EXAMPLES IN ELECTRICAL ENGINEERING

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PREFACE

MANY of the examples in the following pages have been collected during the past few years to illustrate the author's lectures to Advanced and Honours Students in Electrical Engineering, though the majority are here published for the first time.

Originally intended as a collection of exercises, the explanatory matter forming the bulk of the text was, however, found necessary to make the book more complete in itself, though it is not intended to act as a full treatise on the subject. These explanations, together with the tables at the end of the book, will, it is hoped, be found very useful by draughtsmen and others engaged in electrical machine design.

The author's best thanks are due to such writers as have been made use of, too numerous to mention by name; and also to two of his third-year students, Messrs. A. B. Mallinson and W. K. Meldrum, for many carefully executed diagrams.

Lastly, and not the least, the author's thanks are due to his friend Mr. E. S. Shoults, for considerable assistance in checking examples.

S. JOYCE.

LATCHFORD HOUSE, GREENHEYS,
MANCHESTER,
July, 1896.

NOTE.—The author will be much obliged if readers will kindly notify any errors that may have escaped observation.

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EXAMPLES IN
ELECTRICAL ENGINEERING.

CHAPTER I.

SIMPLE CIRCUITS.

The Simple Electric Circuit consists of a conducting path, insulated so as to confine the electric flux as much as possible to that path. In it the relationship known as Ohm's Law holds good, viz.—

$$C = \frac{e}{R}$$

If e be stated in volts, R in ohms, then C will be in ampères. The value of e in the above expression must be considered as being the algebraic sum of all the electro-motive forces (E.M.F.) acting in the circuit, and will be called the effective or active E.M.F.

The resistance of a simple circuit may be composed of a number of separate resistances in series; in which case R will be the sum of all these other resistances, thus—

$$R = r_1 + r_2 + r_3 + r_4$$

$$\text{and therefore } C = \frac{e}{r_1 + r_2 + r_3 + r_4}$$

$$\text{or } e = Cr_1 + Cr_2 + Cr_3 + Cr_4$$

and each of these quantities may be called a potential difference, or P.D., for short. The E.M.F. e is thus the sum of all the P.D.'s, or is equal to—

$$\Sigma Cr$$

writing the P.D. $Cr_1 = v_1$, we have that—

$$e = v_1 + v_2 + v_3 + v_4$$

The Rate of doing Work.—The amount of work done in a circuit is equal to the quantity, Q, of electricity passed multiplied by the E.M.F. And since Q is the product of the current and the time, then the work done, W, in the time t will be—

$$W = eCt$$

from which the rate of doing work, or power, or activity, is—

$$P = \frac{W}{t} = \frac{eCt}{t} = eC$$

and as $e = Cr_1 + Cr_2 + Cr_3 + Cr_4$, etc., we have—

$$P = eC = C^2r_1 + C^2r_2 + C^2r_3 + C^2r_4, \text{ etc.}$$

which gives the distribution of energy expenditure round the circuit, and states that the whole rate of doing work in a circuit is equal to the sum of all the activities in the separate parts of the circuit.

The activity or power P is measured in watts, one watt being the activity when the product eC is unity. Owing to the values chosen for the volt and the ampère, the watt is equivalent to the $\frac{1}{746}$ part of the mechanical horse-power, or—

$$H.P. = \frac{\text{watts}}{746}$$

Calculation of Resistance.—The value of the resistance of a circuit is determined by the nature of the material of which that circuit is composed, by its temperature, and by the dimensions of the circuit; the relationship between these quantities being that—

$$R = \frac{L\rho}{a}$$

where L and a are respectively the length and sectional area (average if not uniform) measured in terms of the same unit, and ρ represents the resistivity at a certain temperature of the material; that is to say, ρ is the actual resistance in ohms of the unit cube of the material.

The term resistance has come more into general use than conductance, and represents the opposite idea, the relationship between them being—

$$\rho = \frac{1}{m}$$

where m stands for the conductivity, that is the actual conductance, in mhos of the unit cube.

Thus, the value of the resistance of a circuit can be expressed in two ways, viz.—

$$R = \frac{L\rho}{a} = \frac{L}{am} = \text{ohms}$$

and similarly the conductance may also be written—

$$K = \frac{am}{L} = \frac{a}{L\rho} = \text{mhos}$$

Thus, if the dimensions of a circuit, both electrical and mechanical, be known, its resistance or conductance can at once be found. And in cases where the whole resistance is made up of a number of items, we can find the value of each item r by inserting in the equation—

$$r = \frac{l\rho}{a}$$

the proper values for l, a, and ρ, the latter being possibly different for each item of the circuit, either on account of temperature or on account of difference of material.

The tables on page 209 will give all necessary data for these values.

Different Kinds of Circuits.—There are two main ways in which lamps are connected to form a circuit: the series and the parallel.

The *series* circuit is arranged thus—

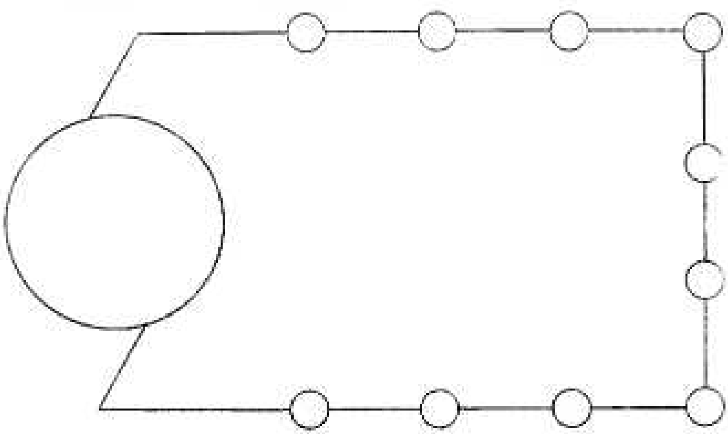

Fig. 2.