CHAPTER III

DESIGN OF EQUIPMENTS AND ACCESSORIES

General equipments and accessories used in investigation the property of the "eddy current brake" are shown in Fig. 3.1 (a).

The "eddy current brake" was constructed with a simple model by using two laminated electromagnetics which were energized by direct current of 110 volts. They were placed on two arms which were supported by a spindle at their middle points. The arms could rotate or incline around their fulcrums freely. A thin copper disk was mounted on that spindle which was supported by the bearings which were fixed with the supporter. The edge of the disk was moved in the air gap of the laminated electromagnetics by a series motor by means of a lathe strap.

The two laminated electromagnets were placed 15.47 centimetres from each other (distance from edge to edge of the two poles.) as in Fig. 3.1 (b).

The design of the laminated electromagnet, the copper disk etc. were as follows:

Laminated Electromagnet Design

The magnetic structure shown in Fig. 3.2 was similar to that of a core-type transformer. It was made of KAWASAKI's cold rolled nonoriented silicon steel sheet and strip[4], commonly called RM Core of KAWASAKI Co., Ltd. Japan. RM Core is the grade of the material which RM-14 (0.35 mm. lamination) was used. The D.C. hysteresis loop, the D.C. magnetization curve and the D.C. permeability curve were shown in Fig. 3.3 and 3.4 respectively.

Consider the material of KAWASAKI's cold rolled silicon steel RM-14 (0.35 mm. lamination), whose saturated magnetic induction is about 13.7 kilogausses[5].

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[4]Cold Rolled Electrical Steel Sheets & Strip Book

(Kawasaki Steel Corporation, Wakinohamacho 3-chome, Fukiai-ku, Kobe), p. 5

[5] Ibid, pp. 69-71.

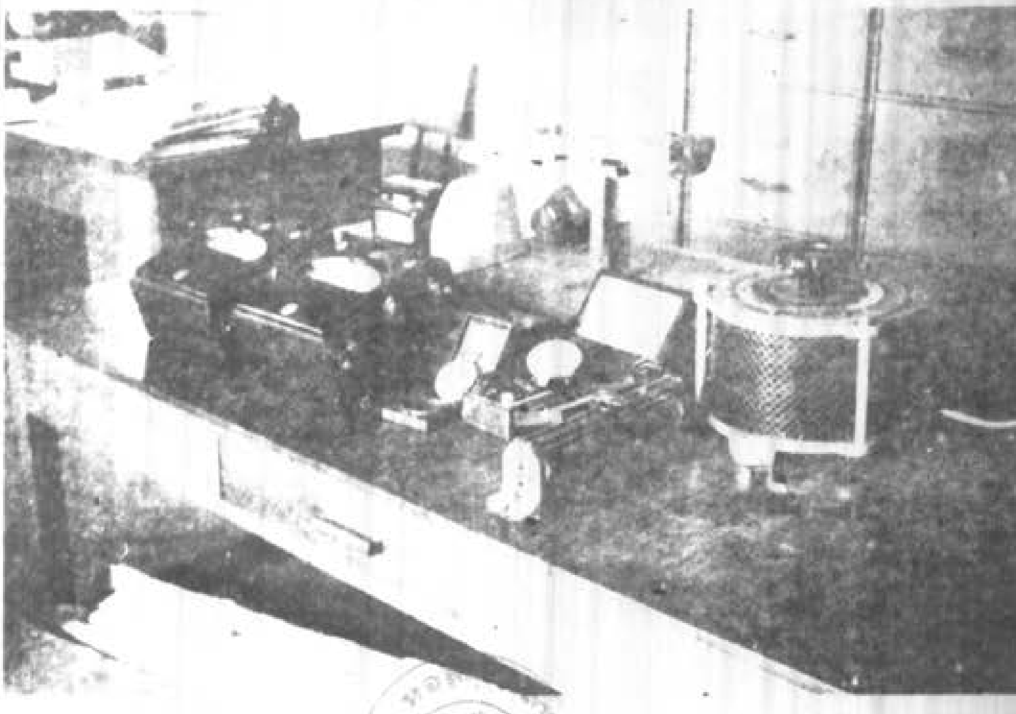
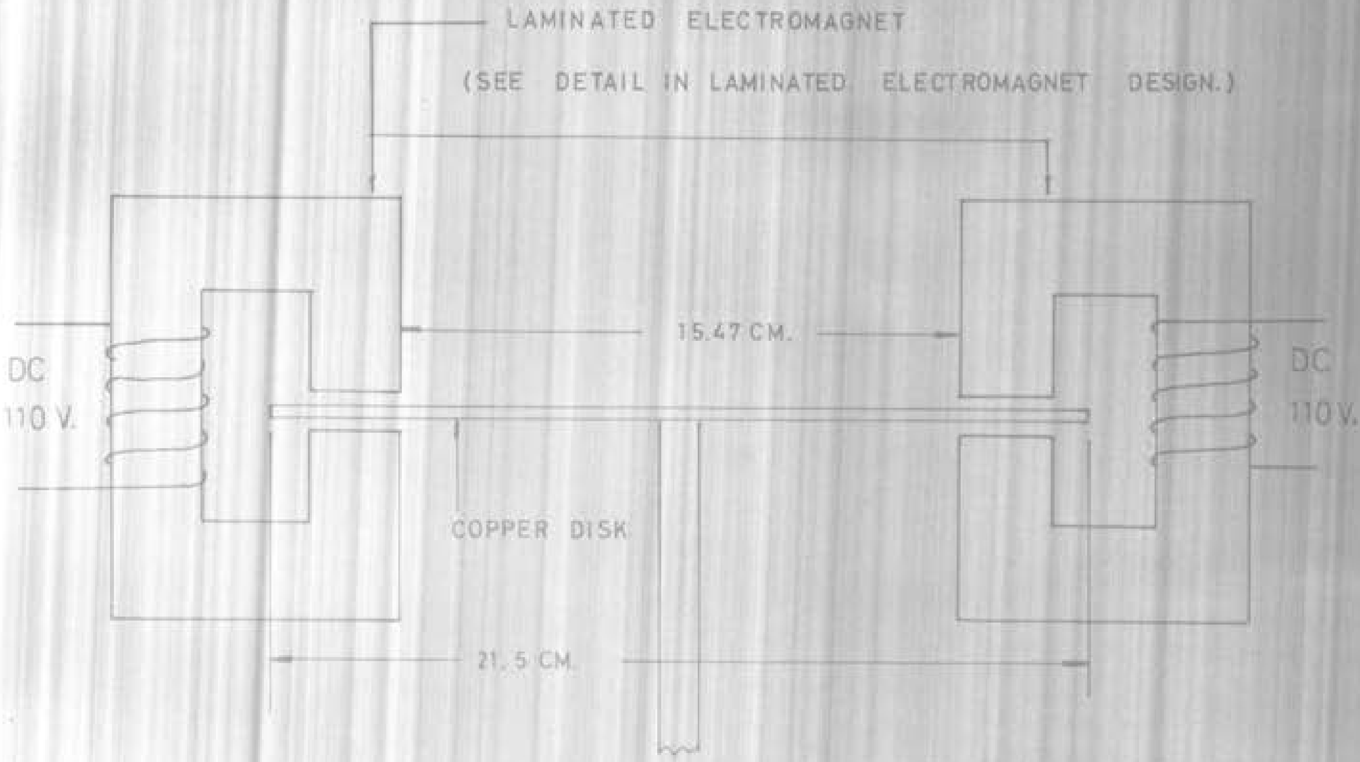


FIG. 3.1 (a) GENERAL EQUIPMENTS.



SCALE 1 : 2

FIG.3.1 (b) APPEARANCE OF BRAKE.

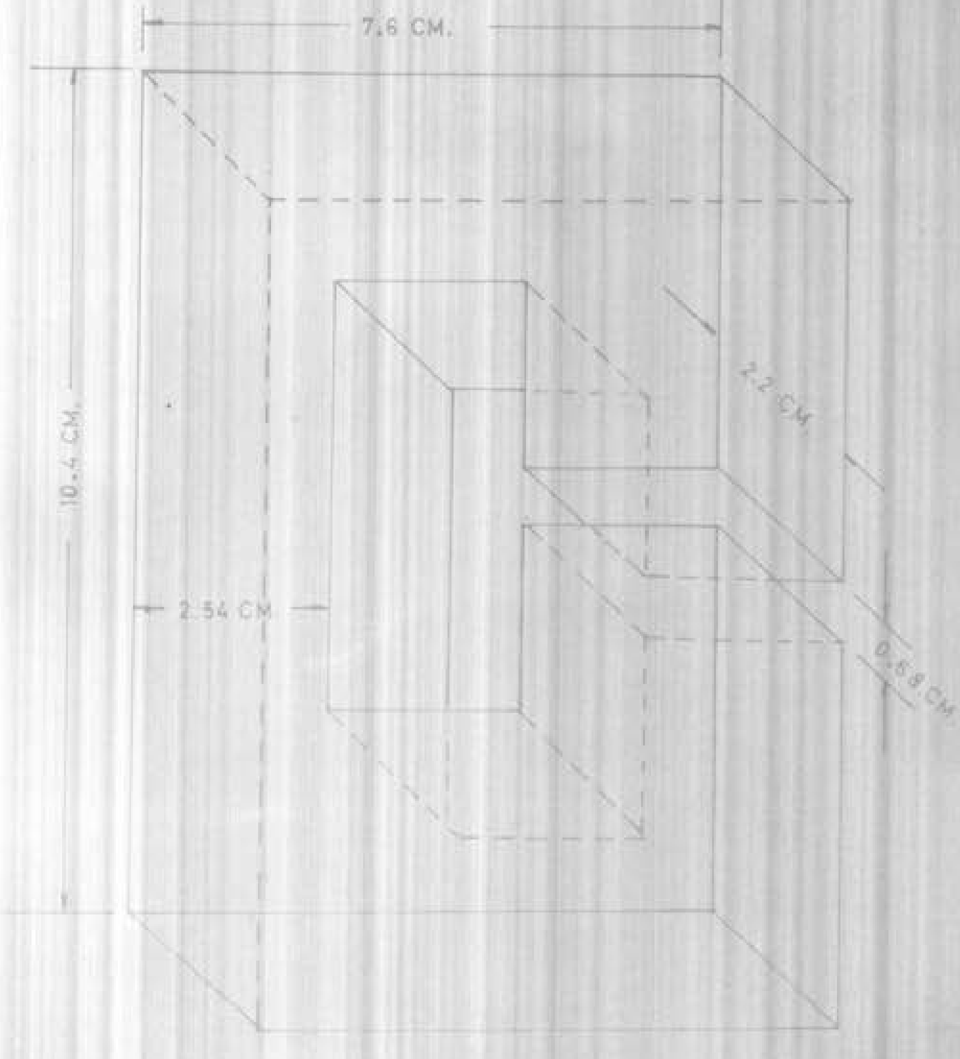


FIG. 3.2 LAMINATED ELECTROMAGNET

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Amp-turns and flux induced about 7,540 amp-turns, and 75 kilolines should be used respectively for the design.

At 13.7 kilogausses of magnetic induction, the magnetizing force

H	=	6.97	Oersteds
	=	6.97/0.495	amp-turns/in.
	=	14.10	amp-turns/in.

From the disk design, the thickness of the disk was 0.32 cm. or 1/8 in.

Let the length of the air gap of the poles be 0.68 cm. with enough clearance between the faces of poles and the copper disk.

From $I_2N_2 = (1/0.4\pi)\, B\, l_2$
$= 0.796\, B\, l_2$

Where B = magnetic induction in gausses
l_2 = air gap length in cm.

Hence $I_2N_2 = 0.796 \times 13.70 \times 10^3 \times 0.68$
= 7,410 amp-turns

Therefore the total amp-turns in the core

= 7,540 - 7,410
= 130 amp-turns

Let the turns of the pole be 1,395

Hence the current required to excite the core

= 130/1,395
= 0.0932 amps.

The length of the core = 130/14.10
= 9.20 in.
= 9.20 x 2.54 cm.
= 23.75 cm.

The cross-section area of the core

= 75/13.70
= 5.475 $cm.^2$

Let the breadth of the core

= 1 in. or 2.54 cm.

Hence the thickness of the core

= 5.475/2.54

= 2.13 cm.

In practice, because of the error in cutting the laminated core, we could not cut the core to the same size as the above design, therefore the exact size shown in Fig. 3.2 was used.

Investigation of the exact amp-turn

Mean length l_1 of flux path in the core

$= (10.4-2.54)+(7.6-2.54)\times 2+(10.4-2.54-0.68)$ cm.

$= 7.86 + 10.12 + 7.18$ cm.

$= 25.16$

Mean length l_2 of air-gap

$= 0.68$ cm.

From Fig. 3.4 the saturation value of magnetic induction

$B = 13.70$ kilogausses.

The magnetizing force

$H = 6.97$ oersteds.

$= 6.97/0.495$

$= 14.10$ amp-turns/in.

Hence

$I_1N_1 = 14.10 \times 25.16/2.54$

$= 139.50$ amp-turns.

For air gap

$I_2N_2 = (1/0.4\pi)B\,l_2$

$= 0.796 \times 13,700 \times 0.68$

$= 7,421.00$ amp-turns.

Therefore total amp-turns

$= 7,421.00 + 139.50$

$= 7,560.50$ amp-turns

Therefore the laminated cores were wound with copper wire whose cross-sectional area is 0.129 mm.^{2}, to take the maximum exciting cnrrent of about I ampere.

Two laminated cores were wound with 1,395 turns in the same direction. This number of turns was proved to be satisfactory for this experiment.

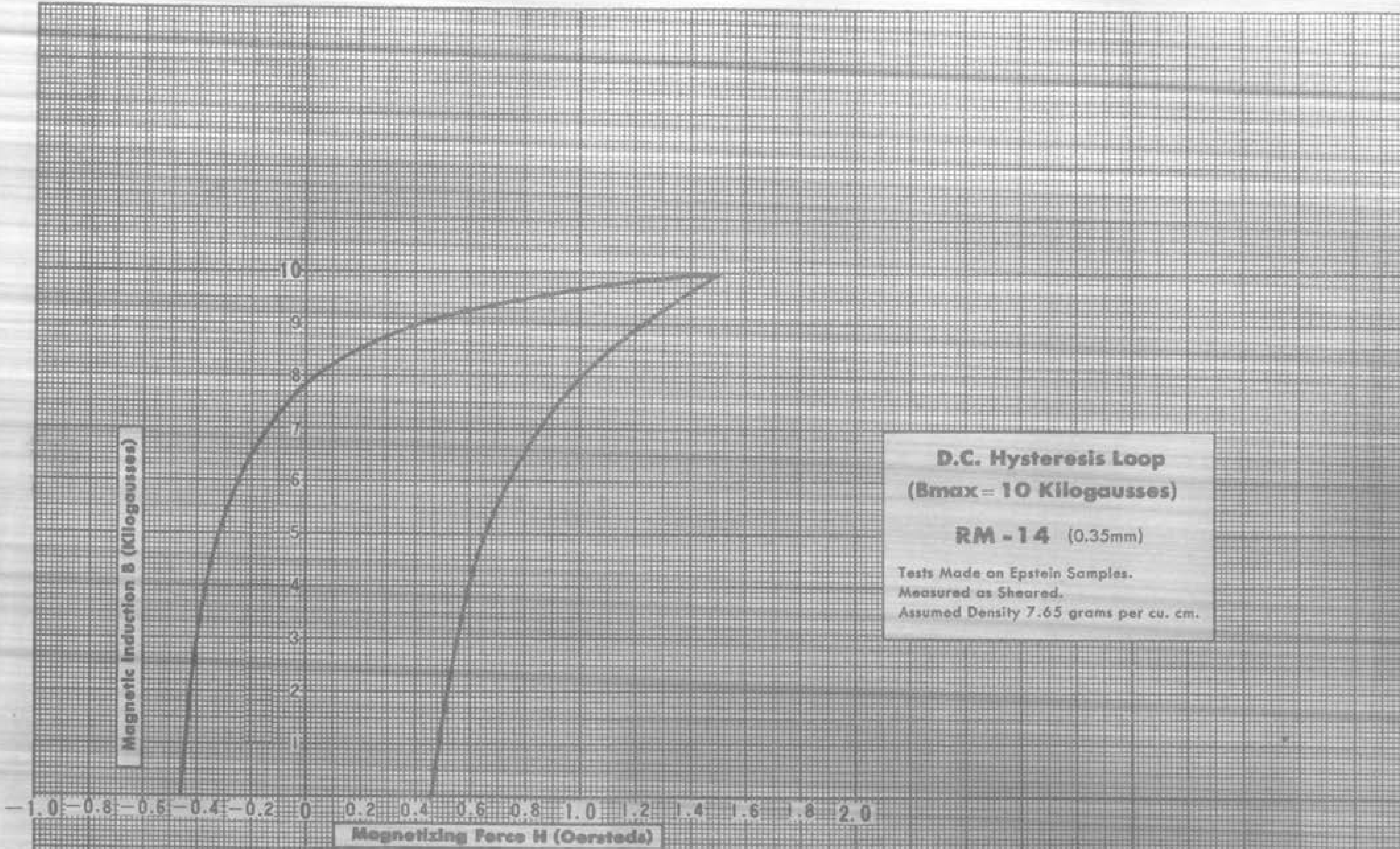

FIG. 3.3 HYSTERESIS LOOP.
(From Cold Rolled Electrical Steel Sheets & Strip Book, Kawasaki Steel Corporation, Wakinohamacho 3-chome, Fukiai-ku, Kobe, p.71)

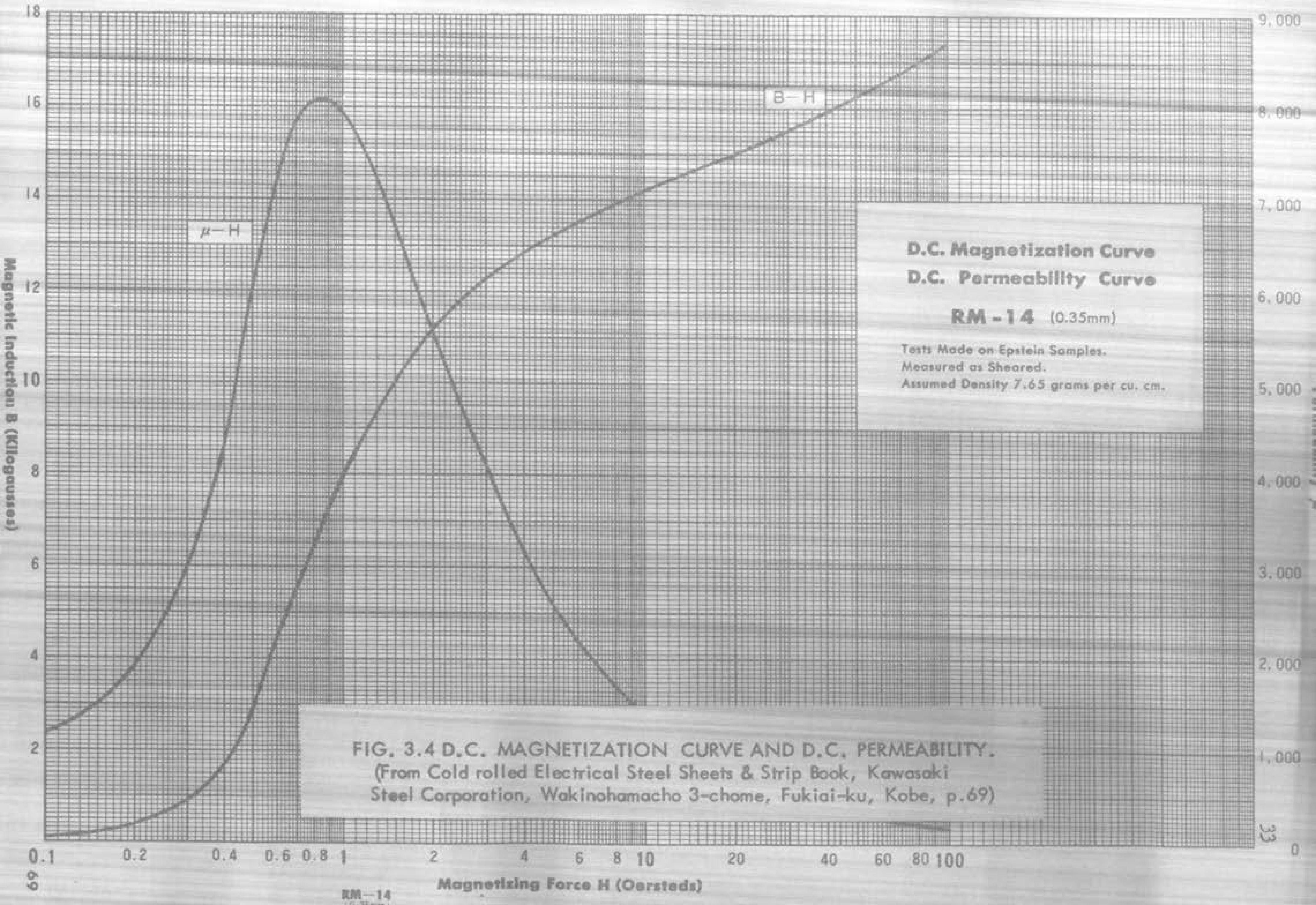

FIG. 3.4 D.C. MAGNETIZATION CURVE AND D.C. PERMEABILITY.
(From Cold rolled Electrical Steel Sheets & Strip Book, Kawasaki Steel Corporation, Wakinohamacho 3-chome, Fukiai-ku, Kobe, p.69)

Disk Design

The circular disk was made of copper with its specific resistivity ρ being taken as 1.724 microhms or 0.000001724 ohm. per centimetre cube[6], and its specific conductivity γ being taken as 580,000 mhos per centimetre cube at 20° c[7].

The copper disk was mounted on a spindle which is 15.52 cm. long. The other dimensions are shown in Fig. 3.5.

Apart from the laminated electromagnet and the copper disk, there were other accessories such as a series motor of 1/15 hp., 110 volts, 3,000 rpm., and a balance with a maximum scale reading of 200 gm. The balance was used to read the weight of the arms which were inclined by the braking torque, while the disk was rotating, and the laminated electromagnets were excited by dc voltage of 110 volts.

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[6] Chester L. Dawes, Electrical Engineering (Mc Graw-Hill Book Company, Inc. New York and London 1937) Vol. 1, p. 7

[7] Ibid, p. 7

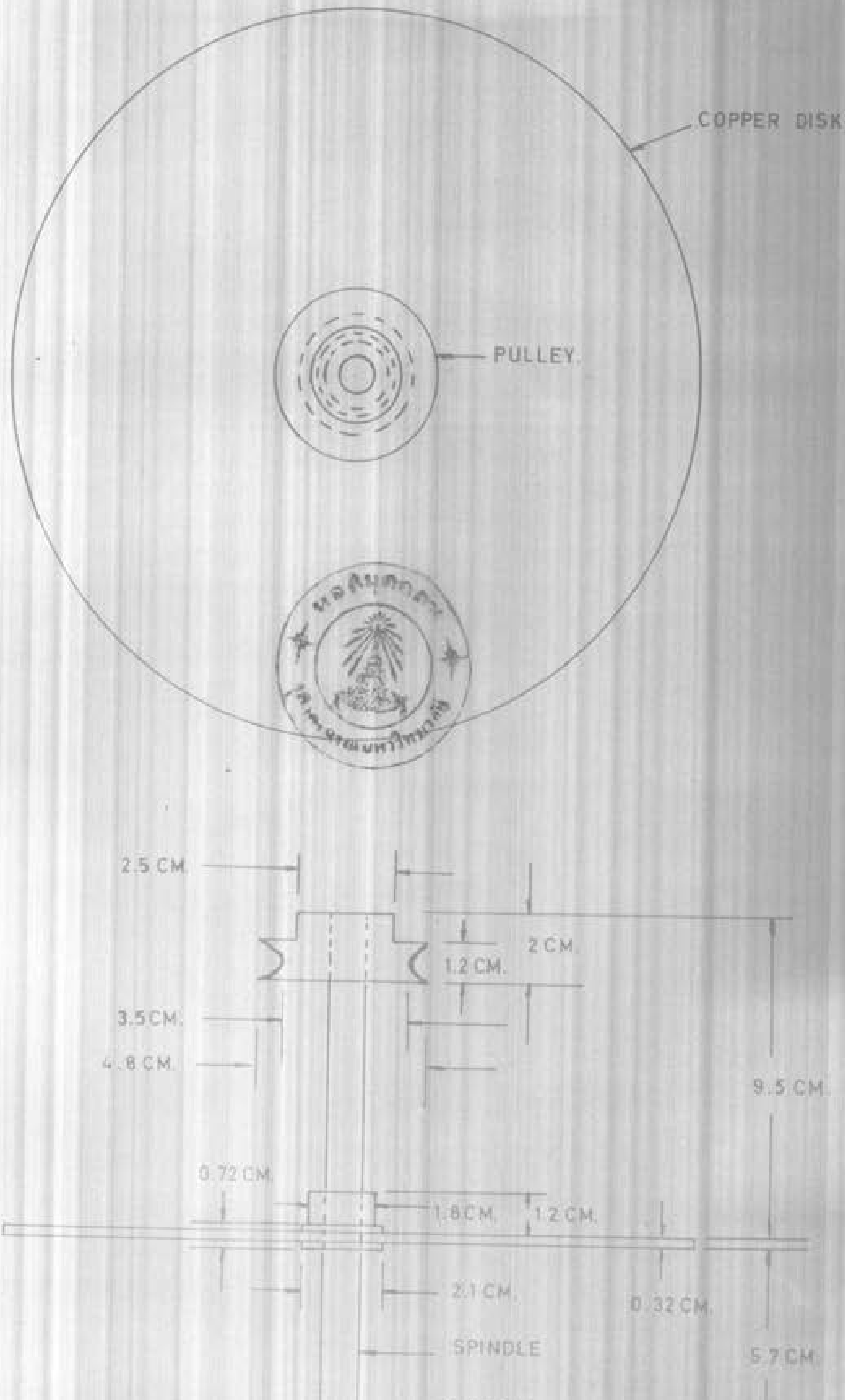

FIG 3.5 DESIGN ON DISK.

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