$$E_a = jaE_{mf} - jaE_{mb} = jaI_{mf}Z_f - jaI_{mb}Z_{mb} \quad \ldots\ (17\text{–}14)$$

Note that aE_{mf} and aE_{mb} are merely the voltages of winding m referred to winding a.

Substitution of Equations 17-9, 17-10, 17-13, and 17-14 in Equations 17-5 and 17-6 then gives

$$V_m = (I_{mf} + I_{mb})Z_{1m} + I_{mf}Z_f + I_{mb}Z_b \quad \ldots\ (17\text{—}15)$$

$$V_a = (jI_{mf}/a - jI_{mb}/a)Z_{1a} + jaI_{mf}Z_f - jaI_{mb}Z_b \quad \ldots\ (17\text{—}16)$$

Rearrangement of terms in these equations and multiplication of Equation 17-16 by $-j/a$ gives

$$V_m = I_{mf}\left(Z_{1m} + Z_f\right) + I_{mb}\left(Z_{1m} + Z_b\right) \quad \ldots\ (17\text{—}17)$$

$$-jV_a/a = I_{mf}\left(Z_{1a}/a^2 + Z_f\right) - I_{mb}\left(Z_{1a}/a^2 + Z_b\right) \quad \ldots\ (17\text{—}18)$$

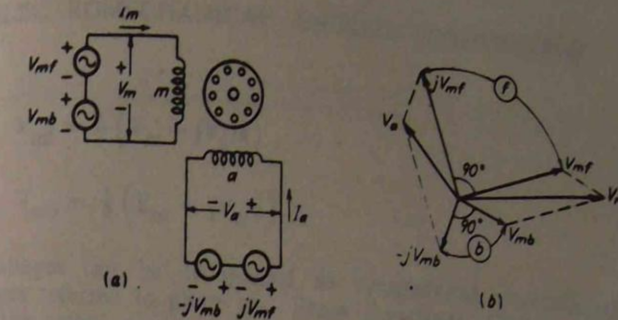
Note that V_a/a and Z_{1a}/a^2 are, respectively, the phase a voltage and stator circuit impedance referred to winding m.

Addition of Equations 17-17 and 17-18 and division of the result by 2 gives

$$\tfrac{1}{2}\left(V_m - jV_a/a\right) = I_{mf}\left(\frac{Z_{1a}/a^2 + Z_{1m}}{2} + Z_f\right) - I_{mb}\,\frac{Z_{1a}/a^2 - Z_{1m}}{2} \quad \ldots\ (17\text{—}19)$$

Similarly, subtraction of Equation 17-18 from Equation 17-17 and division of the result by 2 gives

$$\tfrac{1}{2}\left(V_m + jV_a/a\right) = -I_{mf}\,\frac{Z_{1a}/a^2 - Z_{1m}}{2} + I_{mb}\left(\frac{Z_{1a}/a^2 + Z_{1m}}{2} + Z_b\right) \quad \ldots\ (17\text{—}20)$$



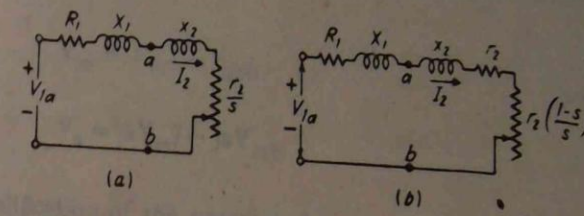


Fig. 17-2.

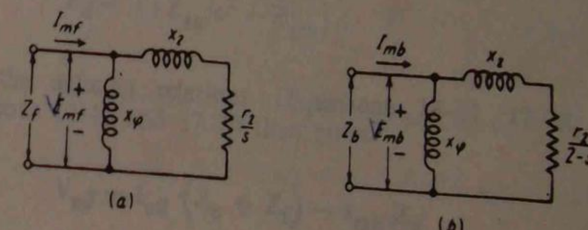


Fig. 17-3.