TEXTBOOK OF ELEMENTARY PHYSICS

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TEXTBOOK OF ELEMENTARY PHYSICS

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ELECTRICITY AND MAGNETISM

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by A. Troitsky

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На английском языке

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PREFACE

This is the second volume of a three-volume work. The title *Textbook of Elementary Physics* given to it by the authors reflects their desire to present a textbook suitable for teaching the elements of physics as a science, a task that inevitably faces all physics teachers in secondary schools, whether general or technical.

The work (which has had seven editions in Russian, the latest in 1970-1) is widely used in Soviet secondary schools and technical colleges, and is equally popular with pupils and teachers. Its merit is that it gives a basic explanation of the physical aspects of various processes in nature and technology, taking into account the latest advances in each field.

The material is presented in clear, simple language with a wealth of illustrations, which makes it useful as a means of independent home study.

This second volume is devoted to electrical and magnetic phenomena. Electromagnetic oscillations and waves will be discussed in detail in Volume 3 together with acoustic and optical phenomena.

The few mathematical calculations are mainly given in small type.

The textbook was written by S. Kalashnikov and L. Tumerman. Great assistance in editing was rendered by E. Starokadomskaya.

The whole work is under the general editorship of the late Prof. G. Landsberg, Member of the USSR Academy of Sciences.

CHAPTER 1

ELECTRIC CHARGES

1.1. Electric Interaction. Let us suspend a light weight such as a paper cartridge on a silk thread. Let us now rub a glass rod on a piece of silk and then move it up to the cartridge. The latter will first be attracted to the rod and then, after it touches it, repelled (Fig. 1).

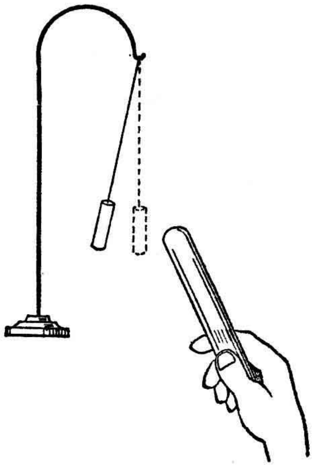


Fig. 1. A paper cartridge is repelled from a glass rod that charges it

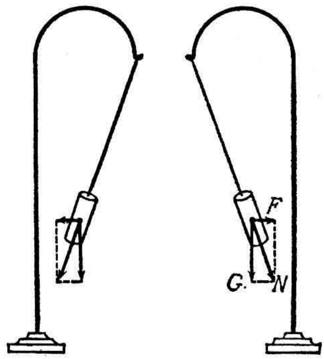


Fig. 2. Two paper cartridges suspended on silk threads and charged by a glass rod repel each other. The figure shows the resolution of the force N that acts on the cartridge and balances the tension of the thread: G is the weight of the cartridge and F is the electric force

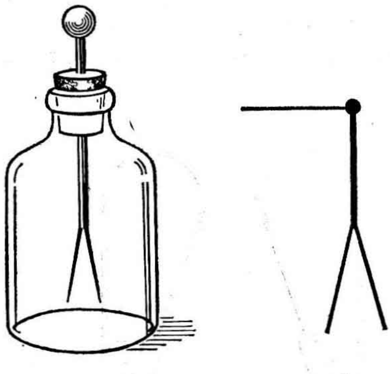
Now touch a similar cartridge with the same rubbed glass rod, remove the latter and move the cartridges toward each other. They will be repelled from each other and deflected to different sides (Fig. 2).

Before contact with the glass rod, the suspended cartridges were in equilibrium in a *vertical* position under the action of the force of gravity and the tension of the thread. Now they are in a *different* position of equilibrium. This means that other forces are also acting on the cartridges.

These forces differ from the forces of gravity, those caused by the deformation of bodies, the forces of friction and other forces that were described in mechanics, and are called *electric forces*.

Bodies that act on surrounding objects with electric forces are called *electrified*, or *charged*, bodies and are said to contain *electric charges*.

In the above experiments the glass rod was charged by rubbing it on a piece of silk. Sealing wax, ebonite, Plexiglass or amber may be used instead of glass, however, and leather, rubber or other materials in place of silk. Experiments show that any body can be charged by rubbing.



(*a*) (*b*)

Fig. 3. A simple electroscope: *a*—general view; *b*—schematic view

The design of an *electroscope*, a device employed to detect electric charges, is based on the phenomenon of electric repulsion. It consists of a metal rod to which there is suspended a thin aluminium or paper leaf (sometimes two leaves, Fig. 3*a*). The rod is secured by means of an ebonite or amber plug in a glass jar that protects the leaf from the motion of air. Figure 3*b* shows a schematic view of an electroscope that will be used in our further exposition.

Let us touch the rod of the electroscope with a charged body, for example a rubbed glass rod. Its leaf will be repelled from the rod (or the other leaf) and deflected through a certain angle. If the charged rod is now removed, the leaf will remain deflected. This means that a charge is transferred to the rod and the leaf when in contact with a charged body.

Let us charge an electroscope with the aid of a glass rod, notice the divergence of its leaf, touch the electroscope once more with another point of the charged rod and remove the latter. The divergence of the leaf will increase. After the third touch it will be still greater, etc. It follows, therefore, that the electric forces causing the leaf to deflect may be greater or smaller, as may the charge on the electroscope be. Hence we can speak of the *magnitude of the charge* on a body, on the electroscope in our example.

1.2. Conductors and Insulators. The preceding experiments show that an electric charge is imparted to uncharged objects touched by a charged body. This was done when charging the electroscope. Thus, electric charges can be transferred from one body to another.

Electric charges can also move inside a body. For example, when the electroscope was charged, the glass rod was brought in contact with the upper end of the metal rod. Nevertheless, both the bottom of