CHAPTER IV

THE APPARATUS

The apparatus and its principle

The Epstein apparatus is the apparatus used in measuring the total core losses of the specimen for comercial and laboratory. It is constructed in such a way that its primary and secondary windings are placed one over the other in four long solinoidal sections along the sides of a square. The coil[illegible] length of the section is [illegible] 42 centimeters, and the ceils are wound on forms
approximately
having a square cross section of inside dimension 3 × 3 or 4 × 4 centimeters. The secondary and primary coil [illegible] 150 or 200 turns per section. The secondary is first wound uniformly over the length of the form and then the primary is wound on the outside in the same manner. The four primary windings are connected in series aiding, and the four secondary windings are similar connected or two of primary windings are connected in series making them into two groups and then connected these two groups in parallel and in secondary windings are connected in similar manner to the primary. The test specimens consist of about 10 kilograms of steel strips of length about 50 centimeters in length and 3 centimeters in width. In

cutting the test specimens, half of them are cutting in row (along the way of rolling) and the other half in column (right angle to the way of rolling) in order to get the true average of the losses, because of their micro structures of the material in rolling are not the same. The like sample are placed on opposite side of the square. The strips are placed in-side the solinoid in edge to side and vice versa until they filled the space inside the solinoids and the strips are always placed on the square board, while the primary and secondary terminals were led to some places on the board.

Fig. 5

Epstein apparatus

The total core loss $= k_h f B^n_{max} + k_e f^2 \tau^2 B^2_{max}$.

k_h = hysteresis constant

k_e = eddy current constant

f = frequency

τ = thickness of lamination

$B_{max.}$ = flux density

The voltage equation

The induced voltage in Epstein apparatus

$$v = 4 \times k \times f \times A \times N \times B \times 10^{-8}$$

Where

k = form factor of the current wave form and

for sinusoidal $k = 1.1$

f = frequency in cps

A = cross sectional area of the specimen in cm^2

N = Number of turns of the primary

B = Magnetic flux density in iron in gauss

The cross-sectional area of the sample.

$$A = \frac{Gm}{Sl}$$

Where Gm = total weight of the total sample

l = averege total iron length

S = specific weight of the sample.

The measuring principle

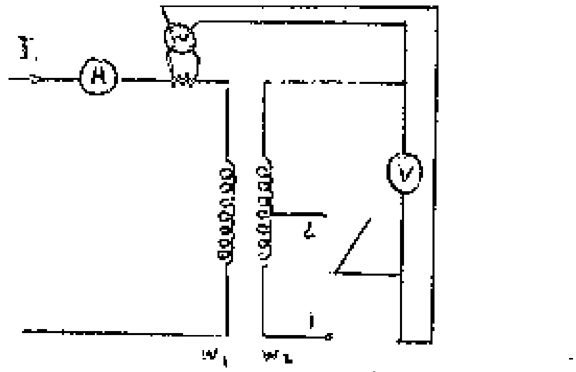

Fig. 6 Connections of Epstein Apparatus

We can compared the Epstein Apparatus with the transformer. The circuit diagram is shown above. Therefore the equivalent circuit of the Epstein Apparatus is

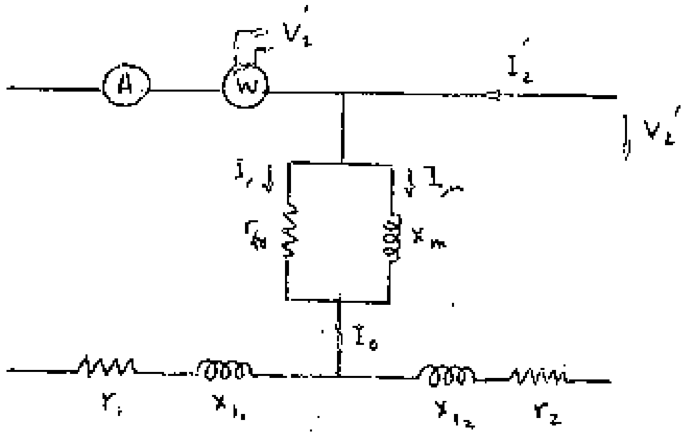

Fig. 7 Equivalent circuit

and its simplified vector diagram is

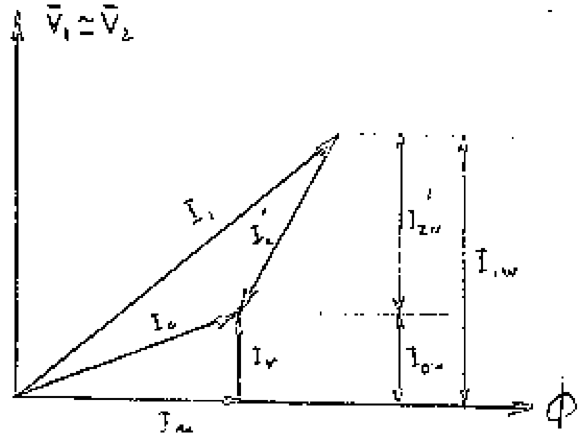

Fig. 8 Vector diagram of Fig.7

Connections of the circuit.

1. The circuit is connected in series.

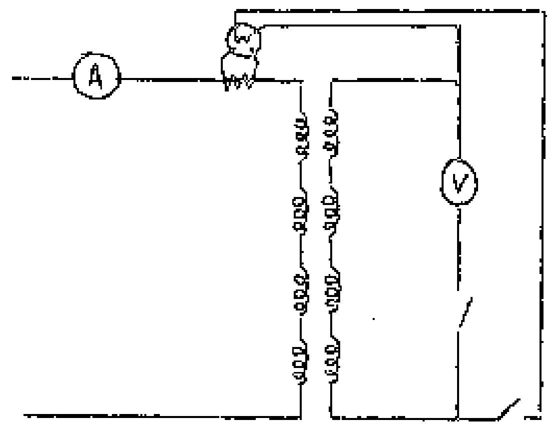

Fig.9 Series connection

2. The circuit is connected in series-parallel.

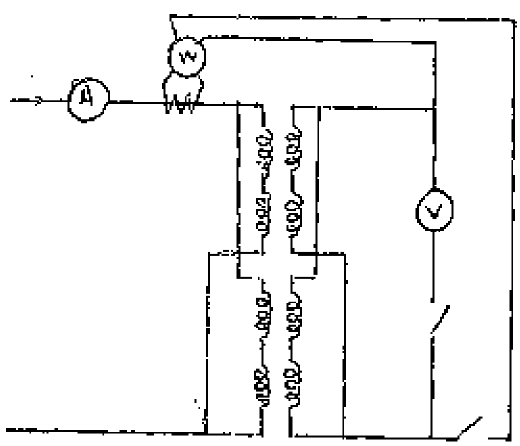

Fig.10 Series-Parallel connection

The watt meter reads $W = V_2 I_{1w}$

The amplitude of the active component of the current is.

$$I_{1w} = I_{ow} + I'_{2w}$$

$$W = V_2 (I_{ow} + \frac{w_2}{w_1} \cdot I_{2w})$$

$$I_{ow} = I_r = I_{fe}$$

$$I'_{2w} = \frac{w_2}{w_1} I_{2w}$$

where $\frac{w_2}{w_1}$ is the turn ratio. (Fig.6)

For the series connected $\frac{w_1}{w_2} = 1$

$$W = V\ I_{ow} + V\ I_{2w}$$

$$= W_{fe} + V.I_{2w}$$

$$W_{fe} = W - V\ I_{2w}$$

$$W_{fe} = W - \frac{V^2}{R_{pc}}$$

Where W_{fe} = watt loss in iron

W = wattmeter reading

V = voltage input

R_{pc} = Resistance of the potential coil of wattmeter.

Rules of iron testing.

According to VDE - Verschriften - GRUPPE 5 Band III

1. In measuring the iron losses and magnetization characteristic of iron must composed of the same kind of iron.

2. The weight of sample is approximately 10 kg.

3. The core loss are stated in watt per kg. The wave form of the induced voltage is pure sinusoidal and at the maximum flux density of 10 kilogausses and 15 kilogausses.

4. The per cent of changing loss factor is measured at $B_{max.}$ = 10 kilogausses after having heated to 100°C, for 600 hours.

5. The specified magnetizing characteristic ought to specify at the two different values of magnetic field intensities and usually a pair of 25, 50, 100 or 300 ampere turns per centimeter.

6. The thickness of a sheet is normally of 0.35, 0.5 and 1.0 mm. Its thickness must be uniform, the tolerence is ± 10 per cent of the value of thickness stated.

Design and construction.

The design has been worked by following the rules of iron testing stated above.

1. Using 3 samples of:

a. Transformer grade, 4 per cent of silicon sheet steel.

b. Varnish coated, about 1 per cent of silicon sheet steel.

c. Tin coated sheet steel.

Each of sample were cut of about 10 kg. weight, half was cut off parallel to the rolling direction and the other half was cut off in quadrature to the rolling axis. It's length was 47 centimeters and 3 centimeters in width.

2. Given the maximum magnetic field intensity to be 100 ampere turns per centimeter.

The mean length of the magnetic path of sample is 188 centimeters.

The total ampere turns of the solinoids

= 18800 ampere turns.

If the solinoid is wound of 400 turns.

Therefore the total turns of the four solinoids = 1600 turns.

Then the maximum current in the winding is

= 18800/1600

= 11.75 amperes.

D.C.C. No. 16 S.W.G. with the rated maximum current 12 amperes is the suitable size of the winding.

The maximum in put voltage is 220 volts.

For series connection, the solinoid is stood for 1600/220 = 7.3 turns per volt.

For series-parallel connection, the solinoid is stood for 800/220 = 3.7 turns per volt.

The primary and the secondary of each solinoid were wound with D.C.C. No.16 S.W.G.. The number of turns of the secondary is 400 turns and the primary is wound over the secondary of the same number of turns. In construction of winding, yield the solinoid length of 35 centimeters and the number of turns per layer is 200.

Two sets of solinoids were constructed. The first set is composed of four square coils and the second set is composed of four round coils. In doing this, we can use them in comparision the loss in the round coil test set and the square coil test set at the same frequency and amount of ampere turns. Each set was placed on the square board and the terminals of the coils were led to the terminals on the board.