נספח <u>לניסוי 6 מדידות במערכת תלת-פאזית.</u>

להלן הוכחה למדידת הספק תלת-פאזי ע"י חיבור "ארון" של שני ווטמטרים. המקור:

E. W. Golding and F. C. Widdis, Electrical Measurements and Measuring Instruments, Sir Isaac Pitman & Sons, London, 1963, pp. 773-774.

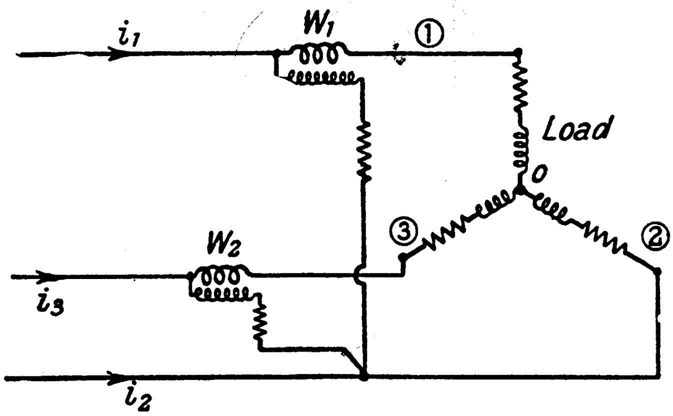

FIG. 20.10. TWO-WATTMETER METHOD OF MEASURING THREE-PHASE POWER

TWO-WATTMETER METHOD. This is the commonest method of measuring three-phase power. It is particularly useful when the load is unbalanced. The connections for the measurement of power in the case of a star-connected three-phase load are shown in Fig. 20.10. The current coils of the wattmeters are connected in lines (1) and (3), and their voltage coils between lines (1) and (2) and (3) and (2) respectively.

Fig. 20.11 gives the vector diagram for the load circuit, assuming a balanced load—i.e. the load currents and power factors are the same for all three phases. E_{10}, E_{20}, and E_{30} are the vectors representing the phase voltages, and are supposed to be equal, while I_1, I_2, and I_3 are vectors representing the line currents. The voltages applied to the voltage-coil circuits of the wattmeters are E_{12} and E_{32}, which are the vector sums of the phase voltages as shown.

Then, total instantaneous power in the load

$$= e_1 i_1 + e_2 i_2 + e_3 i_3$$

where e_1, e_2, e_3 are the instantaneous phase voltages and i_1, i_2, and i_3 are the instantaneous line currents.

Since $i_1 + i_2 + i_3 = 0$, $i_2 = -i_1 - i_3$

$\therefore$ Total instantaneous power $= e_1 i_1 + e_2(-i_1 - i_3) + e_3 i_3$

$$= i_1(e_1 - e_2) + i_3(e_3 - e_2)$$

Now, $i_1(e_1 - e_2)$ is the instantaneous power deflecting wattmeter W_1, and $i_3(e_3 - e_2)$ is that deflecting wattmeter W_2. These wattmeters measure $I_1 E_{12} \cos \alpha$ and $I_3 E_{32} \cos \beta$ respectively, where α and β are the phase angles between I_1 and E_{12} and between I_3 and E_{32}. The

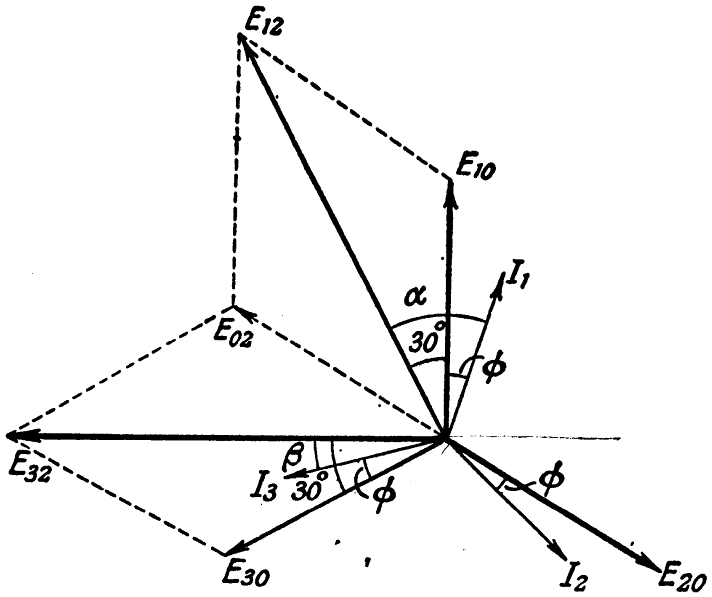

FIG. 20.11. VECTOR DIAGRAM, TWO-WATTMETER METHOD

sum of the wattmeter readings thus gives the mean value of the total power in the load.

Now $\alpha = 30° + \phi$

and $\beta = 30° - \phi$

Also, $E_{12} = E_{32} = \sqrt{3}E$

where E is the phase voltage.

Therefore the sum of the wattmeter readings is

$$W = \sqrt{3}\, IE \cos (30° + \phi) + \sqrt{3}\, IE \cos (30° - \phi)$$

If $I_1 = I_2 = I_3 = I$

$$W = \sqrt{3}\, IE \; [\cos (30° + \phi) + \cos (30° - \phi)]$$
$$= \sqrt{3}\, IE \; [2 \cos 30° \cos \phi]$$
$$= 3\, IE \cos \phi$$

which is, of course, the total power in the load.