NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.*

5. RELATION OF AIR-GAP TO DIAMETER OF ARMATURE AND NUMBER OF POLES IN DIRECT CURRENT MACHINES.

HAVING established the proportionality of the volume and diameter, it is easy to find the relation which must exist between the diameter and length of air-gap for any particular angle of embrace in order that sparking may not occur. I need not take up time ringing changes on the several equations, as to obtain the relation now referred to, all that has to be done is to substitute for v in (1) its value in terms of the diameter accordingly, as the winding is of the cylinder or drum type, and find the connection between l and d. Preserving the same safety factor throughout, it will be found that two-pole dynamos with a mean gap induction of 5,000 C. G. S. units per square centimetre, and pole-pieces embracing an angle of 130 deg., must have—the volume being related to the diameter as described—a gap of not less than

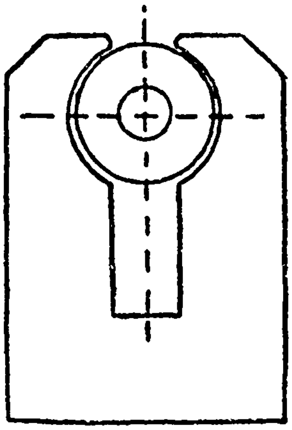

FIG. 3.

.036 d if cylinder-wound, or '054 d if drum-wound. As will have been observed, the air-gap may diminish as the induction is increased, or as the volume is reduced.

But, as is also seen from the equation, the gap required for any particular volume is proportional to the angle of embrace, and if we substitute for two poles a greater number of correspondingly less angular width, working with an increased diameter and volume without a proportionally increased gap is made possible. This is where the advantage of the four, six, or even eight-pole machine comes in. Keeping to two poles, increasing the diameter requires either a proportional increase in the gap, whether the space is required for the conductors and clearance or not, or an increased induction, or a diminished polar angle, or a combination of these. In either case, the magnetizing force spent in the gap is increased; and, other things remaining the same, obviously it would be of some advantage to adopt a construction which, while producing no greater tendency to sparking, would admit of the air-gap being reduced until its length was just sufficient to accommodate the conductors and allow of the necessary clearence. The workdone by an armature of given external dimensions we have seen to be quite independent of the number of poles, and the choice of this number can only be a question, therefore, of structural and working economy.

6.—DIMENSIONS OF THE ARMATURE

It has been observed that the output of an armature is proportional to d^2 L ; and the induction being the same, the weight of the core for a given number of poles must be proportional to the output, the radial depth increasing directly as the diameter, so that a proportionally increased field may be carried. The number of poles being fixed, the weight of the core for a given output may be taken, therefore, as approximately constant, whatever the ratio of L to d.

As the number of poles isincreased, the induction remaining the same, the radial depth of the core is diminished in proportion, and, within the limits of practice, we make the further assumption that theweight is inversely as the number of poles. The money value of a reduction in the weight of material due to increasing poles can easily be arrived at.

The power wasted in hysteresis is proportional to the weight of iron magnetized, and to number of reversals per second. The weight being inversely, and the reversals directly, as the number of poles, the power wasted is for a given out-put the same; furthermore, as the output is proportional to the speed, we may say that for a given induction to the loss in hysteresis is about proportional to the output only, without reference to speed of rotation, weight of core, or number of poles. If it be more important to reduce the loss by hysteresis than to reduce the weight of material, it can, of course, be done. It is a point for the designer to consider.

So much for the core; let us now consider the copper part. Taking Gramme-wound armatures having an interior opening equal to .66, or two-thirds of the core-diameter, it is found—the output, speed, and temperature being predetermined—that the ratio from L to d may vary through a considerable range without making any great difference in the weight of copper or efficiency. For instance, the most efficient relation being $L = \frac{d}{3}$, it may be varied on the one hand till L $= d$, or on the other till $L = \frac{d}{6}$, without increasing the copper by more than about 10 per cent. Of course the watts wasted in the armature are correspondingly increased, but within the limits of the large variation mentioned the reduction in the electrical efficiency of the machine is under one-half per cent. In two-pole machines L varies from .5 to 1.5 d, the normal relation being about L $= d$. As has been seen, the gap has to be increased in proportion to the diameter, unless a greater number of poles be employed; and the disadvantage of an increased magnetizing force would, in machines with only two poles, counterbalance the slight advantage of getting the armature dimensions nearer the best proportion. When the poles are increased, however, the gap may remain fixed, and if the radial depth of the core be correspondingly diminished, the proportions for least copper and highest efficiency are altered : thus, in a four-pole Gramme we can work from $L = \frac{d}{3}$ up to $L = \frac{d}{12}$ without a greater variation than 10 per cent. in the weight of copper. Observe, this is a question differing altogether from the one which was considered in my former paper. In that case the length and radial depth of the armature over the winding were fixed, the problem then being to find the best relation of copper to iron. Here both radial depth and length of core alter, also the peripheral velocity, though the revolutions per minute remain the same. Why the velocity is allowed to alter will be immediately apparent; I only show at the moment that the dimensions of the armature may have their relations altered considerably without making any considerable difference to the weight of copper or efficiency.

To drum wound armatures precisely the same reasoning applies. Here, speed and temperature being fixed as before, the best proportion for two-pole machines is about L $= 3.3 d$; but

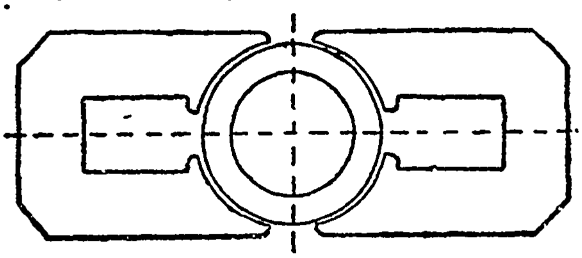

FIG. 4.

because of the distance between the bearings which such a relation would necessitate being inconveniently great, we rarely find L $= 2 d$ exceeded. The latter requires about 5 per cent. more copper than the former ; while for the usual proportion, L $= 1.5 d$, 12½ per cent. more is required than for L $= 3.3 d$. The variation which can be made without over-stepping the limits of economy has a smaller range in drum than in cylinder machines, owing to the greater relative importance of the end wires, because of their greater length. If the length of the core is reduced below L $= 1.5 d$, the copper in machines with two-poles increases rapidly ; but if the number of poles be increased, the length of the end wires being shortened nearly in proportion, the core length may be reduced to a fraction of the diameter without sacrifice of copper or efficiency. In a four-pole machine, for instance, the same copper is used with L $= .5 d$, as in a two-pole one with L $= 2d$; while for six poles, without increasing the copper, the relation may be as small as L $= .25 d$. The effect of adding poles when the diameter is relatively great is not so

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