DISCUSSION AT PITTSBURG, FEBRUARY 2, 1904, ON ALTERNATING-CURRENT RAILWAY MOTORS.

V. KARAPETOFF:—The connection between ordinary direct-current series motor and the modern types of alternating-current commutator motor seems to be as follows:

First of all a neutralizing winding, N , was brought in to compensate for the armature reaction (Fig. 1). Then the idea came that in an alternating-current motor induction can be used instead of conduction. This gave two different schemes (Fig. 2 and Fig. 4), with either the armature or the neutralizing winding as secondary. In the first of these "transformer-type" motors (Fig. 2) both field coils have the same current, and can be re-

Fig. 1

Fig. 2

placed by a single coil having the resultant number of ampere-turns (Fig. 3); this is the repulsion motor. The second type (Fig. 4) can be simplified by using the armature winding itself as a neutralizing coil. To that end two auxiliary short-circuited brushes, $N N$, must be set at 90° to the principal brushes (Fig. 5); this is the principle used in the Winter-Eichberg and in the Latour motors.

The theory of the repulsion motor, as given by Mr. Steinmetz, is based upon two equations:

$$e_o = Z (I + I_1 \cos w) + I Z_o$$

and

$$0 = -a x I \sin w + Z (I_1 + I \cos w) + Z_1 I_1$$

The first of these equations expresses Ohm's law applied to the primary circuit of the motor, and the second to the secondary circuit, if the e.m.f., $a \times I \sin w$, induced by rotation, be considered as the applied e.m.f. of secondary circuit. All the rest of the theory simply consists in algebraical transformations of these equations to get the power-factor, the input, torque, speed, and so on.

Fig. 3

Fig. 4

Fig. 5

An analogous equation, for straight-series motor can be given (one equation, because there is but one circuit.) Let Z_m be the impedance of the field-magnet system, and Z_a the combined impedance of armature+neutralizing coil. Then with the same notations as in Mr. Steinmetz's paper

$$e_o = a \times I + I (Z_m + Z_a);$$

Describe the semicircle $B C_L D$, which has its centre on $A B$, perpendicular to $A E$, and passes through B and C_L . Then on $A D$, as a diameter, describe a second semicircle $A C_0 D$. The first of these semicircles is the circle of speed and the second is the circle of torque. Thus, for a load C , the speed is represented by the ratio $\frac{C S}{S D}$, and torque by the product $C A \times C T$.

Besides, $D C$ represents the secondary current in phase and magnitude (reduced to primary circuit.) It may easily be seen that C_L is the locked point, because for this point the segment $C S$ is equal to zero, hence the speed is zero.

The point C_0 corresponds to no-load run, because for this point the segment $C T$ is equal to zero, or torque is zero.

This diagram takes into account primary and secondary ohmic drop and primary and secondary leakage, but does not take into consideration iron loss and friction, which must either be added to the input or subtracted from the output.

A similar diagram can be developed for straight-series motor (Fig. 7). $A E$ and $A C_L$ have the same meaning as before, but $A C_L B$ circle of input is a semicircle, having its center upon $A B$, instead of being an arc of circle, as in Osnoff diagram. Connect C_L to B and draw the arc of circle $A P B$ tangent to $C_L B$ and passing through A . Then draw any line parallel to $A B$, as $S S_0$. $A P B$ is the circle of output and $S_1 S_2$ is the line of speed. For any load, as C , the vector $A C$ represents the current; $C C_3$ is proportional to the input and $P P_b$ to the output; the angle $E A C$ corresponds to the power-factor; abscissa $A C_b$ measures the torque, and segment $S S$ represents the speed. For C_3 (locked point) speed is equal to zero, and torque is maximum. For A (theoretical no-load) torque is zero, and speed equals infinity. The iron loss and friction can be accounted for by drawing a certain line, $F F$, and taking output equal to $P R$ instead of $P P_b$. The torque can also be measured from a certain point, T , instead of A , $A T$ representing the torque lost by iron loss and friction.