AN ALTERNATING CURRENT MODEL.

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IN view of the fact that models illustrating the mechanical analogies of alternating current phenomena, though often described, are not commonly used, it has seemed worth while to give an account of such a model, which has proved very useful in the University of Wisconsin, and which can be made in half a day by almost any one, at practically no cost.

In this machine, that which corresponds to the driving electromotive force is furnished by the hand of the person operating it ;

Fig. 1.

mechanical friction gives an imperfect but adequate imitation of resistance, while inertia and the tension of an elastic cord correspond to self induction and the action of dielectrics where there is capacity. In order to show the action on the current of each of these four

components of the electromotive force, the current itself is represented by the motion of a body separate from all of them and as free as possible from the action of any force, frictional or other. This condition is secured by using a light, balanced lever, oscillating on two sharp points. This, the "current lever," is shown in Fig. 2 at *C*, and is of light wood, about 2 x 2 x 100 cm. It is attached by means of a vertical piece of wood to the crossbar, *Y*, from each end of which a large, sharpened nail, *N*, projects downward, resting on the uprights, *U*, which are simply pieces of wood nailed on opposite sides of a box, *B*.

The action upon the current lever, *C*, of the various bodies whose inertia, elasticity, etc., represent the components of the electromotive force is made much easier to understand and follow by means of the "phase indicators," shown at 1, 2, 3, 4, Fig. 2, and alone in Fig. 1. Each one is a very small tube, turning on a nail, with a wire

soldered to it so as to form a bent lever, with arms 1 cm. and 8 cm. long. The nail is driven into the current lever, and the long arm of the phase indicator is allowed a few centimeters' play between two other nails; the acting body—that is, the body representing resistance or self-induction, etc.—instead of being fastened directly to the current lever, is connected by a projecting pin to the loop in the short arm of the phase indicator. Thus, according as the body is urging the current one way or the other, the indicator will point to the right or left, and whenever the direction of pull changes the indicator will fly from one stop to the other with a sharp click, which emphasizes strongly the beginning of a new phase, and which enables all four sets of phase relations to be followed and studied while the machine is in motion.

Fig. 2.

The driving force is transmitted longitudinally along the stiff rod, *M*, to the phase indicator, 2. This ought to be an undulating pressure, rising and falling without too great suddenness. It is more difficult to give such a pressure with the hand alone than might be supposed, on account of a tendency the mind has, in directing the action, to will the motion and not the pressure. Now as the machine is most useful in the hands of the students themselves it ought not to require any special practice or skill on the part of the operator. Accordingly, the flexible rod, *E*, is tied at *P* to *M*; when *E* is bent to and fro by the hand holding it at *H* it gives a pressure which depends on the amount of bending, and is quite satisfactory.

The effect of self induction is given by the lever, *L*, which swings on two nails driven through its cross bar, *X*, inside of and in line

with the nails, N . It is heavily loaded at the ends to give high moment of inertia, is attached to the current lever, C , when desired, by the phase indicator at 3, and is tipped down to the left when not in use. From four to eight kg. is a suitable weight; this lever, like the current lever, should be carefully adjusted so as to be in neutral equilibrium.

The elastic loop, S , is stretched if the current lever is displaced either way from a middle position. The reaction due to this mechanical displacement imitates the action of the dielectric of a condenser, which opposes the current with a force proportional to the electric displacement. The loop is made of string and stout rubber bands. The analogue of resistance is the bar, R , turning about the metal rod, F , as the lever turns, with friction which can be varied by the screw which clamps R on F .

If the lever, L , and the loop, S , are disconnected, and the machine operated, we have a representation of a simple circuit without self-induction or capacity. The two phase indicators, 1 and 2, keep time with each other, as the current lever swings with the impulses of the driving force. If capacity is now added to the make-believe circuit, by simply stretching the loop, S , over its frame three distinct clicks are heard every oscillation from the three indicators, 1, 2 and 4, which are now in different phases. The force exerted on the current lever by the resistance is still in step with it; the capacity phase indicator flies over as the current-lever passes the middle point, and is half an oscillation ahead; the interval between the clicks of phase indicators 1 and 2 marks the lead, whose dependence on varied resistance, capacity, and frequency may be studied as fully as desired.

In class demonstration the machine readily shows the motion of the current, lag or lead, and the phase relations of the different forces, as affected by variations in frequency, resistance and capacity. It is especially useful in making clear the reason for certain phenomena which are puzzling to the beginner. For instance, it shows clearly how a capacity, which resists the current, can at the same time cause it to "lead," how self induction and capacity can neutralize each other, and how resonance depends on the frequency of the electromotive force.