DYNAMOS FOR MOTOR ROAD-VEHICLE LIGHTING.

(SECOND PAPER.)*

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In a former paper† the author described a number of representative generators for use in the electric lighting of motor road-vehicles. The present paper is intended to be supplementary to the former one, and gives an account of the more important or more representative machines of a number which the author has recently had occasion to test.

The question of efficiency has not yet become of serious importance in car-lighting dynamos, as the power required by them is comparatively small, and the necessity for good regulation over a large range of speed variation is greater than the demand for economical generation. There is, however, at present a movement in the direction of making the dynamo convertible, so that it can also be used as a motor for engine-starting purposes. In this connection it is necessary to give attention to efficiency if the machine is

FIG. 1.

required to run without modification as a motor. Efficiency tests have therefore been made on the machines described. Such tests are based upon measurements of the net tension of the driving belt.

MACHINES WITH COMPENSATING WINDINGS.

It is well known that if in conjunction with a pair of ordinary brushes placed centrally between a pair of poles there is employed an extra brush placed mid-way between the two ordinary brushes and connected to one of these through a field winding, the current through the said winding reverses its direction after a certain speed has been exceeded. This fact is utilized in an ingenious manner by Messrs. Joseph Lucas, Ltd.

Fig. 1 illustrates the arrangement of the windings in a machine recently produced by them. Three distinct windings are adopted, *a* being a series winding connected to the negative brush, *b* a shunt winding connected to the positive brush and the end of *a* remote from the negative brush, and *c* a shunt winding connected between the intermediate brush and the junction of the windings *a* and

b. The machine is adapted for operation with an 8-volt battery of about 75 ampere-hours' capacity. At low speeds all the windings contribute to the excitation of the machine, but as the speed increases the current flowing through *c* diminishes, and the excitation is correspondingly diminished. Above a certain speed the current through *c* reverses in direction and increases with further increase of speed. Simultaneously the current in *a* diminishes until it finally reaches zero value, the return to the machine being then entirely through the winding *c*. The excitation therefore progressively diminishes with increase of speed, and the action of the windings *a* and *c* enables an extraordinary amount of field variation to be obtained. With

FIG. 2.

this arrangement the regulation is very good, as is shown by Fig. 2. The voltage and current increase to a maximum and then remain practically constant, notwithstanding a large increase in the speed of rotation. In the figure only the earlier portion of the test is recorded, as it is the behaviour at the lower speeds which enables an opinion to be formed of the merits of these machines, provided, of course, that at the higher speeds there is no serious variation of voltage or current; for in addition to the necessity for constancy of the maximum voltage it is important that the maximum should be reached quickly, and when the voltage rise is slow the range of speed over which the machine is useful is limited.

It will be observed that the maximum output of the machine is only about 2 amperes higher than that required by the lamps. The necessity for this was indicated by the author in the earlier paper, and it is interesting to note that manufacturers are generally

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realizing the fact that a current output largely in excess of the requirements is detrimental both to the battery and the regulation. When it is impossible to avoid a relatively excessive output at high speeds means are sometimes adopted for cutting out the dynamo from the system after the current has exceeded a predetermined value.

The efficiency of the Lucas machine, as in all electrically regulated machines, is low, being only 30 per cent at

FIG. 3.

the highest. But this figure remains remarkably constant after it has been attained, a result due no doubt to the fact that the winding *a* goes out of action at the higher speeds.

In the same class as the above is the machine of Messrs. Rushmore, Ltd. This is illustrated in Fig. 3. A demagnetizing winding *a* is employed in conjunction with

FIG. 4.

an ordinary shunt winding *b*. The winding *a* is arranged in shunt with an iron-wire resistance *c*. Regulation of the demagnetizing current through *a* is obtained by taking advantage of the known peculiarity in the variation of the temperature coefficient of resistance of iron. When a small current passes through *c* the potential drop in the coil is small, and in consequence the winding *a* has little effect upon the operation of the machine. But as the current through *c* increases, the potential difference across

the ends of the coil increases largely, and in consequence a rapidly increasing current is diverted through the winding *a*. This result, though depending upon a perfectly well-known property of iron, finds an interesting application in the Rushmore machine, and a curve is therefore shown in Fig. 4 to illustrate the variation of potential and current in an iron-wire coil. From this it is evident that small variations in the higher values of the current passed through the coil would cause relatively large variations in the current through a winding connected to the ends of the coil.

The machine tested was adapted to operate with a 6-volt

FIG. 5.

battery, and in the tests a battery of about 75 ampere-hours' capacity was used. A typical result of a large number of tests is shown in Fig. 5. It will be seen that the regulation is good, and the efficiency, though low, is of the same order as is usually found in this class of machine. Compared with the Lucas machine the efficiency curve possesses a different characteristic in that it gradually falls from the maximum with an increase of speed.

MACHINES UTILIZING ARMATURE REACTION.

Of this class the machine made by Messrs. Brolt, Ltd., is a good example. In its simplest form (which is illus-

FIG. 6.

trated by the diagram in Fig. 6) it consists of an ordinary shunt-wound dynamo fitted either with exceptionally broad brushes or with an equivalent pair (*a*), each of which consists of two electrically connected parts arranged so as to subtend a large arc on the commutator and to short-circuit a number of coils on each side of the armature. According to the makers, the object aimed at is to short-circuit those armature conductors which are intersecting the cross-field produced by the conductors under the main pole-pieces, and by the currents thus obtained to create a

regulating flux which directly opposes the main flux. Auxiliary poles (wound or unwound) may be arranged adjacent to the short-circuited conductors to intensify the cross flux. In the machine tested there were no auxiliary poles and the brushes were of the divided type as illustrated.

FIG. 7.

The machine was designed to work at 12 volts and was tested in conjunction with a battery of 75 ampere-hours' capacity. Fig. 7 gives curves which are representative of

FIG. 8.

the normal working of the machine. The high quality of the results is self-evident, the maximum voltage being quickly reached, and both the voltage and the current being kept constant over a wide range of speed variation. The efficiency curve has a somewhat similar characteristic to that of the Rushmore machine, and is similar to the curves usually obtained in electrically regulated machines.

Another machine which depends upon armature reaction for its self-regulating property is that made by Messrs. C. A. Vandervell & Co. One of the most recent forms of their machine is illustrated in Fig. 8. It consists of a pair of main pole-pieces *a* and a pair of auxiliary pole-pieces *b*. The former are provided with an ordinary shunt winding, and each of the latter is fitted with a winding which is connected between one of the main brushes *c* and an auxiliary brush *d*. The action of the machine in detail is somewhat complicated.* But in the main the action appears to be as follows:—At low speeds the conductors between the brushes *c* and *d* cutting the residual magnetism of the pole-pieces *b* produce a current in the windings on *b*, the flux due to which opposes the said residual magnetism. When the speed increases beyond that at

FIG. 9.

which the residual magnetism of the poles *b* is neutralized, the direction of the current through the conductors between *c* and *d* and the windings on *b* reverses, whereupon a field is produced which acts in opposition to the field of the pole-pieces *a*. This opposition increases with the speed and produces the required regulation at the higher speeds. A typical result of tests on this machine is shown in Fig. 9, from which it will be seen that the regulation is good.

At the present time the electrically regulated machines appear to be more in favour than those which are regulated by a slipping clutch. The mechanical simplification obtained in the electrically regulated machines is not, however, an unmixed blessing, as special precautions have to be taken to avoid injurious effects from over-heating.

* A full account is given in the British Patent Specification No. 17838 of 1912.