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NEW DEMONSTRATIONS FOR A COURSE IN ELECTRICITY

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Usp. Fiz. Nauk **84**, 730-731 (December, 1964)

THE demonstrations described below were shown on 2 June, 1964 at the all-Moscow seminar of instructors in institutions of higher learning held at the Moscow State University.

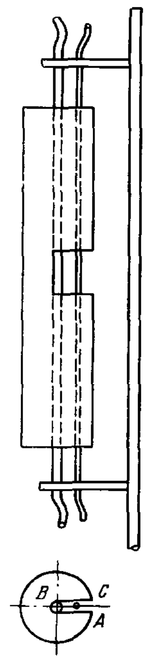

FIG. 1

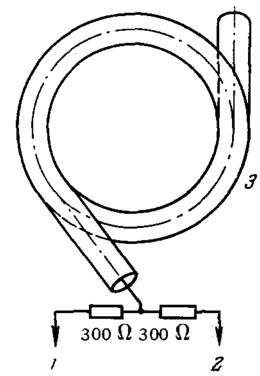

FIG. 2. 1 – To the oscillator of IChKh-1; 2 – to the detecting head of IChKh-1; 3 – coil of cable RK – 106.

I. INTERACTION OF PARALLEL CURRENTS IN A MAGNETIC MEDIUM

This demonstration has as its aim to complement the traditional experiment on the interaction of straight parallel currents in air by showing the increase in their interaction in a medium of high magnetic permittivity. If a straight line current is surrounded by a continuous homogeneous magnetic medium then the lines of magnetic induction are in the form of circles with centers lying along the line of the current. The induction in a magnetic medium lying inside any cylindrical surface coaxial with the current will not be altered if the magnetic medium lying outside the surface is completely removed. Therefore, in setting up the experiment on the interaction of parallel currents in a magnetic medium we can restrict ourselves to a magnetic medium in the form of a cylindrical rod along the axis of which we must place a current carrying wire. In order to observe the effect of this axial current on another current parallel to it, it is necessary to make this second test current in the magnetic medium sufficiently small compared to the axial current, so that the presence of the test current would introduce as little distortion as possible into the field of the induction vector in the rod. Moreover, it is necessary to make along the whole length of the rod a radial slot within which the wire with the test current must be placed. Within this slot the test current can be displaced as a result of its interaction with the axial current. It is also clear that the induction in such a slot is close to the value of the induction in the rod.

The arrangement which realizes the considerations mentioned above is shown schematically in Fig. 1. For the magnetic medium we have utilized "Armco" soft iron in the form of a rod (length 700 mm, diameter 30 mm) with the slot ABC of 6 mm width. In the middle portion of the rod an additional slot is cut specially to observe the wires in projection. On a separate mobile stand are fixed two wires (900 mm) at a distance of 10 mm from one another. The axial wire is an insulated copper rod (diameter 55 mm), the wire carrying the test current is a soft multi-stranded one. The axial wire is made to carry a current of 50 amp, while the test current is 3 amp. The tension of the test wire is chosen such that when it is outside the rod its displacements when the current is switched on and off would be small. Then by moving the stand the wires are introduced into the slot of the rod and a considerable increase in their interaction in the magnetic medium is demonstrated.

II. RESONANCE PROPERTIES OF A LONG COAXIAL CABLE

In order to demonstrate the resonance properties of a long coaxial cable an oscillographic frequency characteristic meter (IChKh-1) is utilized. This is an oscillograph provided with a special oscillator of variable frequency. The frequency of this oscillator varies in synchronism with the horizontal displacement of the beam along the screen. The maximum variation of the frequency within the limits of the screen is 8 Mc/sec. The average frequency lies between 0.1 and 20 Mc/sec. The voltage from the oscillator is applied to the circuit being investigated, while the signal taken off the output of the circuit is detected and applied to the vertical deflection amplifier. As a result of this a representation of the frequency characteristic of the circuit under investigation is observed on the screen of IChKh-1. The dimensions of the screen (220 × 220 mm) are sufficiently large for a demonstration in a large auditorium. This experimental arrangement can be utilized to dem-

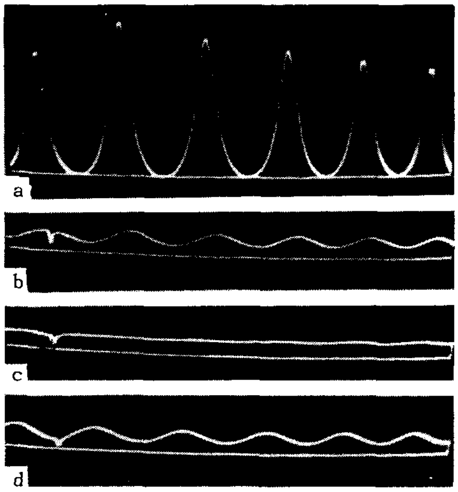

FIG. 3

onstrate resonance curves of single and coupled circuits, frequency characteristics of inductive and capacitive resistors, etc. In the demonstration being described the apparatus is utilized to observe the resonance properties of a long coaxial cable RK-106 (100 m), wound on a large wooden coil (cable of a different type could be used, but it is desirable to have it with a many stranded central conductor). The circuit for connecting the cable is shown in Fig. 2. Figure 3a shows the shape of the frequency characteristic of the cable open at the end opposite from the frequency characteristic meter. Figures 3b—d show the changes in the frequency characteristic when different resistors: 75, 56, 32 ohm are connected across the open end of the cable. The resonance properties of the cable completely disappear when the 56 ohm resistor is connected—it is close to the characteristic wave impedance of the cable. By shorting the free end of the cable by a short conductor and opening it again one can demonstrate the shift in frequency of the frequency characteristic of the cable.

The cable can also be connected as a line coupling the oscillator and the detector head of the IChKh. In this case one observes the dependence of the transmission coefficient of the cable on the frequency analogous to Fig. 3. In order to make the transmission coefficient of the cable independent of the frequency one connects across its ends resistors equal to the characteristic wave impedance of the cable. In this case one observes a pattern similar to Fig. 3c.

Finally, the same coaxial cable is utilized as a delay line to demonstrate the velocity of propagation along it of a short electromagnetic pulse as proposed by Vekshin[1].

S. I. Usagin and L. I. Bashtannik have provided valuable advice and have aided in carrying out the demonstrations described above.

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[1] Vekshin, Fizika v shkole (Physics in School) No. 6, 69 (1963).

Translated by G. Volkoff