENT

SPEED OF MOTOR (rpm.)	VOLTAGES	AMPERES	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
160	50	1.17	6.20	165.00
410	55	1.07	10.10	275.00
870	60	0.98	12.00	330.00
1,340	65	0.90	10.00	275.00
1,900	70	0.83	8.10	220.00
2,500	75	0.78	6.40	175.00
3,080	80	0.73	6.00	165.00
3,340	85	0.68	5.40	150.00

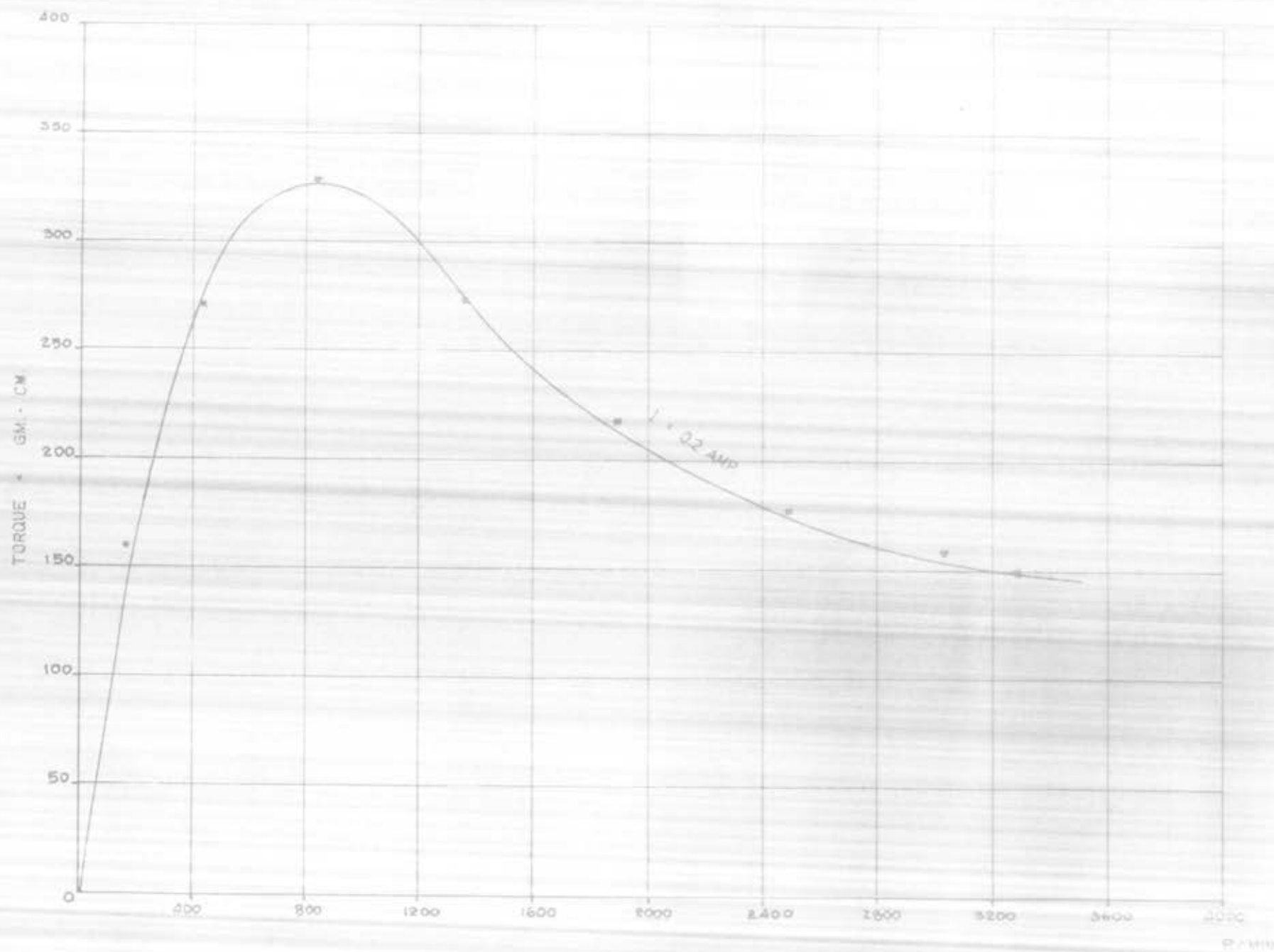


FIG. 47 TORQUE VS. SPEED CURVE FOR 0.2 AMP. EXCITING CURRENT.

TABLE VI VALUES OF BALANCED WEIGHT AT VARIOUS
SPEEDS OF MOTOR AND 0.1 AMP. EXCITING CURRENT

SPEED OF MOTOR (rpm.)	VOLTAGES	AMPERES	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
165	50	1.17	2.50	68.75
280	52	1.12	3.00	82.50
870	55	1.06	4.00	110.00
1,190	59	0.99	4.00	110.00
1,470	60	0.98	4.00	110.00
1,860	65	0.90	3.50	96.25
2,260	70	0.84	3.50	96.25
2,800	75	0.78	3.20	87.00
3,400	80	0.73	3.20	87.00

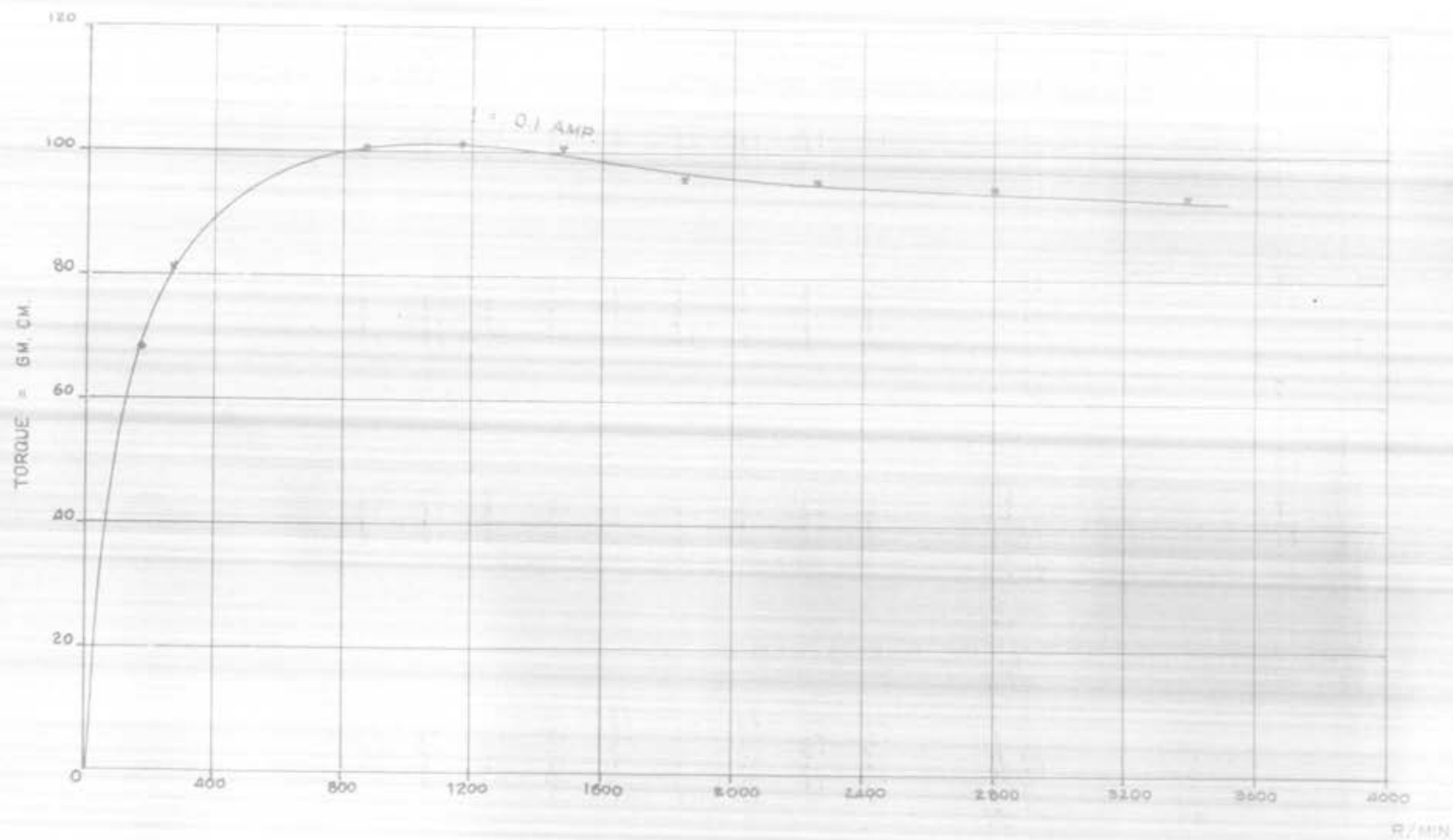


FIG. 4.8. TORQUE VS. SPEED CURVE FOR 0.1 AMP EXCITING CURRENT

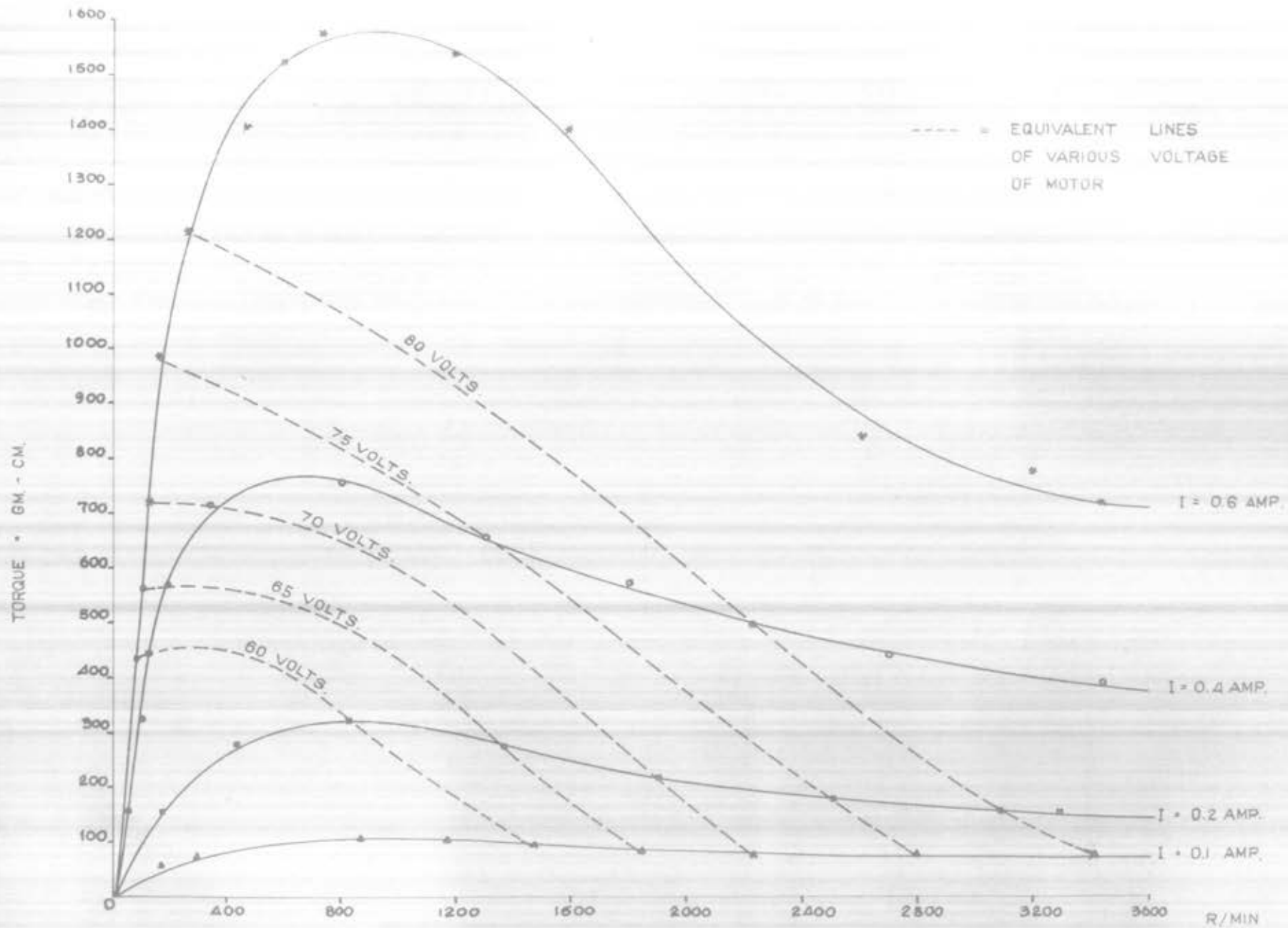


FIG. 4.9 TORQUE VS. SPEED CURVE FOR VARIOUS EXCITING CURRENTS.

TABLE I a VALUES OF MOTOR SPEED AT VARIOUS
APPLIED VOLTAGE AND NO EXCITING CURRENT

SPEED (rpm.)	VOLTAGE (Volt)	AMPERE (amp.)
520	50	1.17
920	55	1.07
1,500	60	0.98
1,920	65	0.90
2,320	70	0.83
2,600	72	0.81
2,850	75	0.78
3,200	77	0.76
3,500	80	0.73
3,950	85	0.68
4,100	90	0.65
4,350	95	0.62
4,650	100	0.58

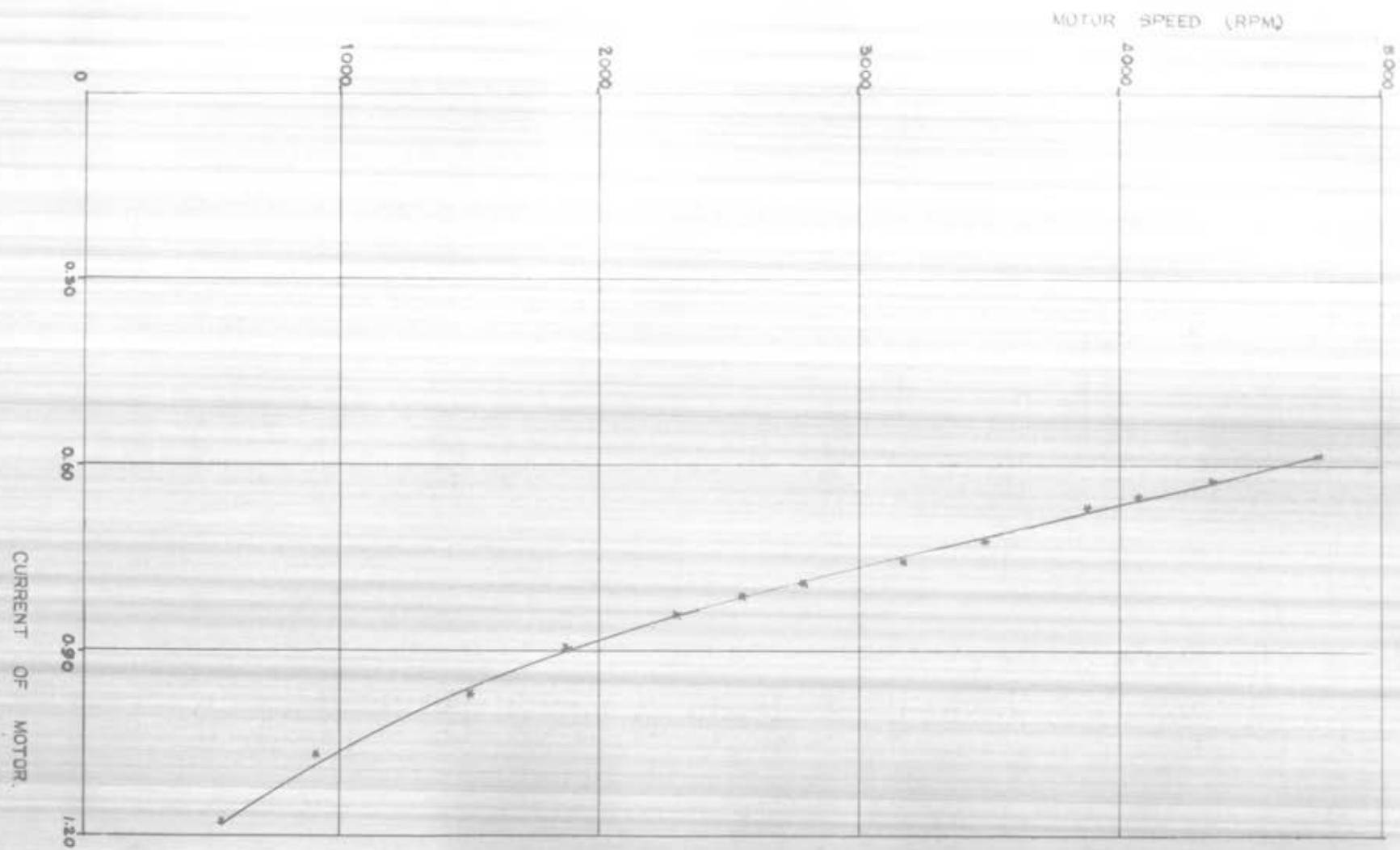


FIG. 4.10 NO LOAD CURRENT - SPEED CURVE (NO EXCITING CURRENT)

TABLE I b VALUES OF TORQUES AT VARIOUS EXCITING CURRENT,
60 VOLTS APPLIED VOLTAGE AND 1,500 RPM. MOTOR SPEED

EXCITING CURRENT (amp.)	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
0.10	4.50	124.00
0.20	10.00	275.00
0.40	16.00	440.00
0.60	17.00	467.50
0.80	14.00	385.00
1.00	12.00	330.00

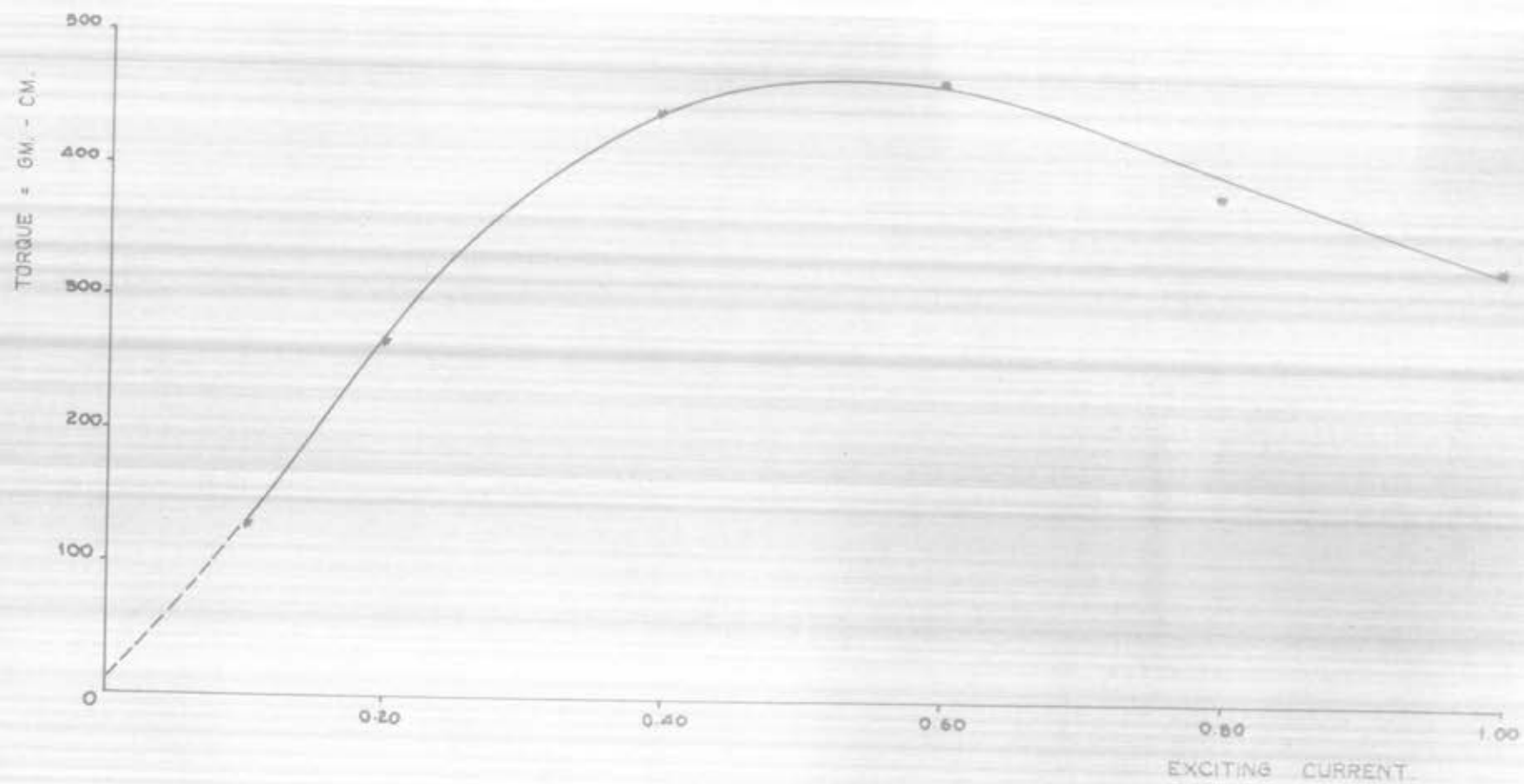


FIG. 4.11 TORQUE - EXCITING CURRENT CURVE DURING 1500 RPM. RUNNING MOTOR.

TABLE II b VALUES OF TORQUES AT VARIOUS EXCITING CURRENT,
70 VOLTS APPLIED VOLTAGE AND 2,350 RPM. MOTOR SPEED

EXCITING CURRENT (amp.)	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
0.10	3.60	99.00
0.20	8.00	220.00
0.40	23.60	650.00
0.60	26.20	720.00
0.80	24.00	660.00
1.00	21.00	580.00

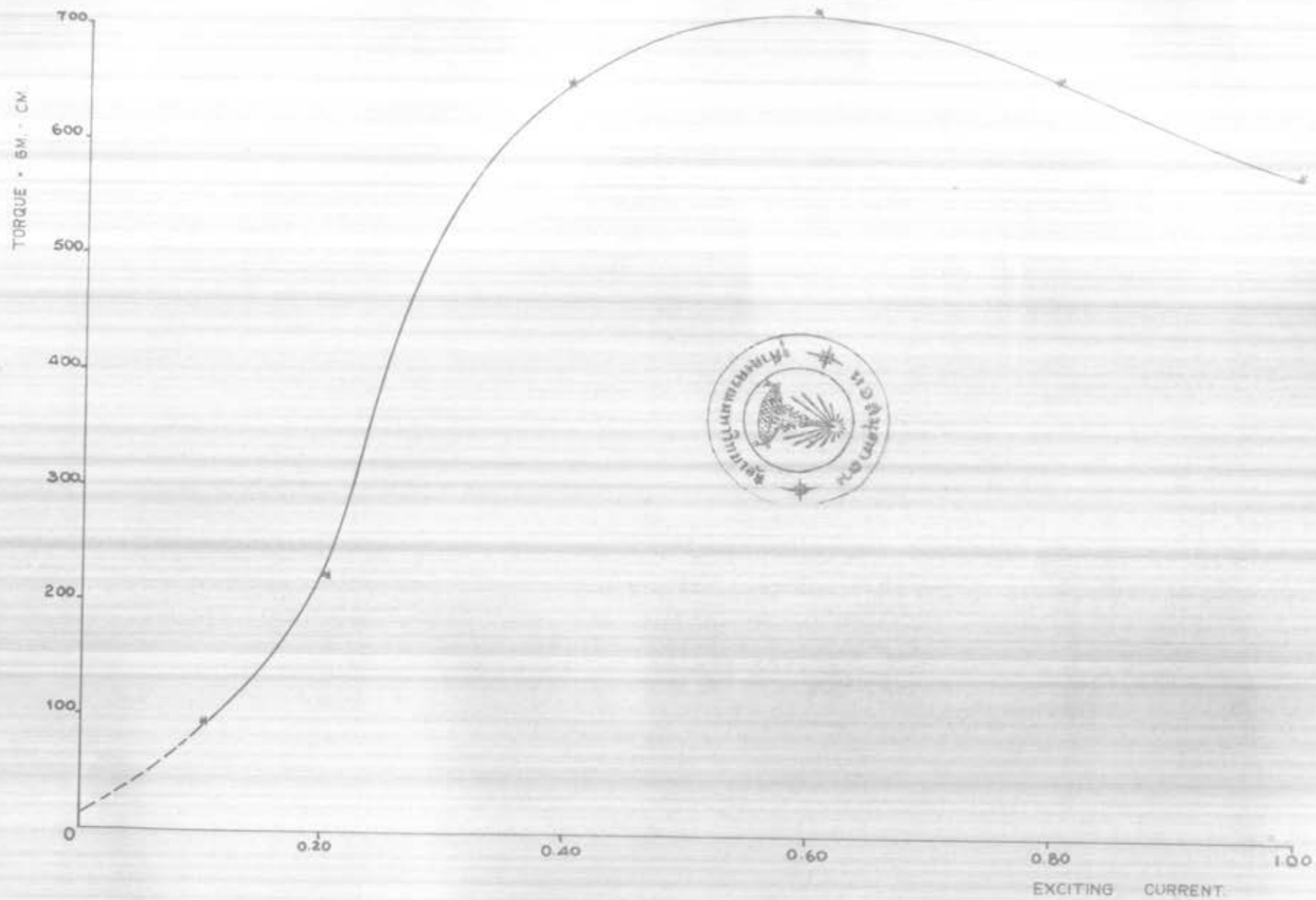


FIG. 4.12 TORQUE - EXCITING CURRENT CURVE DURING 2350 RPM RUNNING MOTOR



TABLE III b VALUES OF TORQUES AT VARIOUS EXCITING CURRENT,
80 VOLTS APPLIED VOLTAGE AND 3,500 RPM, MOTOR SPEED

EXCITING CURRENT (amp.)	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
0.10	3.00	82.50
0.20	6.10	168.00
0.40	24.00	680.00
0.60	41.00	1,150.00
0.80	40.00	1,100.00
1.00	35.60	980.00

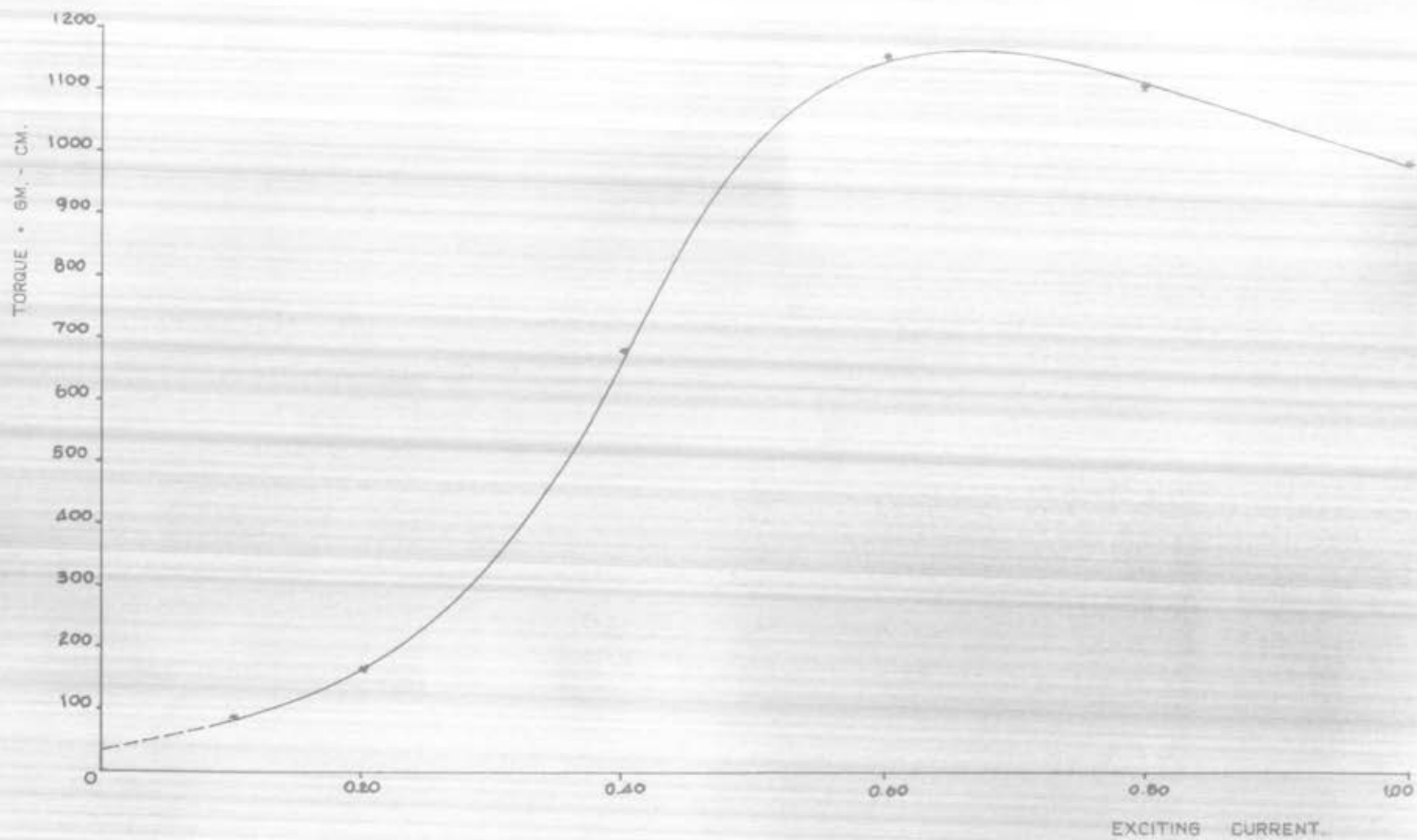


FIG. 4.13 TORQUE - EXCITING CURRENT CURVE DURING 3500 RPM RUNNING MOTOR.

TABLE IV b VALUES OF TORQUES AT VARIOUS EXCITING CURRENT,
90 VOLTS APPLIED VOLTAGE AND 4,100 RPM. MOTOR SPEED

EXCITING CURRENT (amp.)	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
0.10	3.20	87.00
0.20	4.00	110.00
0.40	16.00	450.00
0.60	51.00	1,400.00
0.80	61.30	1,690.00
1.00	59.00	1,622.50

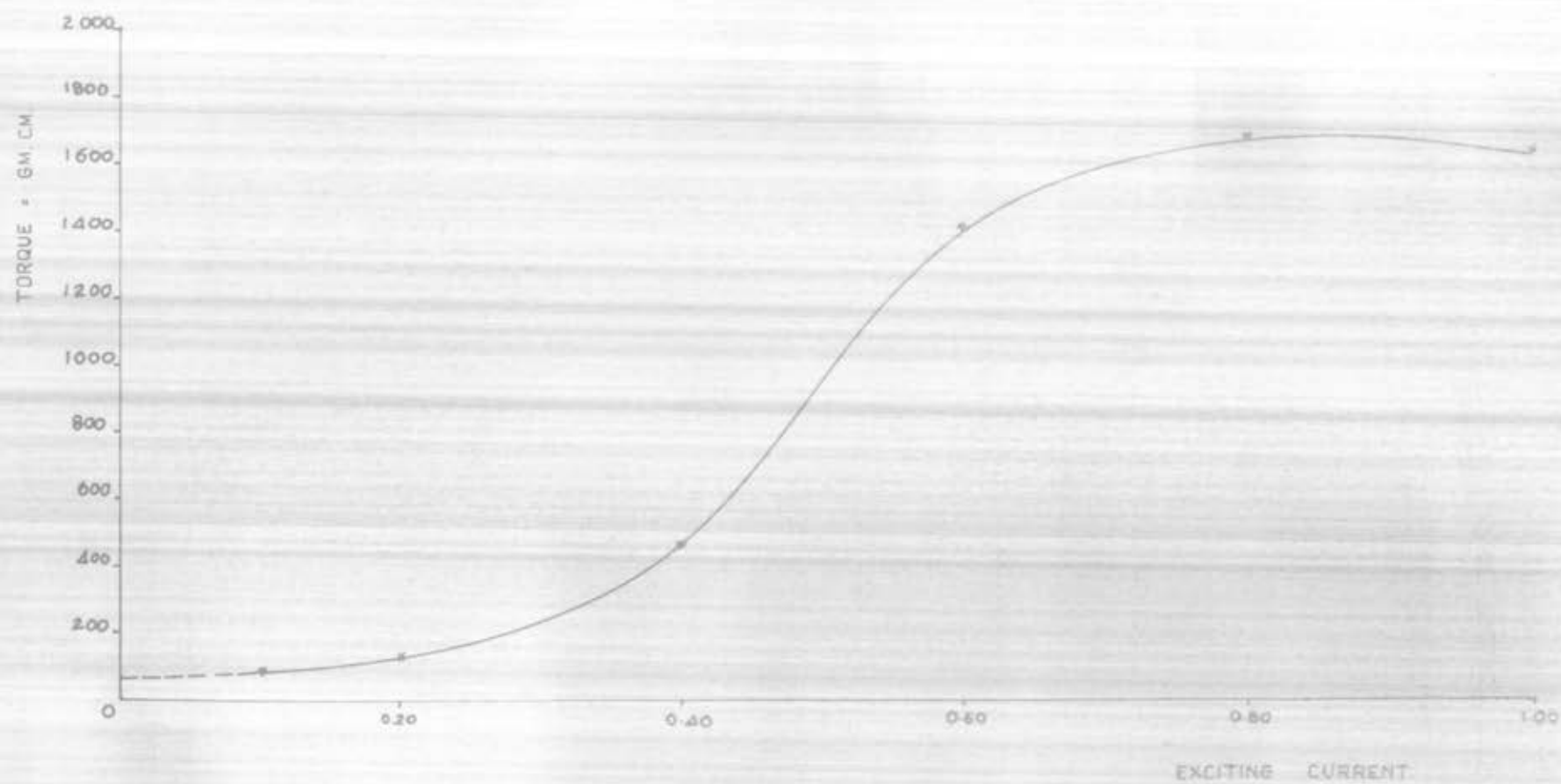


FIG. 4.14 TORQUE - EXCITING CURRENT CURVE DURING 4100 RPM. RUNNING MOTOR

TABLE V b VALUES OF TORQUES AT VARIOUS EXCITING CURRENT,
100 VOLTS APPLIED VOLTAGE AND 4,650 RPM. MOTOR SPEED

EXCITING CURRENT (amp.)	BALANCED WEIGHT (gm.)	TORQUES (gm. - cm.)
0.10	3.20	87.00
0.20	3.82	105.00
0.40	12.50	343.00
0.60	30.80	850.00
0.80	77.00	2,120.00
1.00	89.00	2,365.00

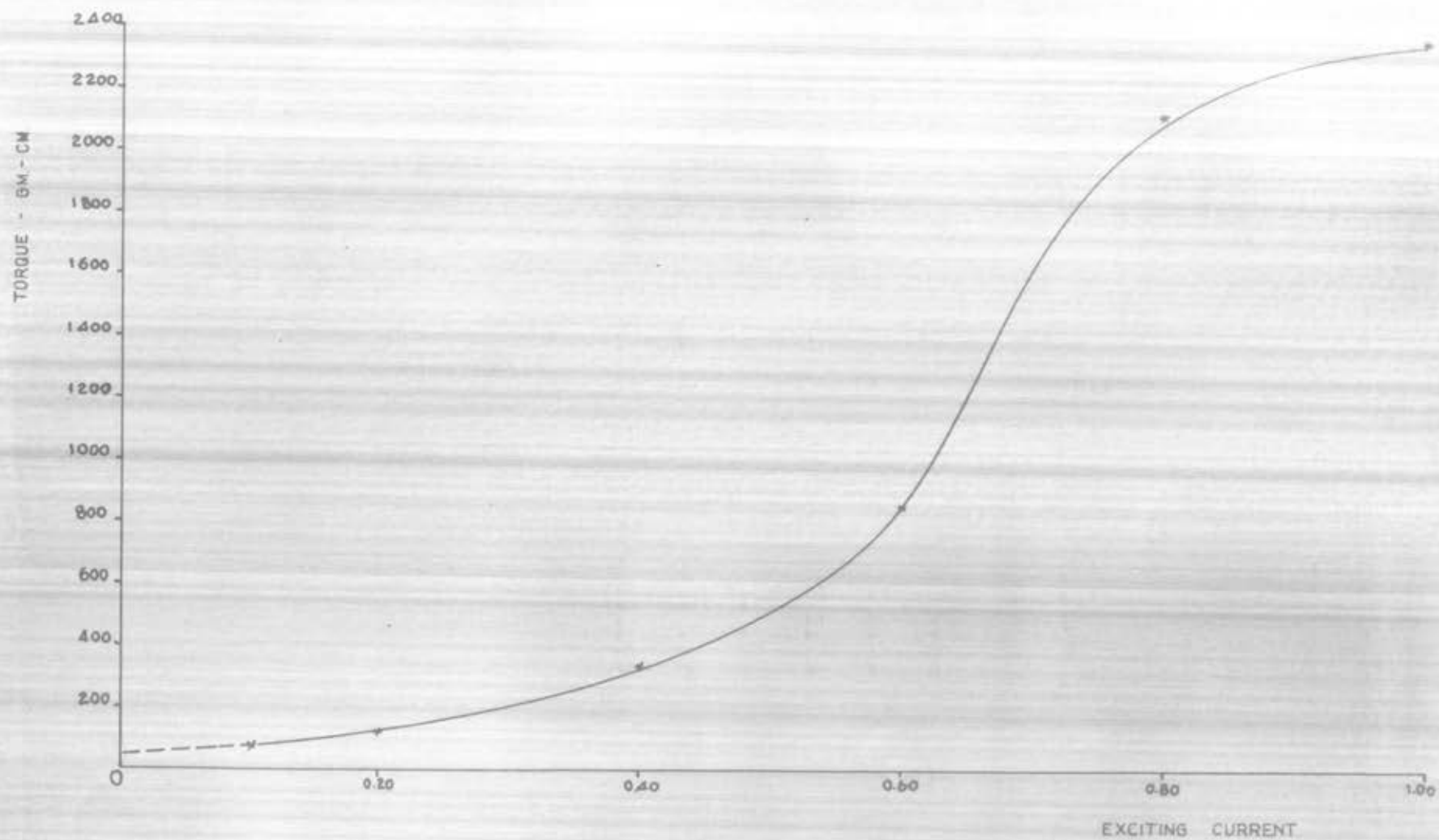


FIG. 4.15 TORQUE - EXCITING CURRENT CURVE DURING 4650 RPM. RUNNING MOTOR.

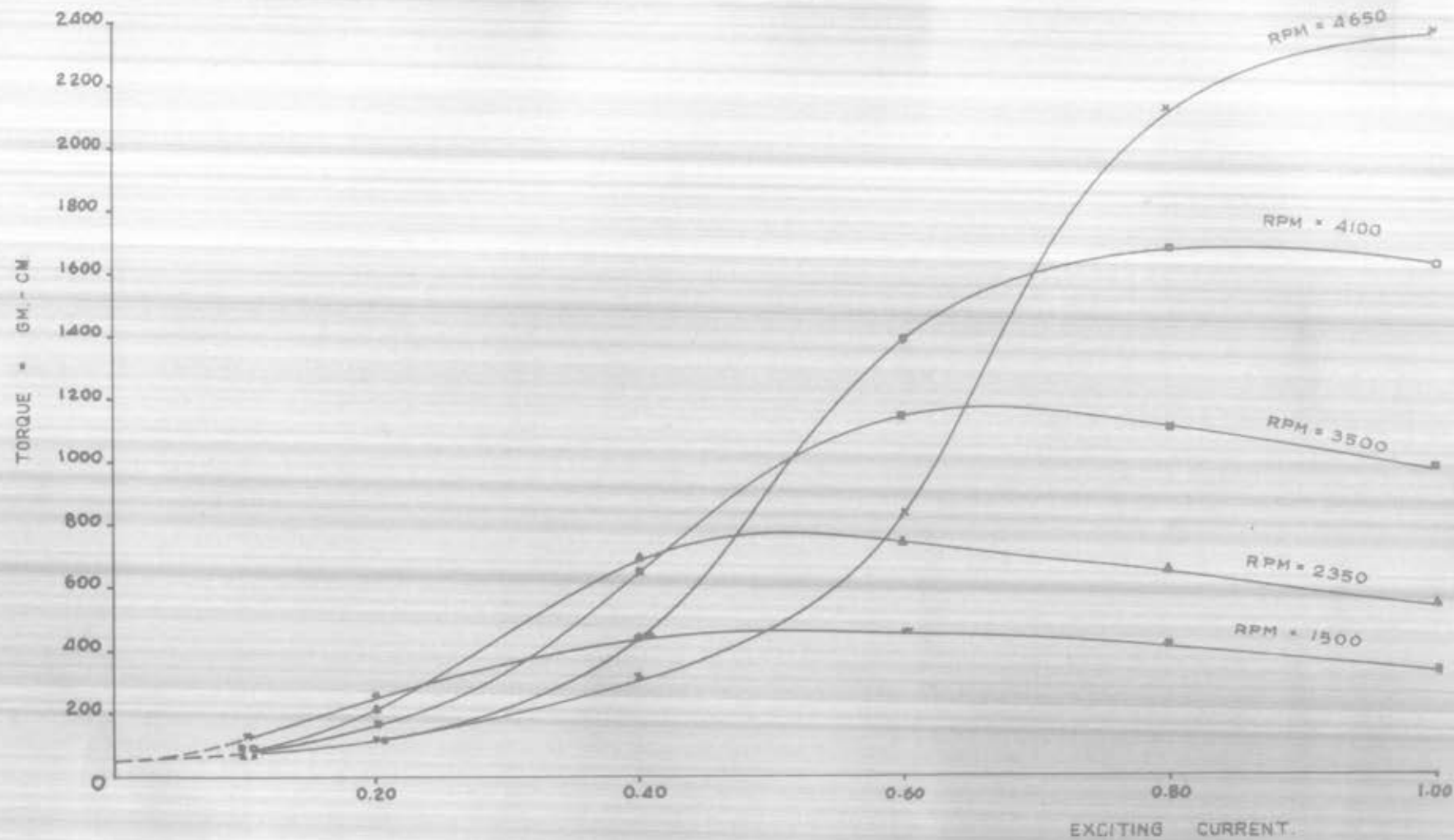


FIG. 4.16 TORQUE - EXCITING CURRENT CURVE DURING VARIOUS RUNNING MOTOR.

TABLE 1 c VALUES OF MAXIMUM BRAKING
CONSTANT AT VARIOUS EXCITING CURRENT

EXCITING CURRENT (amp.)	MOTOR SPEED (rpm.)	TORQUES (gm. - cm.)	MAXIMUM BRAKING CONSTANT (gm. - cm. per rad. per sec.)
0.1	1,040	130.00	1.90
0.2	950	327.50	3.29
0.4	800	750.00	8.94
0.6	750	1,575.00	20.00
0.8	430	2,240.00	49.60

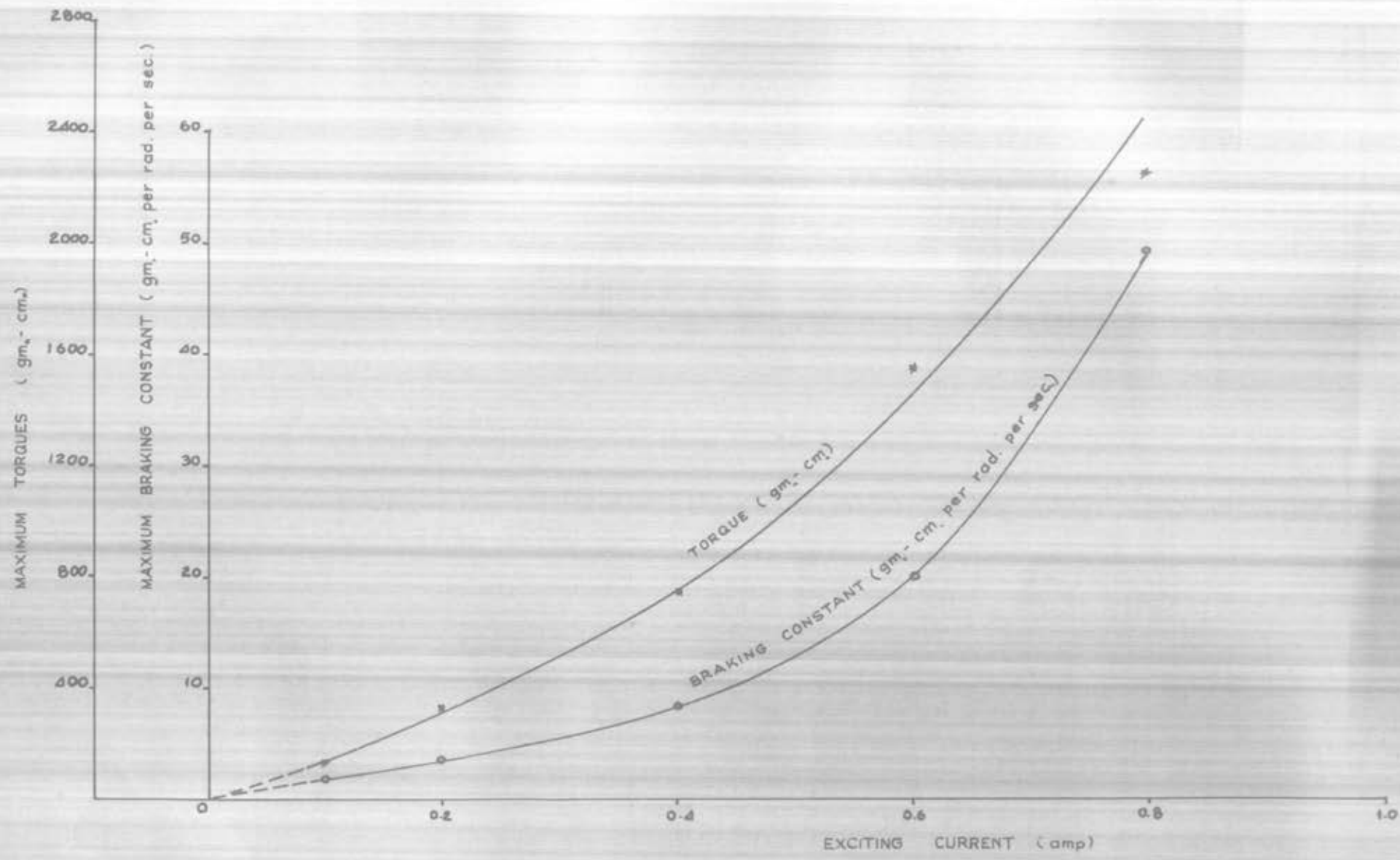


FIG. 1.17 RELATION BETWEEN MAXIMUM TORQUE AND MAXIMUM BRAKING CONSTANT WITH EXCITING CURRENT.

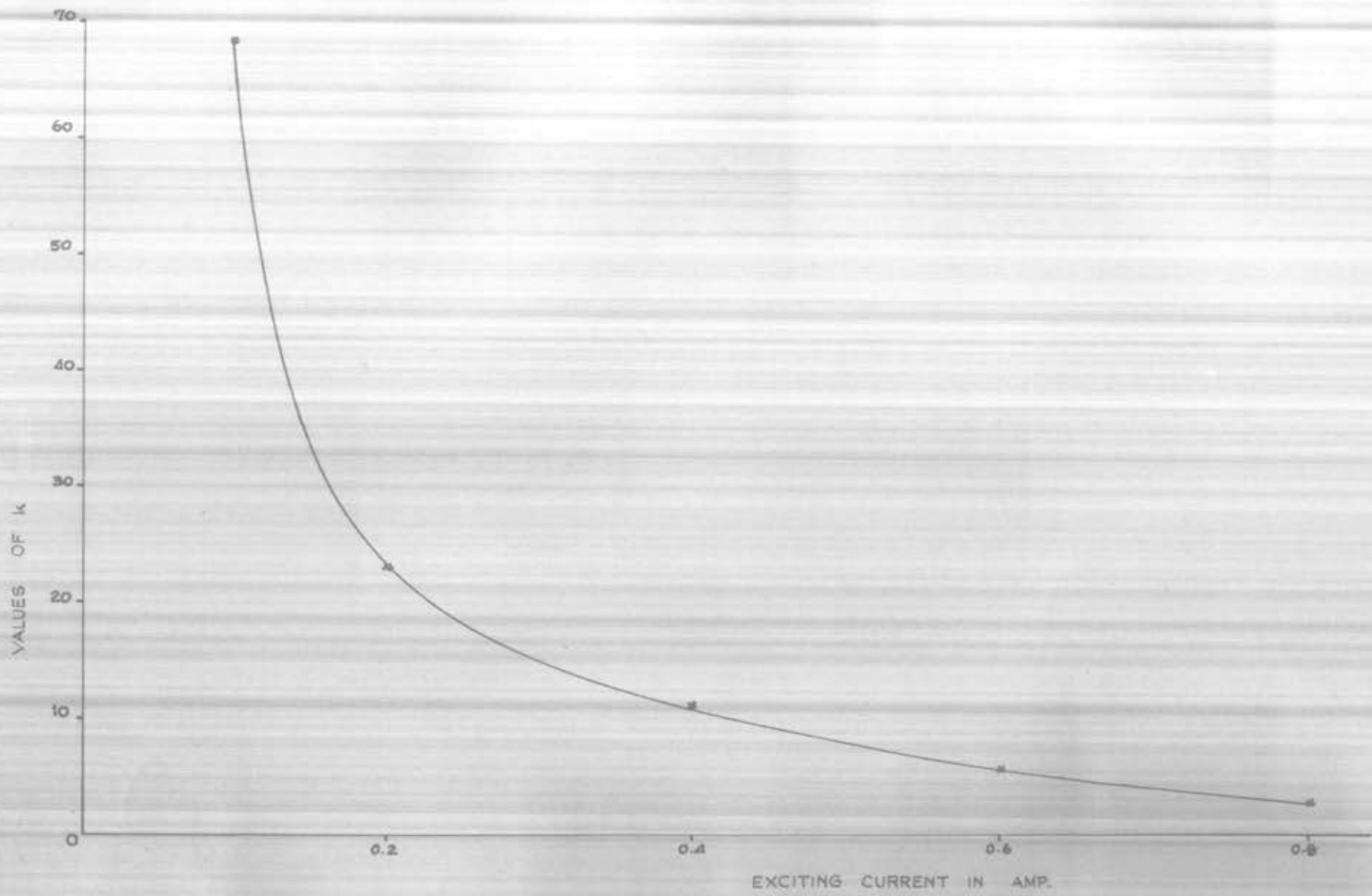


FIG 4.18 CURVE SHOWING VARIATION OF k WITH EXCITING CURRENT