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BY

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PREFACE

What do you know about electricity? Can you explain simple circuits, losses, power and efficiency, wiring calculations, how generators and motors are installed, how they work, what efficiency means and how to calculate it, and how current for electric lighting and heating is estimated?

"Know the fundamentals" is the cry of the hour. Here is a series of discussion which has appeared in the columns of the Journal of Electricity in cooperation with the Extension Division of the University of California on the all-important subject of elementary laws of electricity. The forwarding of this movement is a matter that strongly appeals to every member of the electrical industry — manufacturers, jobbers, central station men, electrical contractors and dealers—and has received the heartiest endorsement of the electrical industry from all quarters. These discussions which appeared in the columns of the Journal of Electricity during the year of 1919-1920 under the endorsement of the California Electrical Cooperative Campaign, an organization composed of all members of the electrical industry, have received wide and emphatic endorsement.

The author, Mr. H. H. Bliss, for a number of years was head of the technical instruction of the Extension Division of the University of California, and while occupying that position gave this course through the University Extension in cooperation with the Journal of Electricity. The course proved unusually successful, and aroused interest throughout the West in the study of fundamentals. It is with this same hope that this group of papers may prove of increasing helpfulness that the Journal of Electricity has compiled these pages into book form in order that a permanent record may be had with these papers in one volume so that the biggest and most intensified use of this valuable collection may be offered to that ever growing group of young and enthusiastic as well as ambitious men in our industry who wish to forward themselves to greater remuneration from their employers and to greater usefulness in their chosen profession.

ROBERT SIBLEY, Editor,
Journal of Electricity.

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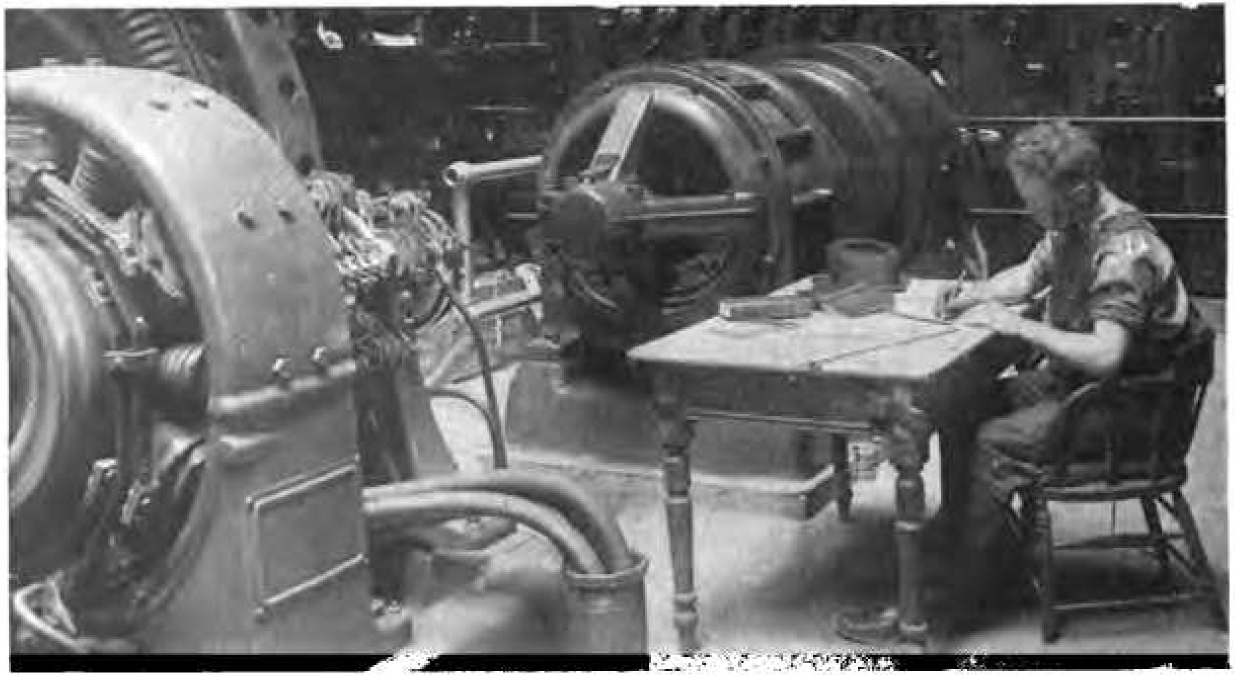

Electrical computation in the power plant. The best investment of spare time is in study leading to self-improvement and to advancement in one's vocation. Electrical workers enjoy exceptional opportunities of this kind.

ELEMENTS OF APPLIED ELECTRICITY

I

OHM'S LAW AND THE ELECTRIC CIRCUIT

Our discussion of electrical principles and practice begins with the consideration of Ohm's Law, which is the basis of all quantitative knowledge of circuits and machines. Its fundamental character is recognized in the industry, and the National Electric Light Association has adopted for its official emblem the Ohm's Law formula "$C = E/R$," which appears upon all the stationery and official documents of this nation-wide organization.

Electric Currents.—In order to utilize electric energy it is necessary to connect the source of the current, such as a battery or generator, to other apparatus, such as motors, heaters, or lamps. There must be a continuous path for the current from the source to the point of use and back again to the source. As soon as this circuit is broken at any point the current stops.

The materials which can carry electricity are called "conductors." They include all metals, both when solid and liquified (as mercury or melted iron); carbon; impure water; earth; moist woods, etc. Materials which stop the flow of electricity more or less completely are termed "insulators." These include glass, porcelain, marble, slate, rubber, paper, cloth, wax, dry wood, etc. The fact that any water, except chemically pure distilled water, can carry electricity causes such materials as wood, cloth, paper, dirt, etc., to fall into one class or the other according to whether they are dry or wet. And

A current of gas may be measured in cubic feet per minute, by means of this meter and a watch; an electric current is more easily measured, in "coulombs per second" or "amperes," by means of a single instrument, the ammeter. The current in either case must go through the meter. (See Fig. 1.)

small particles or veins of metal in insulating materials sometimes lead the current to places where it is a source of annoyance or danger. Air is generally an insulator, but under certain circumstances it becomes a conductor, as, for example, in the electric arc where large currents flow for a short distance through air.

Measuring Electric Current. — A current of water in a pipe or a river can be metered in various ways, and the rate of flow can be stated in terms of gallons per second. In a similar way the rate of flow of an electric current can be stated as so many "coulombs per second," but it is more customary to substitute for this phrase the single word "amperes." A statement that "the current is 16 amperes" means that 16 coulombs pass a given point in the wire every second.

Tungsten lamps take currents ranging from .23 to .91 amperes in the sizes commonly used (25 to 100 watts); arc lamps take from 3 to 20 amperes; a 10 horsepower motor on a 250 volt circuit will take about 40 amperes.

To measure the rate of flow in an electric circuit we use an instrument called an "ampere meter" or "ammeter." It is inserted into the circuit, as shown in Fig. 1, so that the current must go through the instrument between the source and the load. A needle shaped pointer moving over a scale gives a reading of the current in amperes.

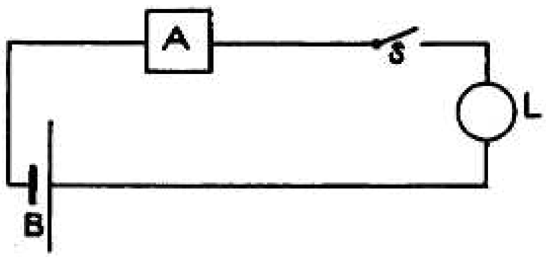

Fig. 1.—The current goes through the ammeter between the battery and the lamp. When the switch (S) is opened the battery (B) can no longer send current to the lamp and the ammeter needle points to the zero mark.

Resistance.—If in the circuit of Fig. 1 we replace the lamp by one of different candle power or by a piece of fine iron wire or by an electric bell, we shall find the ammeter giving an entirely different reading. The battery tries equally hard to force electricity through the circuit, but the amount it can send depends upon the apparatus through which the current must flow. We may say that the lamps differ in the amount of "**resistance**" they offer to the passage of electricity. If one takes three times as many amperes as a second, we may say that it has one-third the resistance of the second.

Electrical resistance is measured in "ohms." It is thought of as a sort of "electrical friction," like the opposition a rough pipe offers to the flow of water through it. The resistance of a 25 watt Tungsten lamp is about 485 ohms; that of an electric