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"THE PRESENT STATUS OF HIGH SCHOOL PHYSICS."

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In considering this subject, the present status of high school physics, it seems fitting and proper that both high school and college teacher should participate. It has been said that the high school resents interference on the part of university. This may be true, and indeed it is perfectly natural, so far as *interference* is concerned, when it comes to the question of *coöperation*, however, the case is entirely different. In matters that relate to educational advancement, high school and university should stand together, for there never was a time when the interests of the one were so closely linked with that of the other as is the case to-day; hence it will not be out of place for a representative of a university to discuss a topic which bears directly upon the high school.

We are all more or less well acquainted with the history of the development of high school physics—acquainted with its remarkable advance in recent years; its elaborate methods; its satisfying-disappointing results. Also are we acquainted with the fact that there is today an unrest among physics teachers which is becoming more and more pronounced—an agitation which manifests itself in public discussion and private debate; in the resolutions of associations and the reports of committees; and especially in a plethora of elementary texts each heralded, in its preface, as a sure antidote for the ills, pedagogic and otherwise, which have fallen upon us. That there is such an agitation, deep and wide spread, no one acquainted with the facts will deny; just what this agitation for reform signifies, however, few seem to know.

In discussing this subject, I have no pet method to exploit; no special plea to make. I wish to take a philosophical rather than a pedagogical view of the subject. I propose to sum up the facts

†Address delivered before the Physics Section of the Central Association at its St. Louis meeting, November 30, 1907.

of the present situation; I desire to review the causes which have given rise to this so called "New Movement" for reform; and in conclusion, I wish to point out certain principles which should govern a reform, if reform be necessary.

Now, a careful study of the whole situation—that is to say a study of the various phases of this agitation which have led up to what has generally come to be known as the "New Movement"—reveals some very interesting and at the same time some exceedingly suggestive facts.

In the first place for example, this state of unrest is of comparatively recent origin. To appreciate the force of this remark one needs but to recall that it is not more than a dozen years since high school physics plumed itself as being one of the elect, and its complacency was equalled only by the envy with which it was regarded by certain other high school studies.

And second, that this subject has aroused an unusual interest, not only among high school teachers but among college men as well, is evidenced by the number and warmth of the discussions which have occurred within the past year or two. For example, in one of our educational journals—the most prominent that represents the interests of our high schools—there recently appeared in five consecutive numbers no less than seven articles bearing on some phase of the subject of reform in the teaching of high school physics; and the greater number of these articles were characterized by a tone so dogmatic as to be truly representative of the school-master spirit. Indeed in this whole discussion the dominant note has not been one of temperance. For example, as an illustration of the tendency of a good many writers to make extreme and extravagant statements in defending their position, I quote the words of a prominent eastern educator who says, in speaking of the relation of mathematics to physics, "Some physics teachers congratulate themselves when they have crowded out of their classes the great majority, and have left only the mathematically elect, and they avow it to be their purpose to kill enthusiasm wherever they find it." And again, the same writer in a recent number of *SCHOOL SCIENCE AND MATHEMATICS* says, in referring to the relation of certain college methods to college students, "These students have a starvation course in measurements called physics. Their tutors having just passed through the same course with excessive specialization are suspicious of that expansive thing called culture. They effect to despise not only the pub-

lic but all departments of learning other than their own. They surpass the theologians in narrowing down their lines of orthodoxy . . . their standards would outclass Davy, Faraday, Tyndall, Pasteur, Humbolt, Maxwell, Huxley, Agassiz, Cooke, Shaler and the like, for these men all preached the doctrine that science is good for culture and should be given to all." And then, as if to cap the climax, he continues, "The influence of the college in all departments, classical as well as scientific, is toward driving culture out of the schools."

This is a terrific indictment, and if it be true, we had better close up our colleges and quit teaching physics.

Again, in the third place, these discussions reveal the fact that physics teachers in general are entirely at sea as to what constitutes a fundamental method of procedure. When it comes to the three great pedagogical questions—the What, the When and the How of the subject, our leaders both in high school and college physics, seem to be able to agree on only one thing, *and that is that they disagree*. For example, one of the most prominent teachers of high school physics in my own state (Michigan) says in a pamphlet, "Let us understand at the outset that physics is not phenomenology." Then I turn to a recent number of the Educational Review and read the words of an equally prominent eastern teacher who says, "High school physics should be mainly phenomenology." One college professor said at a recent state meeting, "In the matter of individual laboratory work, I consider the *quantitative* exercise only as of value;" another, already quoted, refers to the quantitative exercise as a "starvation" course in physics. And again, a recent writer advocates a year's preliminary training in general science as a preparation of the regular course in physics. This is followed by another writer in the same journal who counters by saying, "I look upon this proposed preliminary course as a dangerous proposition." But these, you say, are isolated examples. I will give, then, one that is not an isolated example—one that may be considered a sort of concentrated extract of the general opinion with reference to fundamental methods in elementary physics. I refer to the recent report of the National Commission on the Teaching of Elementary Physics. This commission in summarizing the results of its labors—a work involving an enormous correspondence and including reports from teachers of high schools, normal schools, colleges, and universities of nearly every state in the Union—in Circular V makes the

following remarkable and extremely significant statement: "Thus far the only conclusion that can be drawn is that we teachers of physics are far from united *on any one point*."

And finally, a definite, organized effort is now being made to bring order out of an apparent chaos of conflicting opinions. I have already referred to the National Commission on the Teaching of Elementary Physics.¹ This commission is composed at present of forty-eight members, chosen as representatives of twelve state and inter-state associations. Its object, as stated in Circular IV, is two-fold. "First, to find out just what is wanted by the teachers as a whole for the improvement of physics; and second, having found this out, to attempt to secure it for them." Its labors thus far have been confined mainly to the preparation and publication of a series of circulars bearing on a proposed new syllabus, the object of which is to reform, systematize, and unify prevailing methods of teaching elementary physics.

Personally, I am very much interested in this so called "New Movement," and in my judgment its most significant feature is the proposed syllabus. I do not look for great things from this source directly, for I think the syllabus is more of a symptom than a remedy, but indirectly it will no doubt play an important part in that it will serve as a bone of contention—that is to say, it will precipitate a row. The storm has long been gathering and is now ready to break, and if this syllabus should prove to be the means of clarifying the atmosphere, it will have served no small purpose.

So much then for the present situation. Let us now consider some of the causes which have brought it about. To read an account of the rise of high school physics to its present high and honorable position is to read very modern history indeed. So young is this member of our educational family that there are many today who can recall nearly every phase of its evolution. High school physics has passed through three distinct stages. It began as a study of the more pronounced phenomena of the outside world. These were the days of the old natural philosophy—phenomenology—beautifully typified by the famous "Fourteen Weeks" science series. Some no doubt, will recall the picture which appeared as a frontispiece in Steele's "Fourteen Weeks in Physics." It was a full page illustration of the leaning tower of

¹C. R. Mann, Secy, University of Chicago.

Pisa and its environs. At the bottom of the page appeared the following account: "In the foreground stands the Leaning Tower. Next to this is the Cathedral. In front is the Baptistry, and back of the Baptistry, the Campo Santo, a cemetery containing sacred soil brought by the Crusaders from the Mount of Olives." Here is something that would delight some of our modern reformers. A course prefaced by such a combination of science and history and theology surely could not be well classified as a "starvation course in physics."

This phenomenology era was followed by what may be called the "inductive stage." Those were the days when the inductive method was the *fad*—both in the realms of science and out. Immature pupils were set to the business of rediscovering laws and manufacturing definitions. The seriousness with which these children went about this task was equaled only by the ingenuity they displayed in guessing before hand just what sort of a law was demanded, or what brand of definition was most acceptable. In this respect they did in elementary science precisely what they did in answer to the queries of the child study enthusiast of a few years ago—they gave as nearly as possible just what they thought was expected of them. They were interested to be sure, but in a good many instances it is to be feared that this interest was of the same brand as that of the small boy, who was noted for his inattention. One day his interest was aroused, however. He watched his teacher's face intently as she talked. At the close of the exercise she asked him what he had learned. He responded, "Teacher, your upper jaw hasn't moved once this afternoon."

The third stage followed, partly as a reaction from the methods just described, and partly as a natural consequence of the great impetus given to high school physics by the famous Report of the Committee of Ten. This report, together with the new standard of entrance requirements adopted by Harvard and other leading universities about this time, gave an enormous stimulus to the subject of elementary physics and at the same time did much to shape the policy of its methods up to the present day. In the Report of the Committee of Ten, three things were directly or indirectly emphasized. First, the value of physics as a high school study; second, the importance of the quantitative side of laboratory work; and third, the necessity of securing college trained teachers. Physics at once became one of the most important courses of the high school curriculum. The number of students pursuing this sub-

ject was large; teachers were enthusiastic; and laboratories and laboratory exercises grew and multiplied. The pendulum of favor in things that related to laboratory methods swung sharply from the purely qualitative exercises of the old school to the quantitative, of the new. Now, add to this the fact that a large number of the teachers of physics were fresh from college where their training in science had been dominated to a certain extent by mathematics and by quantitative methods, and it is not difficult to guess the direction given to elementary science teaching. Classroom work became more and more strenuous; and the laboratory exercise daily demanded larger things of the pupil. In a word high school physics became more difficult than that presented by the majority of old time college courses.

Now I do not pretend to say that every teacher of elementary physics carried matters to such an extreme. There were teachers—many of them—who were not carried off their feet by the wave of popularity which had swept their subject into such high public favor—teachers who tempered their teaching by moderation and good judgment. In speaking, however, of the general movement, one is forced to admit that high school physics was not made a bed of roses upon which the incompetent or indolent could recline with ease. Elementary physics demanded serious consideration on the part of the pupil. No student began this course with the idea of having a play spell. It involved the learning of lessons, the working of problems, the doing of experiments, and the writing up of note books, and all this took time—a good deal of time. As a consequence, therefore, teachers of other subjects began to complain that physics was taking more than its share of the student's time. This complaint was not heeded at first by the physics teachers. Indeed it is a rare thing to find a case in which a teacher of any subject does heed such a complaint. The matter, however, did not rest here. Complaint began to come from another quarter, and the agitation, started by teachers of other high school subjects, began to assume more formidable proportions. Superintendents had been appealed to, but at first they were slow to act. Soon however, their sensitive ears became aware of a rumbling sound more fearful than that of faultfinding teachers—namely, the voice of protest of school patrons—parents whose sons and daughters—principally the latter, had found physics a stumbling block in the way of graduation honors. Now, if

there is one thing more than another that will "energize" a superintendent, it is the voice of protest of a belligerent parent, and this voice had become so pronounced that a good many of the aforesaid superintendents made haste to espouse the cause of those who were demanding a return to the good old days of easier lessons and qualitative exercises. I am not finding fault with the superintendents' attitude in this matter; neither am I trying to excuse the over enthusiastic teachers of physics. I am simply stating the facts.

At this stage of the agitation a new factor began to manifest itself—a factor hitherto unnoticed, and even today not fully appreciated. This was a force that has played, and if all signs fail not, is destined to play an important, though unfortunate, role in our educational scheme. I refer to the kindergarten movement. I hasten to say, before proceeding further, that I have no fault to find with the kindergarten movement as such, when confined to the kindergarten department. The kindergarten has proved a blessing to childhood. It has taken from the primary grades the lock-step discipline of the prison, and has substituted the discipline of love; it has taken away from the lower grades paralyzing inactivity, and has substituted directed work and joyous play.

Notwithstanding all this, however, the kindergarten has not probed an unmixed blessing. Before such be the case, two conditions must be imposed upon it. The first is that its administration be placed in the hands of skillful teachers—true kindergarteners; and the second, that its methods be confined within proper limits—and these limits, in my opinion, most emphatically do not include the high school. Up to the present, these conditions have not been realized. Kindergarten methods were at first confined to the primary department. They gradually worked upward through the intermediate grades, and today these same methods are beginning to manifest themselves in the high school. It is the opinion of an increasingly large number of teachers that our high school work shows unmistakable signs of this influence, both in the character of the instruction given and also in that of the product turned out. *The tendency of the times seems to be toward making everything interesting and easy for the child.* And it is significant to observe in this connection, what a large number of high school pupils have come to consider the terms *interesting* and *easy* as synonymous expressions. Now, no

one in his right senses will object to making a subject interesting, nor yet to making it reasonably easy—that is, as easy as the nature of the subject will permit; but, on the other hand, when it comes to trimming every subject, irrespective of its nature, with reference to making it *interesting* and *easy*, it is neither good pedagogy nor good sense.

It thus appears that this agitation is a resultant, so to speak, of several forces. It originated in a protest by teachers; it was augmented by the complaint of parents; and of late it has been mightily stimulated by the sweeping indictment of those disciples of Froebel who claim that high school physics is too difficult; that it lacks interest; and that it is devoid of culture value. Then to summarize further, the whole agitation is traceable to two causes. First, faulty methods on the part of teachers of physics; and second, faulty ideals on the part of would be reformers.

Now comes the question of reform. Teachers of high school physics are today in a ferment. Some are loud in their demands for reform; others are equally strenuous in insisting that no reform is necessary. We must admit that “where there is so much smoke there must be some fire;” where there is so much agitation, there must be some exciting cause. That the prevailing methods of high school physics are above criticism, I do not claim; that they are altogether bad, I will not for a moment admit. In a certain sense physics, no doubt, needs reforming; this, however, is equally true of nearly every other subject. So long as the world moves, a continual readjustment of matters educational, as well as matters economical and political, will be necessary.

In all this business of reforming, however, it is important to keep in mind certain fundamental principles. We are by nature prone to rush to extremes. It has been said that the American possesses two notable characteristics. The first is the long suffering patience with which he endures intolerable conditions; and the second, is the headlong manner with which he goes about reform when once aroused. Therefore if reform in high school physics be necessary, let us go about it “decently and in order.” And, to repeat, let us keep in mind that there are certain laws which should govern every reform. It is of these fundamental principles I now wish to speak.

In the first place, we should consider the *nature* of the subject to be reformed. All high school studies cannot be measured by

the same standard. Some are by their nature easy; some difficult. Algebra, for example, is not an easy subject; Latin is not an easy subject; and physics most assuredly is not an easy subject, and no amount of trimming or doctoring will ever make it an easy subject. Physics deals with the laws of the physical universe. These laws are as they are, and they cannot be changed to suit the whim of every passing faddist or would be reformer. Physics, to repeat, is not an easy subject; it is not an appropriate subject for the kindergarten. If it turns out that the mastery of its elementary laws and principles is too difficult for the modern high school pupil, then throw it out and substitute something easier—nature study, say; but in the name of truth let us call it “nature study” and not “physics.” Some of our would be reformers would reform high school physics in the same way the man reformed his neighbor’s dog. The dog in question had killed some sheep, and the owner of the sheep remonstrated with the owner of the dog, and as a result of the conference it was decided to punish—that is to reform, the dog by cutting off his tail. The man who had lost the sheep agreed to hold the dog by the tail while the owner wielded the axe. As the weapon descended, the man suddenly jerked the dog backward, *and his tail was cut off just behind his ears*. Thus would they deal with physics, if one may judge of future actions by certain present recommendations. They ask us to trim and trim until it would seem that nothing would be left that can be called physics. I repeat, in this matter of reform the nature of the subject demands consideration. If we are to teach physics, let it be physics.

But what is “Physics”? exclaim both conservative and radical. I am perfectly well aware that the key to the whole situation lies in our definition of physics. This whole question of reform hinges upon the interpretation put upon this word. Personally I have very definite ideas with regard to the meaning which should be attached to the word physics, as applied to a high school course. High school physics should concern itself primarily with a study of the fundamental laws of the subject. These laws should furnish the skeleton—the framework of the course. Round out the structure with important facts; ornament it, if you please, with interesting illustrations; show the relation of part to part by means of the mathematical equation; get it into the experience of the student by means of labora-

tory work. But after all, let us not forget that the law is the important thing. Not that the mere learning and reciting of laws is of any great importance. The value lies in the mastery of the law—in the acquisition of a “realizing sense” of its significance. A student’s head may be full of facts and illustrations and, other things, yet he may know very little physics. When he is confronted with a question concerning physics, his attitude of mind should not lead him to inquire, “Where have I seen an answer to this question?” but rather, “What physical law governs the case?”

The laws of elementary physics are not so numerous as to seriously burden the student of average ability. Some of them are interesting and some are uninteresting, depending a good deal on the experience and view point of the pupil. Nevertheless, interesting or not, the student who has completed a course in elementary physics should be acquainted with these fundamental laws and principles; he should know their meaning and their application to the ordinary affairs of life. This, then, to repeat, is my personal notion of the nature and function of the high school physics. Let us make it as interesting as possible; let us make it as easy as possible, but let us not sacrifice the subject merely for the sake of making it easy—for the sake of conforming to the general tendency of the day which demands that everything be made easy.

Now this whole question of making physics easy centers about two points—the first is the use of the mathematical equation in elementary physics; and the second is the quantitative exercise in laboratory work.

I am not an extremist with respect to these two factors. I have never been in the habit of taking off my hat whenever a mathematical equation, for example, presented itself. I think that in some cases too much has been made of the mathematical equation. Some teachers of elementary physics have carried its use to an extreme. But is the fact that a few teachers have misused the equation a sound argument for throwing it out altogether? I know of no method of showing the relationship of one physical quantity to another that is so elegant and so usable as this same much abused mathematical equation. If we can represent, for instance, the relation of force to mass and acceleration, or any other set of relations, by the use of a simple mathematical equation, let us by all means have it, for surely no better opportunity will ever

come to the high school student for learning the real significance of the mathematical equation than that presented by the simple equations of elementary physics.

And what I have just said with respect to the use of mathematics in elementary physics, applies in a general way to that other disturber of the peace—the *quantitative* exercise. What oceans of ink have been spilt in discussing the relative merits of qualitative and quantitative laboratory work. The fact is that both forms of exercise have much to commend them; yet neither is perfect.

The qualitative exercise, for example, presents the subject to the student “in the large;” it appeals to his imagination; it arouses his interest. Hence the wise teacher will make use of this form of exercise, to a certain extent. It does not follow, however, that he should adopt it to the exclusion of all other methods. Every experienced teacher knows how readily the purely qualitative exercise degenerates into mere entertainment, in which the pupil fritters away his time in playing at laboratory work.

On the other hand the quantitative exercise can easily be made too strenuous and too exacting for high school pupils. Perhaps in no other department of elementary physics have matters been carried to such an extreme by over enthusiastic instructors, as in this particular line. Yet this does not offer a valid argument that the quantitative exercise should be discarded. As in the case of the mathematical equation, elimination would not necessarily mean reform. While I have no patience with those teachers who speak of quantitative work as if there were something sacred about it, yet I am persuaded that the backbone of a laboratory course should consist of just such work. For giving point, and direction, and definiteness to laboratory work I know of nothing so valuable as an exercise involving some sort of a measurement.

I find by actual investigation that our most successful teachers of high school physics are using *both* methods. They are adopting from each that which best suits the particular needs of their classes and the conditions under which they work.

And in this connection it will be pertinent to say that what high school physics needs today more than reformed methods, and reformed texts, and reformed manuals is the competent teacher—the teacher who has academic training and native common sense. These teachers who bring discredit upon physics belong to three

classes. First, the teacher who attempts to use university methods with high school pupils; second, the teacher who doesn't know his subject; and third, the teacher who thinks he knows it all. From these three abominations may our schools be delivered, and especially from the last. Colonel Parker was entirely right when he said that the nearest approximation to absolute rest in the universe is the mind of the teacher who has *the* method and is content therewith.

And as a last word with respect to proposed reforms, I speak of the child—make a plea for the child. Let us never forget that all the vast and complex machinery of our school system exists not for the glorification of the teacher, but exists for the child; and if it is true that the tendency of our schools and colleges is to crush out enthusiasm and destroy culture then in Heaven's name let us close our schools. I for one, however, do not believe that the indictment is true. I will admit that there is much in our methods that is not above reproach—large opportunity for reform, for improvement. I also think that the modern child is in danger—in a few cases in danger from over work, but in the great majority of cases from *overindulgence*. I have already referred to the tendency to adopt kindergarten methods in the high school, and this is the overindulgence to which I refer. I have absolutely no patience with the spirit of the modern little Adam who comes to a dead stop in the procession the moment a difficulty presents itself—who refuses to move if the way is not made easy and the topic interesting. I have not forgotten my subject, high school physics. What if physics is not all interesting and easy? What if it does take some self control to master its laws? This is just what the modern child needs. Physics, of all subjects of the high school course, is best suited, because of its very nature, to give mental backbone. The function of an education is three fold: *To increase knowledge; to enrich experience; to give control*. That physics gives the first two, no one will deny; and that it is pre-eminently fitted to give the last—self control, I am sure all will agree. The quality that young America most lacks today, hence most needs, is self control—that control which will enable him to face up to and master a proposition whether it is to his liking or no. Has it ever occurred to you that 74 per cent. of all the men who today hold prominent and important positions in this country came from the farm. Not from the city with its magnificent

schools, but from the farm. What is there about the farm that makes masterly men? Is it the clear sky and the song of birds, and all of that? The success of the farm boy comes from the magnificent self control—the self mastery, which farm life gives—the ability to work hard and persistently at a task whether he likes it or not. There may be other factors—no doubt there are, but self control is the key that opens to the country boy the doors of success. And this is one of the great lessons that our schools should teach—the lesson of self mastery, and I repeat, it is one of the qualities that high school physics is preeminently fitted to give, provided we do not reform it beyond recognition or possible use.

THEORIES OF BIRD MIGRATION.

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(Continued from the April number.)

The Homesick Theory

Another attempt at an explanation is based upon the fact that in the spring migration birds are returning home to the place where they were born. May it not be then that they are overtaken by a strong desire to revisit their birthplace as the changing seasons duplicate the climatic conditions which existed when they formerly dwelt there? May they not be driven by a kind of home-sickness to fly north to the scenes of their early life? This is a favorite theory with those who are accustomed to endow birds with semi-human attributes upon a sentimental rather than upon any anatomical basis. The theory suffers somewhat when it is remembered that most birds forsake the home they make such strenuous endeavor to revisit, the moment their nesting duties will allow which would hardly be expected if they possessed such an overmastering affection for a particular locality as the homesick theory implies.

The Desire to Disperse Theory

Again, to say that birds have a "desire to disperse" in the spring of the year, as Dixon suggests, simply begs the question as to what actually causes the dispersal.

The Nestling Food Theory

Alfred Russel Wallace, whose biological opinions are certainly entitled to respect, points out that the food upon which many nestlings are fed consists of soft bodied insects and other materials that become relatively rare