predominant to a degree quite unknown in the German university and the body of investigators in them in any one field is too small to create that which is the most stimulating thing in all research—an atmosphere of investigation.

I venture to say that there is not a single American investigator who has occupied one of the tables of the Smithsonian Institution at Naples (in that wonderful research laboratory of the Biological Station) who will not bear me out when I state that the stimulus of research of that institution comes from the contact that is there encouraged between the investigators of all Europe.

Any institution composed only of a number of men with fixed salaries will gradually become conservative and cease to be productive of great results. It is the young men with the spur of ambition and necessity that create new things in science.

Why not recognize this great factor and do for science what West Point has done for the army? Let the Smithsonian Institution start the movement and get together from the various states a hundred picked men who do not want to be taught but each one of whom has an idea of his own that he is anxious to work out in an atmosphere that is stimulating to research, and where he can be in close touch with other minds that are interested in similar lines of work or at least are broad enough to grasp the importance of the problem that he is absorbed in.

Spend all the money necessary in the selection of these men. Organize the machinery by which this selection is done and, if it is advisable, apportion them out among the different states and make the senators responsible for those from their states. Have each applicant present a definite problem to be solved and in addition, by references and examination, if necessary, show his fitness to hold a table in the institution. In addition, appoint a committee that shall make a study of each applicant proposed for admission and let their decision as to the man's fitness for the place be final. Give this committee every facility to study the problem of selecting men who have the sacred fire of the investigator in them.

Have each table fully equipped with all the necessary apparatus and give to each state investigator a sum of money each year that he can live on comfortably.

Fix the terms of occupancy of the tables at two years, but give to the board of directors the right to retain for two years longer such men as in their estimation have shown marked ability or whose researches are of sufficient promise though not completed to warrant a longer stay.

Get men of prominence in the various lines of research as permanent investigators, with the understanding that they are not to be teachers but will be given the means with which to carry on their investigations, at the same time imposing on them the work of keeping up the spirit of the institution, and assisting in the details of its administration by means of board meetings just as colleges are managed.

Divorce from the Smithsonian Institution the museum idea. Create a separate office to have charge of the collections and the expositions of applied science and put in this office a man whose tastes are those of an administrator.

Once separate, the Smithsonian Institution proper should become the great national institute of research and to be at its head should be a compliment not only to scientific accomplishment but to one's devotion to the great spirit of discovery.

The man for the head of an institution of research such as I have described would be one preeminent in his line of work but in addition, like the great Ostwald, of Leipzig, a believer in the great value of free laboratory discussion.

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U. S. DEPARTMENT OF AGRICULTURE.

SPECIAL ARTICLES.

A MACHINE FOR COMPOUNDING SINE CURVES.[1]

THE instrument about to be described was designed primarily for use in a class in alternating currents. It has proved itself well

[1] Presented before the American Physical Society, February 24, 1906.

adapted for this purpose, and might perhaps also be employed to advantage in illustrating some of the wave-forms that occur in other branches of physics. It does not compound simultaneously a large number of curves of different periods, as does the machine of harmonic, and can be quickly adjusted to give any desired amplitude and phase relation. The curves are large enough to be seen distinctly from all parts of a good-sized lecture room. The whole instrument is very compact and easily portable. Much praise is due to

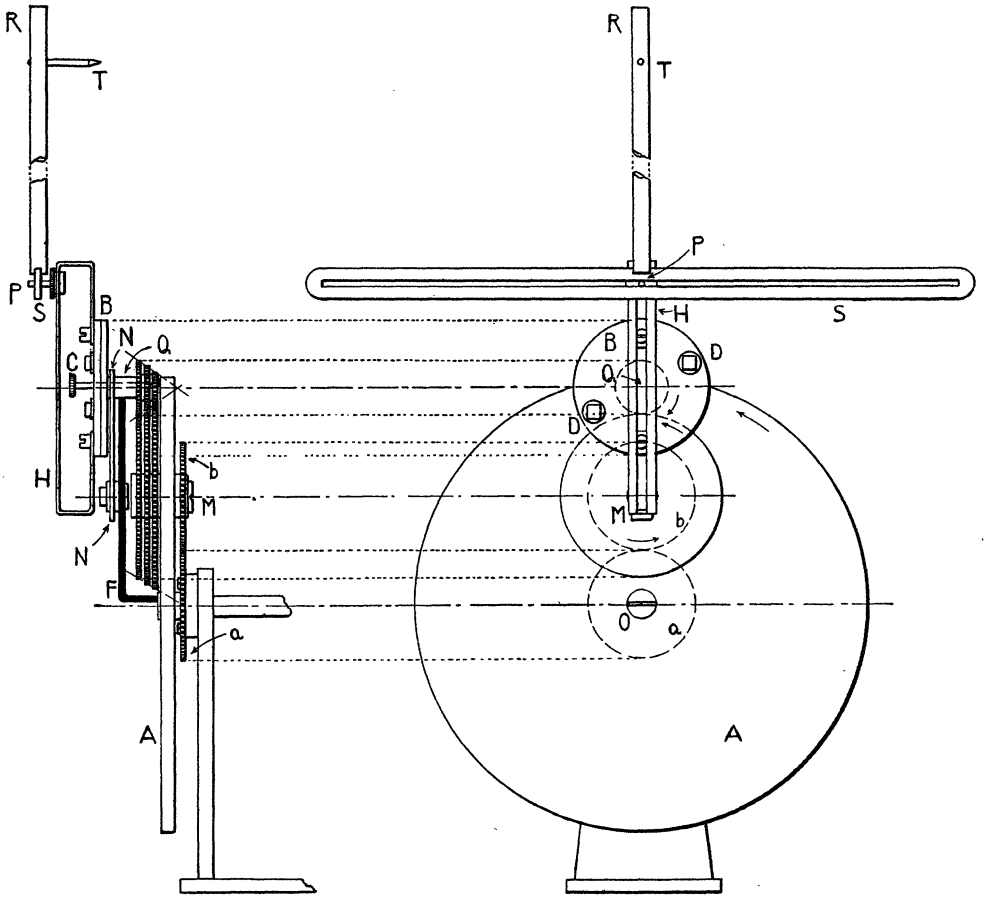

Fig. 1.

Mach,[2] Michelson's harmonic analyzer,[3] or the arrangement recently devised by Lord Rayleigh for illustrating the nature of white light.[4] It is, however, capable of drawing accurately the resultant of a fundamental sine curve and either its second, third or fifth

[2] *Pogg. Ann.*, 129, p. 464, 1866.

[3] A brief description of the harmonic analyzer is given in Michelson's 'Light Waves and their Uses.'

[4] *Phil. Mag.*, 11, p. 127, January, 1906.

Mr. F. H. J. Newton, the college mechanician, for the skill with which he has carried out the details of construction.

Fig. 1 shows front and side elevations of the instrument, somewhat simplified for clearness. Fig. 2 is from a photograph of the entire instrument. The lettering is identical in both figures.

A hard rubber disc *A* 21 cm. in diameter, mounted at the end of a horizontal shaft, carries a smaller disc *B*, to which a short pin

P is attached. P fits in a slot in a movable horizontal bar S, to which is rigidly attached the vertical rod R. The latter slides up and down inside a slotted tube U (Fig. 2), so that the vertical component of the motion of P is transmitted to a pencil mounted on R at T. A large gear wheel G mounted on the shaft O (Fig. 2) engages in a rack on the under

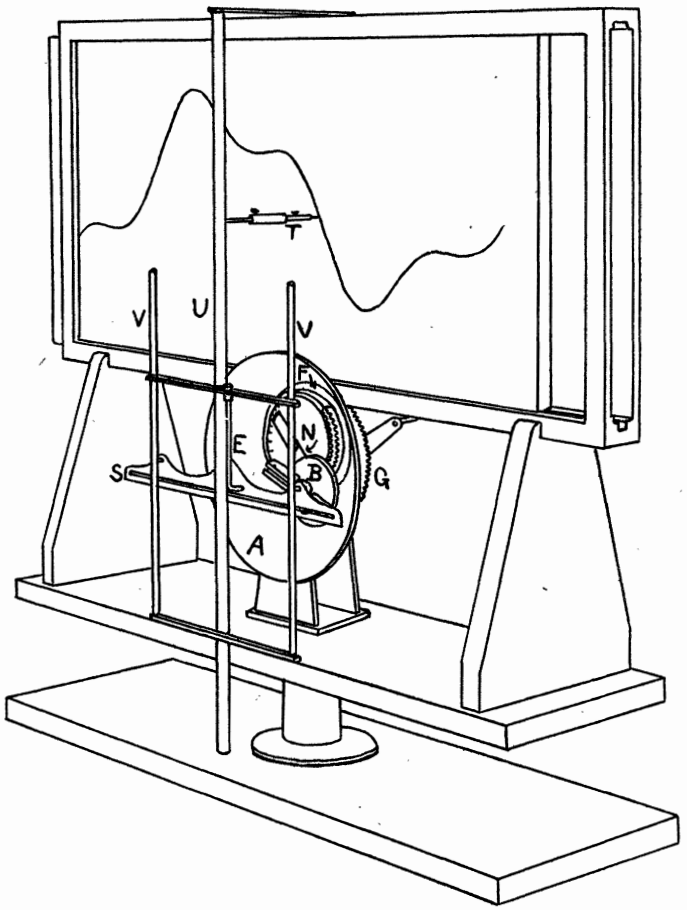

FIG. 2.

edge of a vertical board, 66 x 31 cm., to which a sheet of paper is fastened. When the shaft is turned by means of a crank, the board is advanced horizontally between wooden guides and the pencil T traces a curve, whose form depends upon the setting of the discs A and B.

By means of gearing to be described presently, the disc B can be made to rotate either two, three or five times for each revolution of A. If the pin P is set so as to lie in the axis Q, around which B rotates, the fundamental curve of amplitude OQ will be traced. For any other position of P, the second, third or fifth harmonic, of amplitude PQ, is superposed upon the fundamental curve. When the disc B is shifted so as to make the distance OQ equal to zero, the harmonic alone is drawn. Any phase relation can be produced between the fundamental curve and its harmonic.

Fig. 1 shows the train of gear wheels that rotate the disc B. a represents a stationary two-inch (5.08 cm. diameter) gear wheel screwed to the bearing through which the shaft O passes. The teeth of this wheel engage those of a second gear wheel b of the

same size, which is rigidly attached to a short shaft M passing through the disc A. At the other side of A are mounted side by side on this shaft three gear wheels, of pitch diameters 7.62, 8.12 and 8.71 cm., respectively. These engage three smaller wheels, of diameters 2.54, 2.03 and 1.45 cm., which are mounted loosely on the shaft Q of the disc B. A pin C fitting in a longitudinal slot cut in this shaft can be thrust in or pulled out, so as to lock any one of the three small gears on to the shaft. In the front elevation (Fig. 1) only one of the three pairs of gears is represented. When the disc A is rotated, the gear b rolls around on a, and, as is seen from the relative diameters of the two sets of gears mentioned above, the disc B is caused to rotate two, three or five times for each turn of A, according to the setting of pin C.

The shaft Q is carried by the arm NN, which can be swung around M as a center and clamped so as to give to the distance OQ any desired value from zero to twice OM. NN is clamped to the brass plate F, which is screwed to the disc A and is so shaped as to bridge over the gear wheels, bringing the axis of NN in line with the axis M. The plate F is partly visible in Fig. 2. It will be noticed that the sizes of the three concentric gears on shaft Q, and of the three corresponding gears on shaft M, are such that MQ is 5.08 cm., the same as OM. The period of the fundamental curve is represented by a distance of 48 cm. on the paper.

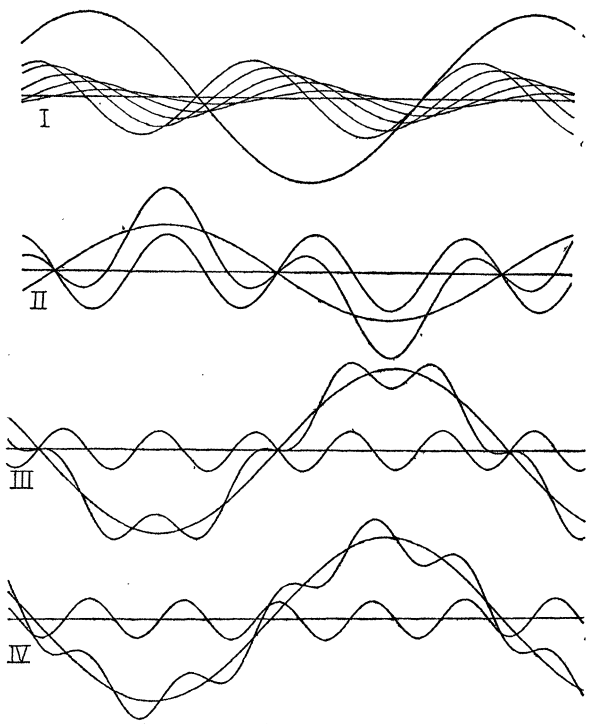

Fig. 3.

The pin P, instead of being attached directly to the disc B, is held by a small brass block that slides in a groove on the bridge H which spans the disc. Space is left below this bridge for the pin that locks the gears on shaft Q, and the pin P can readily be clamped so as to give to the harmonic wave any amplitude up to 8 cm. The bridge is provided with a set of graduations. To adjust the phase of the harmonic, it is only necessary to loosen

two screws *DD* on the disc *B*, when the bridge can be swung around on *Q* as a center as far as is desired.

To aid in setting the amplitude of the fundamental curve, a series of graduations is provided on a disc carried by the swinging arm *N*, which enables the distance *OQ* to be read off directly (see Fig. 2). Before a curve is drawn, the disc *A* may be rotated so as to begin with any desired phase of the fundamental. Great care has been taken to avoid unnecessary backlash on the part of the various gears, so that the curves are practically free from any irregularity due to this cause.

The two side posts marked *V* in Fig. 2 serve as guides to keep the bar *S* parallel to the paper. The bent rod *E* can be swung around so as to hold *S* in its mean position. A base-line can then be drawn by simply sliding the board along without rotating the discs. In drawing curves before a class, the lecturer stands behind the instrument. For ease in making adjustments, the machine is mounted on a swivel, so that it can be rotated about a vertical axis, adjusted and turned to face the class again. A pencil of soft graphite is most convenient for drawing curves, though a pen can be used. The curves reproduced in Fig. 3 were obtained directly with pens made from glass tubing.

In Fig. 3 I. represents a group of second harmonics of various amplitudes and phases. Any one of these might, of course, be combined with the fundamental curve. In II. the third harmonic is drawn alone, then compounded with the fundamental; and in III. and IV. similar curves for the fifth harmonic are seen.

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QUOTATIONS.

THE TEACHING PROFESSION.

No greater evil could befall the educational system of this country than that of becoming definitely crystallized into the type of organization exemplified by mercantile and corporate enterprise. The evil is imminent, and sometimes seems inevitable, so pervasive are the influences that tend to make educational administration a matter of business, and so persuasive is the argument from analogy when addressed to ears predisposed by every familiar association to accept its validity. Material and commercial modes of thinking prevail so largely in our national consciousness, and impose themselves so masterfully upon our narrowed imagination, that most people are ready to accept without hesitation their extension into the domain of our intellectual concerns, particularly into that of the great concern of education. Why, it is naïvely asked, why should not the methods that we apply with such pronounced success to the management of a bank or a railway prove equally efficient in the management of a system of schools or a university? Why should there not result from their employment here the same sort of efficiency that results from their employment elsewhere? Why should not the educational fruits of autocratic control, centralized administration and the hierarchical gradation of responsibility and authority be similar to their fruits in the field of commercial activity?

These questions are not difficult to answer, but it is difficult to frame the answer in terms that the successful man of affairs will find intelligible. The subject is one that he approaches with a prejudiced mind, although his bias is not so much due to perversity as to sheer inability to realize the fundamental nature of the question at issue. He is so fixed in the commercial way of looking at organized enterprise that he can not so shift his bearings as to occupy, even temporarily, the professional point of view. Now the idea of professionalism lies at the very core of educational endeavor, and whoever engages in educational work fails of his purpose in just so far as he fails to assert the inherent prerogatives of his calling. He becomes a hireling, in fact if not in name, when he suffers, unprotesting, the deprivation of all initiative, and contentedly plays the part of a cog in a mechanism whose motions are controlled from without. Yet the tendency in our country is to-day strongly set toward the recognition of this devitalized system of educational activity as suitable and praiseworthy, and the