loss due to eddy currents will be too great; on the other hand, if the wires be too small in cross-section, or the insulation between them be too thick, the magnetic reluctance will be so great as to more than offset the evil effects of the eddy currents. The spools are, of course, slotted, if of metal.

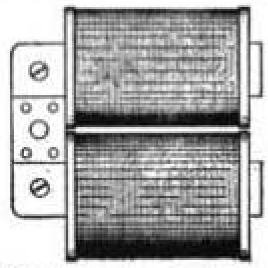

FIG. 147.—A. C. Horseshoe Electromagnet.

Whenever it is feasible, from a mechanical standpoint, to use spools of insulating material, it is electrically advantageous to do so, as the induced currents in the spools will be eliminated.

86. A. C. ELECTROMAGNET CALCULATIONS

From (116) $$E = \frac{4.44\phi N f}{10^8},$$

wherein E is the impressed e. m. f., ϕ the total flux, N the number of turns in the coil, and f the frequency.

Since $\phi = \mathcal{B}A$,

$$E = \frac{4.44\,\mathcal{B}ANf}{10^8}. \qquad (149)$$

On account of the heating due to hysteresis and eddy currents, A. C. electromagnets are usually worked at lower flux densities than for D. C. magnets.

The exact value of the current cannot be easily calculated, due to the variable induction in the iron, but if a curve be plotted showing the magnetic flux for each instantaneous current strength, an accurate value of the effective current may be obtained.

If the saturation curve is considered to be a straight *

* D. L. Lindquist, *Electrical World*, Vol. XLVII, 1906, p. 1296.

line (which is nearly correct for a long air-gap), and the current at the begining of the stroke is I, then

$$I = c_1 \frac{\mathcal{B}}{N}, \tag{150}$$

wherein c_1 is a constant.

From equations (149) and (150)

$$EI = \frac{4.44\,\mathcal{B}ANf}{10^8} \cdot c_1 \frac{\mathcal{B}}{N}, \tag{151}$$

or

$$EI = \frac{4.44\,c_1 f A \mathcal{B}^2}{10^8}. \tag{152}$$

From equation (68) $P = \dfrac{\mathcal{B}^2 A}{8\,\pi \times 981{,}000}$.

Transposing, $$\mathcal{B}^2 A = 8\,\pi P \times 981{,}000. \tag{153}$$

Substituting the value of $\mathcal{B}^2 A$ from (153) in (152),

$$EI = \frac{4.44\,c_1 fP \times 8\,\pi \times 981{,}000}{10^8} = 1.095\,c_1 fP. \tag{154}$$

If $1.095\,c_1 = c_2$, then

$$EI = c_2 fP. \tag{155}$$

From (154) $$P = \frac{EI}{c_2 f}, \tag{156}$$

which shows that the pull decreases as the frequency increases. The efficiency of the magnet also varies with the frequency.

87. Polyphase Electromagnets

Single-phase electromagnets may be operated on polyphase circuits by connecting the magnet in one of the phases only, or magnets corresponding in number to the number of phases may be connected in the respective phases, with their armatures rigidly connected to a common bar or plate, as in Fig. 148.