

NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.*

THOUGH comparisons have frequently been made of the capabilities of machines having two poles and those having a greater number, I am not aware that the design of the multipolar dynamos has yet received systematic treatment in any communication, or that a very satisfactory basis for comparison of the two types has up to the present been suggested. A perusal of the notes scattered about in technical journals, proceedings of societies, and text-books shows that the ideas on this subject are of the vaguest character, their expression having a most uncertain tone, and generally manifesting some erroneous notion. It is with the view of clearing the ground a little, and inducing some expression of correct ideas from members present, that these notes are brought before the Institution.

1.—PREVENTION OF SPARKING IN MACHINES GENERALLY.

In the paper which I submitted for your consideration twelve months ago, attention was directed to certain empirical formulae relating to the armature loads for direct current machines. From the data furnished by a large number of examples, some of which were given in the paper, an expression for the load which could be safely carried by armatures without causing sparking was obtained; this expression, though admittedly of an arbitrary character, having been proved by my own experience, and that of my colleagues, to have been of some service. In that paper the term "ampere turns" was employed to denote the product of the number of conductors on the exterior of the armature and the current carried by each, and I am afraid this may have led to some confusion; at least, so it appears from the discussion. In order that there shall be no misunderstanding in the present case, I shall call this product, quite irrespectively of the number of poles, the *volume* of current carried. The volume is therefore the total current flowing parallel to the armature shaft, independently of direction and whatever the number of poles, and it is obtained by multiplying the conductors on the exterior of the armature by the current flowing in each; or, considering the exterior winding as a copper cylinder, it is the total current flowing in it parallel to the axis.

In his paper on "Armature Reactions," read here last year, Mr. Swinburne had worked out the limiting load from a theoretical point of view, and those who were present will remember that to obtain the results given in his paper the author assumed that the brushes were placed almost close to the polar tips. So far as the practical consideration of the subject goes, it matters little, I think, whether this is strictly accurate or not, because, while moving the brushes back from the tips increases the ampere turns producing the cross field, the magnetic resistance of the cross circuit is at the same time increased, due to the interposition of an increased air gap. For the moment, however, it will be assumed that the brushes are somewhere near the pole tips—in their vicinity, let us say—and that the only conductors concerned in producing the cross field are those covered by the pole pieces. This is sufficiently near the truth for our purpose. Under these circumstances the magnetizing force in ampere turns producing a cross field is, of course, $\frac{v \phi}{360}$, where v is the

volume and ϕ the angle embraced by each pole piece in degrees. Call l the length of the air gap, measured from the surface of the armature core to the polar surface, and I the induction per square centimetre which would be produced in the gap due to field magnets alone. When a current flows in the armature, the field is weakened at the pole tips nearer the brushes, and strengthened at those farther from them. Imagine that the armature is loaded so that the forward induction under the nearer pole tips is just balanced by the cross induction, and we have $\frac{v \phi}{360} = 2 l \times .81$, assuming that the components of the cross circuit, other than the air gap, have no resistance.

According to this equation with a value $v = \frac{576 h}{\phi}$,* the forward and cross induction at the pole tips would be equal, the field would be $.81 I$ at the brushes, and the machine being unstable, any increase of current would at once cause great sparking.

The above expression gives what might be called the theor-

etical load limit, on the assumption that no field is required for reversing the current in the sections as they pass the brushes, but it need scarcely be pointed out that in practice the volume is always much under what would be given by the formula. In the nature of things, one expects in the dynamos of different makers a considerable variation in the relation which the actual load bears to the limit above indicated, and such differences undoubtedly exist; but while one finds, on examining a large number of machines, several under, in few cases are there any having for v a greater value than half that given by the equation. This large margin must be considered in the light of a safety factor, for it would be folly to build machines the commutators of which would be liable to ruin by an occasional increase of current over the normal. No one expects machines to stand in continuous working a current of 50 per cent. over their normal output, for the rise in temperature would then be excessive; but, from the sparking point of view, this increase in a well-designed machine ought to make but little difference to it. Generally, the relation existing between the volume, gap dimensions, and induction in the best machines is expressed approximately by the equation,

$$v = \frac{288 l I}{\phi} \quad (1)$$

which gives, I consider, a very good rule for use in practical work. According to this, the working volume has about half the value expressing the absolute limit, this relation indicating

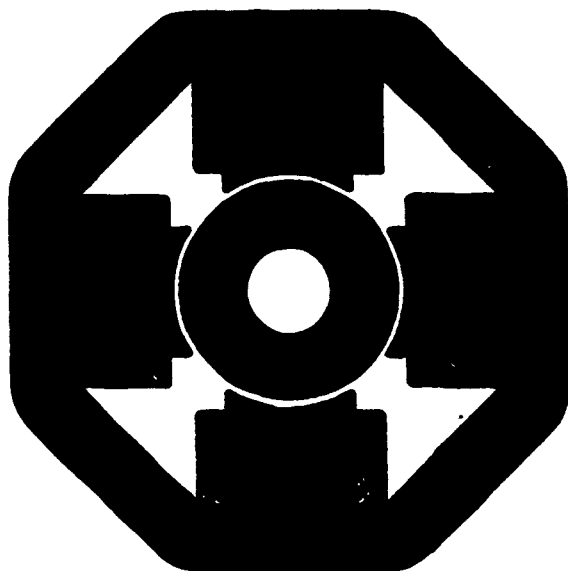


FIG. 1.

the margin of safe working dictated by practice and experience. The formula expresses, in fact, an empirical relation which has a certain degree of flexibility. But with such a large margin it will be readily perceived that the strict accuracy of our assumption about the position of the brushes is of trifling importance, as is also our assuming that the whole of the magnetizing force of the cross-field is spent in the air gap.

It is easy to translate the above expression into the form I previously used for cylinder armatures. Call r the radial depth of the armature core, w the width of the pole piece and I_2 the induction in the core. The induction, I , in the gap is $\frac{2 r I_2}{w}$; and substituting for I its value, we have

$$v = \frac{576 r I_2 l}{w \phi} \quad (2)$$

Taking the induction in the armature core at from 17,000 to 18,000 C. G. S., per square centimetre, and inserting an average value of ϕ we get for bi-polar Gramme-wound machines the expression

$$v = \frac{r I 85,000}{w} \quad (3)$$

* I have pointed out to Mr. Swinburne that the equations $A = \frac{10 h g I_2}{\phi_2 r}$ and $A_2 = \frac{10 B^2 r R l}{w^2}$ which he gave last year on p. 266 of his reply, ought to be $A = \frac{5 h g B^2}{\phi_2 r}$ and $A_2 = \frac{20 B^2 r R l}{w^2}$ respectively. In looking over his paper and reply Mr. Swinburne finds other slips which he will probably correct as discussion on the present paper proceeds.—W. B. E.