

15-5. Techniques for Measuring Core Performance.—As has already been shown, the value of μ_e depends upon pulse duration, lamination thickness, and resistivity, and upon μ_i , as it is defined by Figs. 15-2 and 15-3. For a given material the value of μ_e is affected by ΔB , the amount of gap in the core, and the value of the reverse magnetic field between pulses. Since μ_e depends upon so many parameters, it is necessary that manufacturers and users of pulse-transformer cores and core materials agree upon a set of standard methods for measuring and describing the properties of cores and core materials.¹

It is not within the scope of this book to specify these standard test methods. There are, however, certain experimental techniques involved, which will now be described.

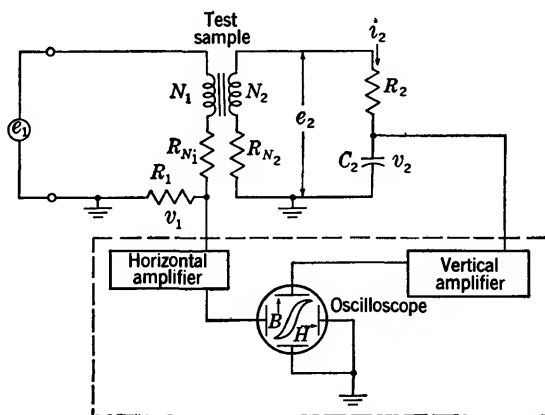


FIG. 15-26.—Circuit for viewing 60-cycle B - H loops on an oscilloscope.

Presentation of 60-cycle Hysteresis Loops on an Oscilloscope.—The circuit of Fig. 15-26, where $e_1 = \sqrt{2} E_{\text{rms}} \cos \omega t$ and $\omega = 2\pi \cdot 60$, may be used for the purpose of presenting 60-cycle hysteresis loops on an oscilloscope.

Since

$$e_2 = \frac{N_2 A}{10^8} \frac{dB}{dt},$$

$$B = \frac{10^8}{N_2 A} \int e_2 dt.$$

If R_2 and C_2 are large, $i_2 = e_2/R_2$. Hence

$$\int \frac{i_2 dt}{C_2} = \frac{e_2 dt}{R_2 C_2} = v_2,$$

¹ W. H. Bostick, "Pulse Transformer Committee Standard Test Methods for Pulse Transformer Cores," RL Report No. 722, May 5, 1945.

and

$$\int e_2 dt = R_2 C_2 v_2.$$

Then

$$B = \frac{10^8 R_2 C_2 v_2}{N_2 A} \quad \text{gauss,}$$

and

$$H = \frac{4\pi N_1 i_m}{10l} = \frac{4\pi N_1 v_1}{10l R_1} \quad \text{oersteds,}$$

where v_2 and v_1 are the deflecting voltage measured on a CRT screen, N_1 and N_2 are the numbers of turns on the coils, A is the cross-sectional area of the core in square centimeters, and l is the mean magnetic-path length in centimeters. The symbols R_{N_1} and R_{N_2} denote the resistance of the coils.

The resistance R_2 must be large enough not to load the circuit and hence not to increase $i_m R_1$ appreciably. The voltage e_2 must be large in comparison with the voltage v_2 in order that i_2 be limited primarily by R_2 . Since it is inexpedient to use a large number of turns, it is necessary to use amplifiers to drive the vertical and horizontal plates of the oscilloscope tube. It is difficult, for example, to put a large number of turns on a continuously wound strip core. If the amplifiers built into the oscilloscope are not adequate, additional stages may be added externally. Care must be taken that no amplitude or phase distortion is introduced by the amplifiers.

If the resistances R_{N_1} and R_1 are so small that the drop $i_m(R_1 + R_{N_1})$ is negligible in comparison with e_1 , the integrating $R_2 C_2$ -circuit may be connected across the input circuit and the second winding may be omitted.

Appropriate circuit constants for use with a ring test sample having an interior diameter of $2\frac{1}{2}$ in. and a cross section of $\frac{1}{2}$ in. by $\frac{1}{2}$ in. may be estimated in the following manner:

First, the values $N_1 = N_2 = 100$ turns No. 20 (which have resistances $R_N = 0.2$ ohms), and $\Delta B = 10,000$ gauss are arbitrarily chosen.

Next, a value of

$$e_2 = \Delta B N_2 A \omega \times 10^{-8} = 6 \text{ volts,}$$

and a value of $v_2 \approx 0.001 e_2$ are chosen. Then

$$R_2 C_2 = e_2 / (v_2 \omega) \approx 3 \text{ sec.}$$

Any values of R_2 and C_2 that satisfy this relation may be chosen, provided that (1) R_2 is large enough not to load the circuit appreciably, (2) R_2 is also large in comparison with the resistance of the winding, and yet small in comparison with the leakage resistance of the winding insulation, and

(3) C_2 is large in comparison with the stray capacitance to ground of R_2 and the oscilloscope input circuit. The following values are satisfactory:

$$R_2 = 1.5 \text{ megohms,}$$

$$C_2 = 2 \text{ } \mu\text{f,}$$

$$v_2 = \frac{e_2}{R_2 C_2 \omega} \approx 5 \times 10^{-3} \text{ volts.}$$

The values of R_1 may be chosen arbitrarily—for example, the value of $R_1 = 0.3$ ohms is selected.

Then

$$e_1 = e_2 + (R_1 + R_{N_1})lH/(0.4\pi N_2) \approx 7 \text{ volts,}$$

for $H = 10$ oersteds, and

$$v_1 = R_1 lH/(0.4\pi N_1) \approx 0.5 \text{ volt,}$$

for $H = 10$ oersteds. The voltage sensitivities should be such as to give deflections of about 1-in:

Vertical sensitivity = 5×10^{-3} volt/in. (amplification $\approx 10,000/1$).

Horizontal sensitivity = 0.5 volt/in. (amplification $\approx 100/1$).

If 500 turns of No. 20 wire are used for N_1 , and if e_1 is correspondingly increased, an error of less than 2 per cent is introduced by connecting the integrating circuit across the input circuit and omitting the second winding.

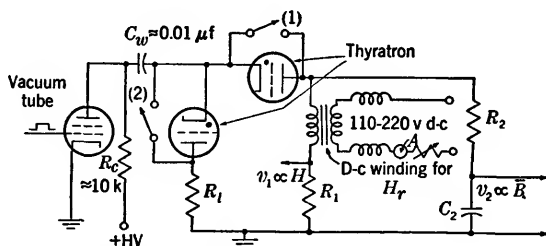


FIG. 15-27.—Circuit for obtaining pulse B - H loops with a hard-tube pulser.

The ring sample may conveniently be wound in the following manner. Each quadrant is wound with a single layer consisting of 25 turns of No. 20 wire, two in parallel. For the 60-cycle tests the windings of the four quadrants are connected in series to give two parallel 100-turn windings. For the pulse test the two windings in each quadrant may be connected in parallel; then the paralleled windings of two opposite quadrants may be connected in series to give a 50-turn winding for application of the pulse voltage, and the windings of the other two quadrants similarly connected for the d-c current that produces H_r (see Figs. 15-27 and 15-28).