tion falls very considerably. It will also be noticed that the relative minimum drop on March 10 is not nearly as large as on March 9. The dotted portions of the curve represent the times when the electroscope was recharged. That all parts of the scale were equally sensitive was shown afterwards when a lead screen was placed around the electroscope. The rate of fall of the gold leaf was then practically constant for the portion of path used. During the day there was a great deal of vibration due to travel on the cobblestone street next the building, so that the error of reading was larger.

Fig. 2 represents the ionization for several days in February and March of the present year. (*a*) is the average of readings for four days and (*b*) for fifteen days. These and other curves show maxima for February and March at about 9 A.M. and 10 P.M., and minima at about 7 A.M. and 6 P.M. Very few observations have as yet been made on the 7 A.M. and 9 A.M. periods. The most conspicuous is the minimum at 6 P.M. This occurs with considerable regularity and is very marked, the ionization often falling thirty or forty per cent. No corresponding change of temperature or barometric pressure was noticed. It will be noticed in the following table, however, that it never drops below the value of the ionization when the penetrating radiation is cut off. It has been found that sudden changes of temperature produce air currents and set the gold leaf in motion, but it hardly seems likely that this minimum is to be explained in this way. Still it seems very remarkable that the penetrating radiation should have such a marked drop and the problem as to whether it is a temperature effect is to be taken up.

The electroscope was then screened with lead plates from 4 to 5 cm. thick. A window was necessary to make the readings, however, so that the radiation was not all screened out. The rate of leak was made much more constant. The marked minimum at 6 P.M. was usually not noticeable.

The following table gives the average ionization for several days. Readings were usually taken from 10 A.M. till 6 P.M. The period of minimum is not included in the column marked average ionization. The ionization during the early part of the afternoon was found fairly constant.

Date	Weather	Average Barometric Pressure	Ionization	Minimum Ionization	Time of Minimum
Feb.					P.M.
16	Clear.		.00113	.00077	5.40–6.00
18	"		.00085	.00064	5.30–7.00
19	Cloudy.		.00100	.00078	5.00–6.00
20	"		.00100	.00092	5.00–7.00
21			.00102	.00069	5.00–5.30
22	Clear.	77.10	.00101	.00058	4.30–5.30
23		77.80	.00093	.00056	5.30–6.00
25	Clear (8″ snow)	76.25	.00090	.00051	5.30–6.00
Mar.					
3		76.50	.00088	.00078	6.00–7.00
4	Clear.	76.50	.00060		
5	"	76.50	.00075		
Apr.					
15	Clear. Lead screen put around telescope.	75.50	.00049	No drop observed.	
16	Cloudy.	75.20	.00051		
17	"	75.70	.00052		
18	Clear.	75.90	.00052		
30	Cloudy.	75.80	.00051		

In conclusion the writer wishes to express his thanks to Professor Ames for his many kindnesses and to Professors Rutherford and Dike for their suggestions.

W. W. STRONG

LABORATORY APPARATUS FOR MEASUREMENT OF THE FORCE ON A CURRENT-CARRYING CONDUCTOR LYING IN A MAGNETIC FIELD

THE method used by Ampère in his investigations of the effect of a magnetic field on a current-carrying conductor was to arrange the conductor so that the forces acting on one part of the circuit just balanced those acting on another part. From observations thus made and without the direct measurement of any forces in force units, Ampère established his propositions with regard to the mutual action of current-carrying conductors.

From these propositions is derived the expression for the force acting on a straight conductor lying in a uniform magnetic field. This is a very special application, but it is perhaps the most common one. Ampère's laws give as the equation for the force, F, acting on a conductor of length l centimeters lying at right angles to a field of intensity f,

$$F = ilf.$$

The lack of any simple means of measuring directly the force acting on the conductor in this case led to the construction of the apparatus herein described.

The apparatus also serves well to illustrate the basis on which we construct our definition of the absolute electromagnetic unit of current.

On account of the smallness of the strength of the earth's field, either a very large current must be used with it, to produce an effect of convenient magnitude to measure, or else delicate means of measurement must be employed. To avoid these difficulties, a field is obtained by using a C-shaped cast-iron cylinder as the core of an electromagnet. The length of the cylinder used is 9.5 cm.; its inside diameter, 7.7 cm.; and its outside diameter, 11.4 cm. The width of the air gap

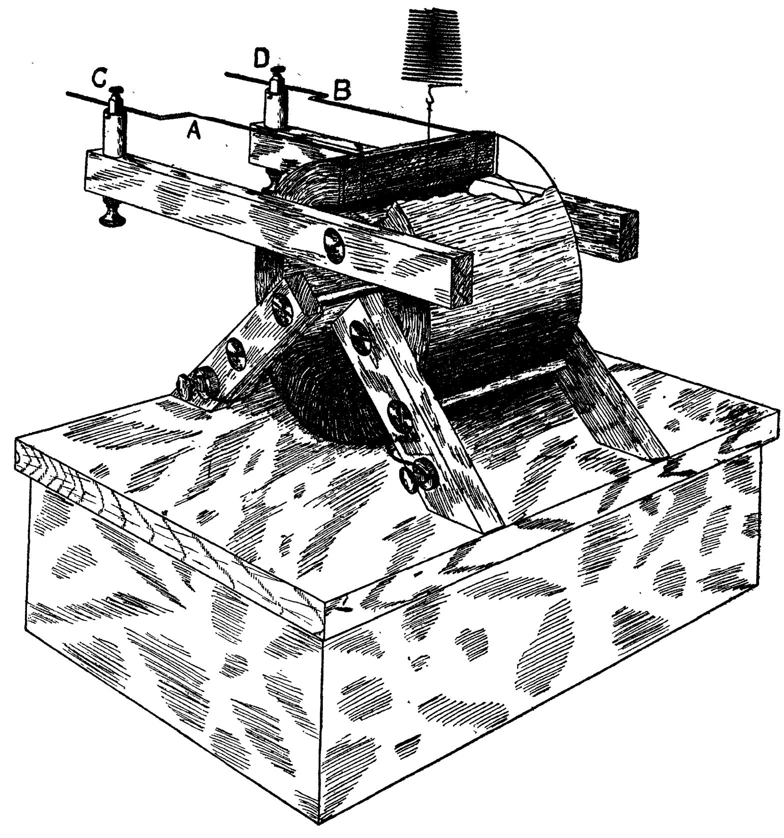

Fig. 1.

is 4.0 mm. The magnetizing coil has 400 turns of number 20 copper wire.

The method of mounting the electromagnet and conductor is shown in Fig. 1. The conductor AB, which lies in the air gap is bent up, then back, and clamped in two binding posts, C and D, through which steel pins are driven. The lower ends of these posts dip into mercury cups. The steel pins form a free axis of rotation.

The force acting on the conductor is measured by the elongation produced in the spring of a balance of the Linebarger type. In taking the observations given below, the magnetizing current and the current in the conductor were measured with two Weston portable ammeters.

Observations were first taken to show that when the field is constant, the force on a given conductor is proportional to the current flowing through it. In taking the observations given in Table I., a wire extending through the slot, then bent straight back and clamped in the binding posts was used. The conductor was therefore not in a uniform field. The table gives the first set of observations taken.

TABLE I.

Current in Conductor	Zero Reading of Balance	Elongation Reading	Elongation	Elongation Current
amperes	cm.	cm.	cm.	
2.045	9.79	16.97	7.18	3.52
2.560	9.75	18.81	9.06	3.54
3.065	9.77	20.63	10.86	3.54
3.560	9.74	22.41	12.67	3.56
4.045	9.80	24.11	14.31	3.54
4.465	9.76	25.80	16.04	3.60
5.000	9.76	27.44	17.68	3.53

Steady current in magnetizing coil, 0.798 amperes.

In taking the next set of observations, Table II., the length of the conductor, as well as the current in it, was varied. To obtain these results, wires of the form shown in Fig. 1 were used. The length of the horizontal part of the wire lying in the slot and measured from center to center of the turned-up ends, was used as the length of the conductor. That this is the "effective" length of the conductor, if Ampere's law is true, may be shown below.

If the force acting on a straight conductor is ilf, then the force acting on an element of the conductor, of length dx, at the bend of the conductor will be equal to the product of four factors, the area of the section of the conductor to the right of dx, the current per unit area, the intensity of the field, and the length dx. Assuming that the current is uniformly distributed throughout the conductor before it reaches the turn and that it becomes uniformly distributed after it passes the turn and before it leaves the air gap, we obtain as the expression for the vertical force acting

TABLE II.

Length of Conductor (l)	Current in Conductor (i)	Zero of Balance	Elongation Reading	Elongation (E)	E/il
cm.	amp.			cm.	
7.70	2.960	3.81	11.97	8.16	0.358
	4.140	4.02	15.36	11.34	0.355
	4.900	4.03	17.48	13.45	0.357
	2.145	4.07	9.93	5.86	0.354
					0.3560
6.06	2.150	7.52	12.10	4.58	0.351
	3.215	7.60	14.48	6.88	0.353
	4.150	7.60	16.46	8.86	0.352
	4.875	7.62	18.00	10.38	0.351
					0.3518
4.96	2.175	6.79	10.57	3.78	0.356
	3.220	6.73	12.44	5.71	0.354
	4.170	6.77	14.14	7.37	0.358
	4.935	6.77	15.44	8.67	0.354
					0.3555

Steady current in magnetizing coil, 0.800 amperes.

on that part of the conductor to the right of the section AB, Fig. 2,

$$\frac{if}{\pi r^2}\int_0^{2r}\left(\pi r^2-\int_0^x 2y\,dx\right)dx,$$

where r is the radius of the conductor. Integration of this expression gives ifr as the

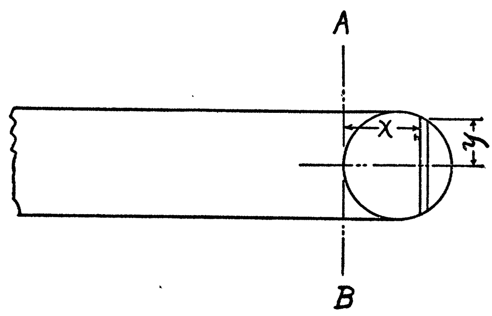

FIG. 2.

force acting on that part of the conductor to the right of AB, or r as the length to be added to the straight part of the conductor.

The third factor in the expression for the force on the conductor is f, the intensity of the magnetic field. This apparatus can be used conveniently for showing the relation between the force and f if a curve is plotted showing the relation between f and the current in the magnetizing coil. To obtain such a curve, a coil, wound on a thin rectangular bobbin which could be slipped into the air gap of the electromagnet, was connected to a ballistic galvanometer. The deflections of the galvanometer when the coil is quickly withdrawn from the air gap being proportional to f, the required curve can be obtained by using such deflections and the corresponding magnetizing currents as coordinates.

The curve obtained will depend on the magnetic history of the ring. If the curve is to be of any use, the initial condition of the iron must be one that can be reproduced. The ring may be entirely demagnetized initially or it may be in the condition in which it is left when a certain fixed magnetizing current has been passed through it. This current should be large enough to magnetize the core quite strongly.

Another curve can be plotted showing the relation between the magnetizing current and the force on the conductor, the current in the conductor and the length of the conductor being constant. If these two curves be plotted to the same axes, it will readily appear that the force is proportional to the intensity of the field.

The results which I have obtained from these curves for the ratio of the field to the force show a larger variation than do the ratios found in Tables I. and II., but with ordinary care the ratio of corresponding ordinates on the two curves will not vary more than three per cent. This seems to be about as great accuracy as may be expected with the apparatus in this present form. The larger part of the error is undoubtedly due to the uncertain variations in the magnetic field.

The apparatus as here described was designed for the use of students of general physics. Its special advantage is the directness with which the force is obtained in terms of quantities already familiar to the student.

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SYRACUSE UNIVERSITY,
March 5, 1907

QUOTATIONS

THE NEW ENGLAND COLLEGE

SOME of the New England college presidents are practically facing the question whether they should not voluntarily limit the number of their students. Within the last ten years, Dartmouth, for example, has nearly doubled in size—an increase due largely to the success of its professional and technical departments. President Hopkins of Williams favors the idea of limitation in the smaller colleges; and there is much to be said for his view, provided that the income of the corporation is sufficient to support an efficient faculty. In colleges like Amherst, Bowdoin, and Williams a first-class education can now be had, even as at the large universities. But there comes a point in the development of a college when the increase in students entails an expenditure out of proportion to the gains by tuition fees. The number of instructors has to be multiplied, and there must be a greater outlay for lecture-rooms and laboratories. Many of the smaller colleges would be helped if the craze for mere numbers could be checked. The energies of the professors could then be concentrated on the instruction of their relatively small classes, they could insist on a higher standard of scholarship, and possibly make the B.A. mean as much as a degree in technology.—*The N. Y. Evening Post.*

NOTES ON ORGANIC CHEMISTRY

ANHYDROUS SULPHOCYANIC ACID

ALTHOUGH numerous salts of sulphocyanic (thiocyanic) acid, HSCN, are known, and some of them are of considerable technical importance, the free acid has, hitherto, never been obtained in a state of purity. Wöhler believed that he had prepared it and Liebig stated that it decomposed with extreme ease. In 1887 P. Klason distilled the aqueous acid and passed the vapor over calcium chloride, heated to 40°, the unabsorbed material was condensed at a low temperature and was thought to consist of the anhydrous sulphocyanic acid, but A. Rosenheim and R. Levy[1] have recently shown that although Klason's

[1] *Ber. d. chem. Ges.*, **40**, 2166 (1907).