CONSTRUCTION AND TEST

Construction of Variable Inductor

Core and Winding.- The magnetic structure was assembled by staking laminations, 4 per cent silicon transformer sheet-steel 0.35 mm. thick, punched in the shape shown in Fig. 3. The grain alignment is along the leg of the core. The laminations were punched in thin U-shape in order to avoid the saturation effects at the lap joints at the corner of the core. The core was clamped firmly near the gap so that the noise from vibrating laminations was reduced. The holes in the core may increase the exciting current and the core loss but they were necessary.

After the coils had been wound, they were thoroughly dried and treated with insulating varnish, then fixed on each leg of the lower part of the core.

Mechanism.- The mechanism for moving up and down the upper part of the core was fixed after the core and coils were assembled. The upper part of the core would be drawn up 1 mm. as the screw at the top was turned by one revolution.

The detail of construction of the variable inductor is shown in Fig. 6.

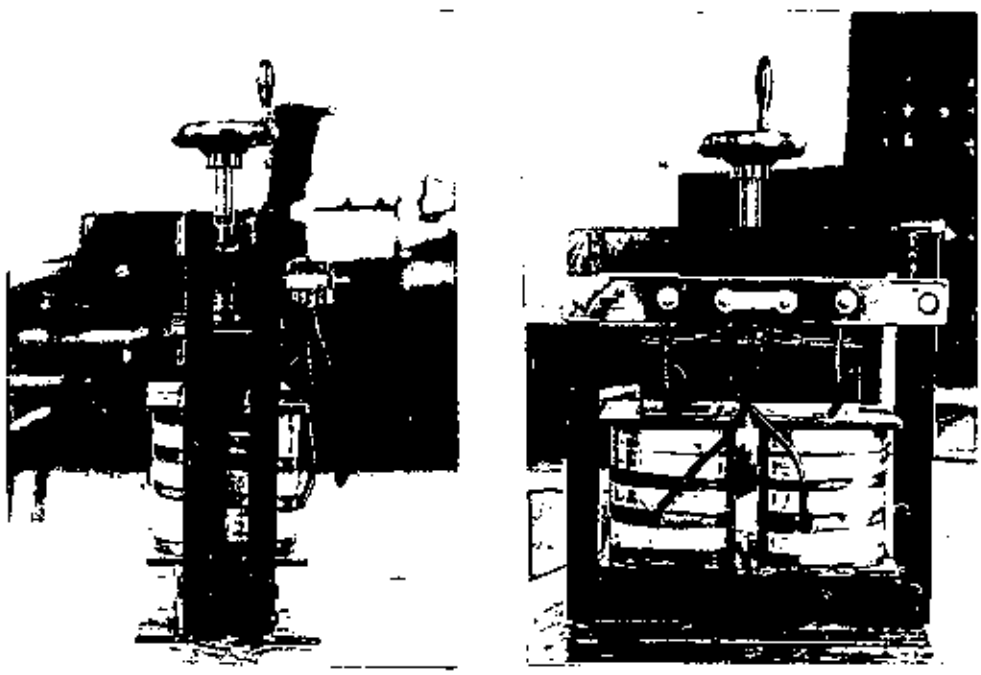

Fig. 7. A variable iron-core inductor of which its inductance being changed by varying the length of the air gap.

Testing Of Variable Inductor

The diagram of connections for the variable inductor test is shown in Fig. 8. The test was made by varying the gap length and the applied voltage at both 50 and 75 cycles per second. The total loss is indicated by the wattmeter.

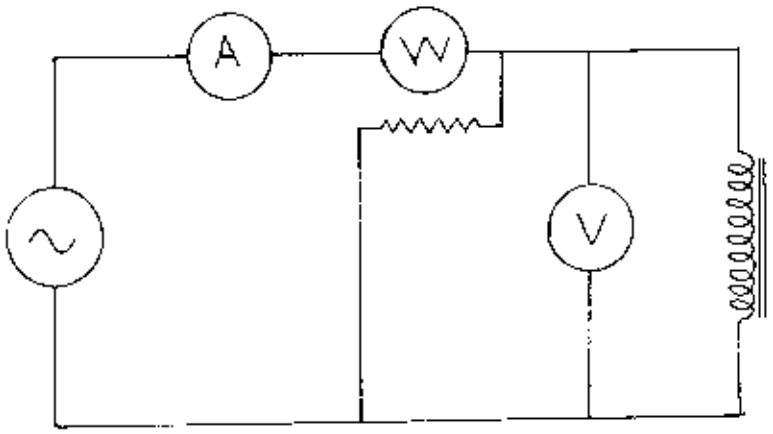

Fig. 8. Diagram of connection for variable inductor test.

The characteristics of the variable inductor are found, the measured values and the computed quantities are shown in the following tables.

TABLE VII CHARACTERISTICS OF VARIABLE INDUCTOR AT 50 CPS.

Applied Voltage = 226 volts.

Air Gap Length 2δ cm.	Rms Current I amperes	Power Absorbed P watts	Apparent Impedance Z_a ohms	Apparent Power Factor $\cos\theta_a$
0	0.50	24	452.000	0.2124
2	1.03	44	219.417	0.1890
4	3.15	46	71.746	0.0646
6	5.10	50	44.314	0.0434
8	6.95	52	32.518	0.0331
10	8.50	60	26.588	0.0312
12	10.00	70	22.600	0.0310
14	11.50	80	19.652	0.0308
16	12.85	90	17.588	0.0310
18	14.15	100	15.172	0.0313
20	15.40	110	14.675	0.0316
22	16.60	120	13.614	0.0320
24	17.80	135	12.697	0.0336
26	19.00	150	11.895	0.0349
28	20.05	165	11.272	0.0364
30	21.25	180	10.635	0.0377

TABLE VIII. CHARACTERISTICS OF VARIABLE INDUCTOR AT 50 CPS (CONT'D)

Applied Voltage = 226 volts.

Air Gap Length 2δ cm.	Apparent Resistance R_a ohms	Apparent Reactance X_a ohms	Apparent Inductance L_a henrys	Quality Factor Q_a	Time Constant T_a
0	96.005	441.627	1.4057	4.58	0.0146
2	41.470	215.459	0.6858	5.18	0.0165
4	4.635	71.597	0.2279	15.45	0.0492
6	1.923	44.272	0.1409	23.00	0.0733
8	1.076	32.500	0.1035	30.20	0.0962
10	0.830	26.575	0.0846	32.00	0.1019
12	0.701	22.590	0.0719	32.30	0.1026
14	0.605	19.643	0.0625	32.45	0.1033
16	0.545	17.560	0.0560	32.25	0.1027
18	0.500	15.964	0.0508	31.93	0.1016
20	0.4637	14.668	0.0467	31.73	0.1007
22	0.4356	13.607	0.0433	31.24	0.0994
24	0.4266	12.690	0.0404	29.75	0.0947
26	0.4151	11.888	0.0378	28.64	0.0911
28	0.4103	11.264	0.0359	27.45	0.0875
30	0.4009	10.627	0.0338	26.51	0.0843

Fig.9. Correlation of Apparent Inductance and Air Gap Length.

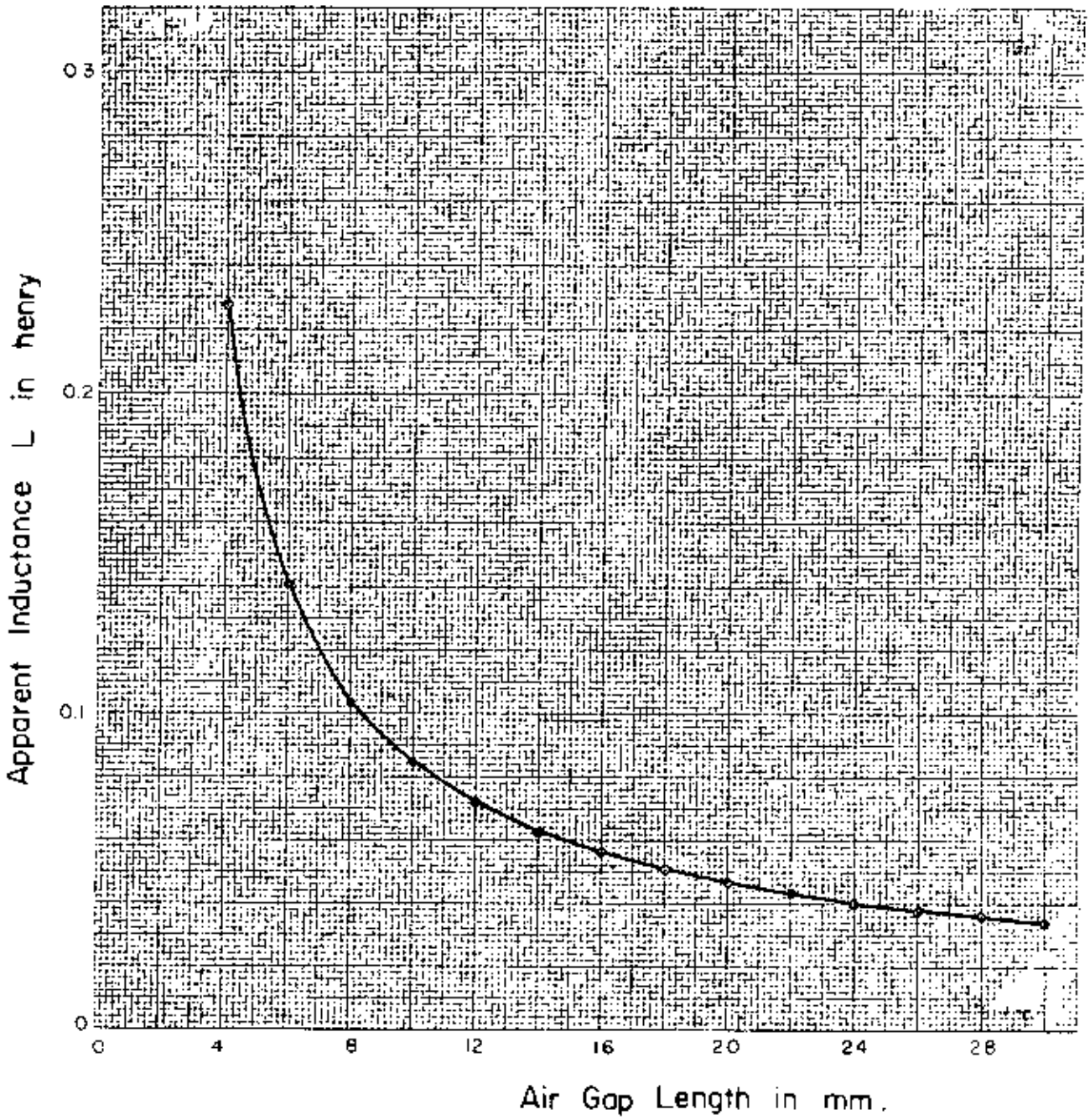

TABLE IX. VOLTAGES AT CONSTANT CURRENTS

Air Gap Length 2δ cm.	Applied Voltage at 50 cps.		
	At 5 amp.	At 10 amp.	At 15 amp.
8	158		
10	129.5		
12	110		
14	97		
16	87		
18	79.5	158	
20	73	145	
22	68	136	
24	63	126.5	
26	59	119	
28	55.5	112	
30	53	106	158

TABLE X. CHARACTERISTICS OF VARIABLE INDUCTOR AT 75 CPS.

Air Gap Length 2δ mm.	Rms Applied Voltage V volts	Rms Current I amperes	Power Absorbed P watts	Apparent Impedance Z_a ohms	Apparent Power Factor $\cos\theta_a$
0	222	0.30	20	740.00	0.3003
2	224	0.78	24	287.17	0.1374
4	226	2.37	30	95.36	0.0560
6	224	3.55	32	63.10	0.0402
8	223	4.65	36	47.96	0.0347
10	226	5.80	40	38.97	0.0305
12	220	6.60	42	33.33	0.0289
14	225	7.70	44	29.22	0.0254
16	219	8.30	46	26.39	0.0253
18	223	9.35	52	23.85	0.0249
20	217	9.93	58	21.81	0.0268
22	223	11.00	64	20.27	0.0261
24	218	11.55	68	18.87	0.0270
26	224	12.40	74	18.06	0.0266
28	219	12.90	78	16.98	0.0276
30	223	13.85	88	16.10	0.0285

TABLE XI. CHARACTERISTICS OF VARIABLE INDUCTOR AT 75 CPS (CONT'D).

Air Gap Length 2δ cm.	Apparent Resistance R_a ohms	Apparent Reactance X_a ohms	Apparent Inductance L_a henrys	Quality Factor Q_a	Time Constant T_a
0	222.22	705.75	1.498	3.18	0.0067
2	39.46	284.44	0.603	7.21	0.0152
4	5.34	95.21	0.203	17.83	0.0380
6	2.54	63.05	0.133	24.82	0.0524
8	1.66	47.93	0.101	29.87	0.0606
10	1.19	38.95	0.082	32.73	0.0689
12	0.96	33.32	0.071	34.71	0.0739
14	0.74	29.21	0.061	39.47	0.0824
16	0.67	26.38	0.055	39.37	0.0820
18	0.59	23.84	0.051	40.41	0.0864
20	0.58	21.80	0.046	37.59	0.0793
22	0.53	20.26	0.043	38.23	0.0812
24	0.51	18.86	0.040	36.98	0.0784
26	0.48	18.05	0.038	37.60	0.0791
28	0.47	16.98	0.036	36.13	0.0765
30	0.46	16.09	0.034	34.98	0.0739

The resistance of the winding R, measured by the Wheatstone Bridge, is 0.31 ohm.

Equivalent Circuit of Variable Inductor

The parameters of the equivalent circuit can be determined as follows:

At 20.05 amp., the apparent resistance 0.4103 ohm, the series resistance of core loss is

$$r_c = 0.4103 - 0.31$$
$$= 0.1003 \quad \text{ohm},$$

and the apparent reactance is 11.264 ohms. The reactor can be represented by an equivalent circuit shown in Fig.10.

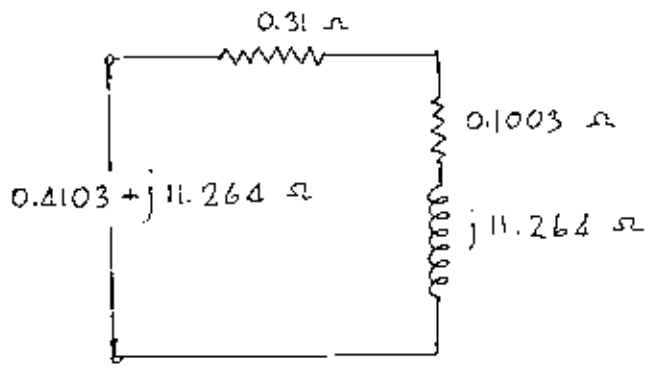

Fig.10. Equivalent circuit for the variable inductor.

Minimum Loss Ratio

In the tested data at 50 cps, P_c = 24 watts, and R = 0.31 ohm. From Eq. 54,

$$I_n^2 \times 0.31 = 24 + \frac{24^2}{226} \times 0.31$$

$$I_n^2 = \frac{24 + 0.0055}{0.31} = 77.45$$

$$I_n = 8.8 \text{ amperes.}$$

Thus the value of I_n that results in the minimum loss ratio is 7.65 amps. The length of the gaps are between 5 to 6 cm.