then fasten by turning the hooks back into place. Cotton wool should be loosely placed in the neck of the bottle to keep out the dust.

The satisfaction derived from this instrument will compensate amply for the small amount of time and trouble required for its construction. It will prove as accurate and efficient in action as many comparatively high priced barometers.

CHANGES OF LENGTH AND HYSTERESIS LOSSES ACCOMPANYING MAGNETIZATION.

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An interesting lecture experiment showing the changes of length accompanying magnetization and the heating effect due to hysteresis has been shown in this university for a number of years. The writer has not seen any published account of a similar lecture experiment, therefore it may be worth while to describe it. A solenoid of about 1000 turns of No. 16 wire is wound in three layers on a brass tube about two feet long and one inch in diameter, mounted vertically on a solid wooden base. Within each end of the tube is placed a brass collar with a central opening about 8 mm. in diameter, into which may be placed a closely-fitting rod of iron or steel somewhat longer than the solenoid. On the top of a stout wooden standard parallel to the solenoid is screwed a magnifying optical lever devised by G. P. Kraus, assistant mechanician, all the parts of which except the springs are made of brass. The small rod r may be adjusted so that its end is held firmly against the top of the iron rod by the spring s . Any change in length in the rod causes a rotation of the lever l about the axis a_1 . The other and longer end of the lever is attached to a stout thread which is wrapped around the axis a_2 and kept under tension by the spring s_2 . The axis a_2 is about 1 mm. in diameter. A displacement of the lever causes a corresponding rotation of this axis and an angular rotation of the mirror m attached to it. The arms of the lever are respectively 8 and 32 mm. long. A change of length x in the rod causes a linear displacement of $4x$ at the long end of the lever. The resulting angular rotation of the axis and of the mirror is $4x/r$, where r is the radius of a_2 . A beam of light reflected from the mirror is subject to twice this angular displacement. If the beam of light is thrown on a screen at a distance L the spot of light moves a

distance equal to $8Lx/r$. If L is 700 cm. this distance is 112,000 x . Thus a magnification of more than 100,000 is readily obtained.

When a current is sent through the solenoid the rod elongates, as shown by the motion of the spot of light. As the current is increased, the rate of elongation becomes less, and finally is followed by contraction, so that the rod may become shorter than it was in the beginning. Soft iron and hard steel differ greatly in the amount of elongation and in the critical value of the field which will produce shortening.

This effect was first studied by Joule¹ and later by Bidwell² and others. It appears that in most cases there is little or no change in volume, the cross section becoming less as the length becomes greater. If an alternating current is sent through the solenoid, the changes in length are synchronous with the alternations of the current and a musical tone of corresponding pitch is heard. This explains the "singing" of the core of an electromagnet when an alternating current is sent through the coil.

A part of the contraction may be due to the action of the field of the solenoid on the induced poles in the iron, but the greater part of this effect and all the elongation must be due to

¹ Phil. Mag., 1847.

² Proc. R. S., 40, 1886.

internal changes in molecular arrangement accompanying magnetic induction. It may be imagined that the first effect is that the molecules orient themselves parallel to the field and crowd into line, thus causing an increase in length; then an increase in the field will crowd them more closely together, causing contraction.

If the exciting current is rapidly interrupted, the core is magnetized and demagnetized many times in succession, and the internal resistance of a frictional character results in the development of heat (hysteresis loss) corresponding in amount to the internal work done in overcoming the coercive force of the magnetic material. If an alternating current is used, the magnetism is completely reversed at each alternation, and the effect is much greater. If the iron is very soft only a small amount of heat is produced; if hard steel of great coercive force is used a large amount of heat is developed. The change of temperature causes the spot of light to move rapidly and steadily across the screen. It is interesting to note the difference in the rate of movement when soft iron is compared with tempered steel.

Some change of temperature might be expected from the heating of the solenoid by the current and from eddy currents in the brass and iron. This very slightly affects the result, however, for if a rod of brass or copper is substituted for the iron the steadiness of the spot of light shows that the heating effect is very small. With the brass or copper core no "singing" will be heard.

Since the coefficient of expansion and the specific heat of the iron are known, probably very accurate measurement of the hysteresis loss of energy might be made by this method. The heating is uniform throughout the rod, and observations might be made so quickly that there would be little loss by radiation or conduction.

Bidwell likewise used an optical lever, but the design was different and it was not nearly so sensitive as that here described. The maximum elongation observed by Bidwell was about one part in one hundred thousand.

President Harry Pratt Judson, of the University of Chicago, announced in his recent Convocation statement that Associate Professor Charles Riborg Mann, of the Department of Physics, has been given leave of absence for a year from April 1st, to carry on an investigation under the direction of the Carnegie Foundation for the Advancement of Teaching. Professor Mann is a graduate of Columbia University and received his degree of Doctor of Philosophy from the University of Berlin.