Now let

$$V_{mf} = \tfrac{1}{2}\left(V_m - jV_a/a\right) \quad \ldots\ (17\text{--}21)$$

$$V_{mb} = \tfrac{1}{2}\left(V_m + jV_a/a\right) \quad \ldots\ (17\text{--}22)$$

These new voltages can be recognized as symmetrical components of the applied voltages referred to phase m. From Equations 17-21 and 17-22, the relations for the actual winding voltages in terms of the symmetrical components are

$$V_m = V_{mf} + V_{mb} \quad \ldots\ (17\text{--}23)$$

$$V_a = jaV_{mf} - jaV_{mb} \quad (17\text{--}24)$$

For further simplification of the notation, let

$$Z_o = \tfrac{1}{2}\left(Z_{1a}/a^2 + Z_{1m}\right) \quad \ldots\ (17\text{--}25)$$

$$Z_d = \tfrac{1}{2}\left(Z_{1a}/a^2 - Z_{1m}\right) \quad \ldots\ (17\text{--}26)$$

Substitution of the defining relations (Equations 17-21, 17-22, 17-25 and 17-26) in Equations 17-19 and 17-20 then gives

$$V_{mf} = I_{mf}\left(Z_o + Z_f\right) - I_{mb} Z_d \quad \ldots\ (17\text{--}27)$$

$$V_{mb} = -\,I_{mf} Z_d + I_{mb}\left(Z_o + Z_b\right) \quad \ldots\ (17\text{--}28)$$

Figure 17-4. Generalized equivalent circuits for 2-phase induction machines.

Equations 17-27 and 17-28 ars also the voltage equations for the coupled circuit shown in Figure 17-4 (a), which is therefore an equivalent circuit for the motor. From Equations 17-25 and 17-26

$$Z_o - Z_d = Z_{1m} \quad \ldots\ (17\text{--}29)$$