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ORIGINAL WORK IN AMERICA.

"Americans are the best mechanics in the world." This assertion was recently made by an English scientific journal of high authority, and so true it was that it has remained uncontradicted. Indeed, European journals abound with descriptions of American accomplishment in the domain of applied science, and the detail of American practice and American criteria prevail to a very important extent in European workshops. But though we have worked this field so persistently and successfully, though we have designed with cunning skill so many devices to lighten the labors and increase the convenience of the human family, much of the credit belongs to the old world, for it was there the laws were discovered or rather interpreted upon which these later applications are based. That investigation in pure science has been sadly neglected here in the past is a matter of record. Perhaps there are Faradays and Davys and Oersteds among us, but they have not come to the surface. Such men labor for the love of science; we have been after dollars.

That there are keen and well prepared minds and cunning observers among us, no one will doubt who has listened to the discussions of some of our scientific bodies, notably the National Electric Light Association. Many look to the universities for discoveries in pure science, and with a view to discover what original work, if any, is being done among them the SCIENTIFIC AMERICAN recently sent a representative. Following is the result of his investigations, the same being as nearly as possible in the language of the scientific men interviewed:

Dr. Josiah P. Cooke, Erving Professor of Chemistry and Director of the Chemical Laboratory, at Harvard, said: The investigations in chemistry conducted during the present year are largely continuations of those of last year; but for obvious reasons we are not yet in a position to judge fully of the results. Under the direction of Prof. Jackson, researches are being conducted in several different subjects. Among these are the study of the reaction between sodium maloric ester and tribromtrinitrobenzol, and also work on the new compounds made by this action. Some study has also been made of the products of the action of sodium acetacetic acid upon tribromdinitrobenzol. A study is also being made of the reaction between sodium maloric ester and the latter acid; also a research on tetrabromdinitrobenzol, with particular reference to its action with aniline and sodium maloric ester. Under Prof. Jackson's supervision, also, three seniors of the college carried on a series of experiments in aromatic compounds, whereby several new compounds were discovered, and the constitution of some old ones determined.

The investigation of chlorpyromucic acids was continued by Prof. Hill and a new dichlorpyromucic acid was discovered, whose constitution has not yet been ascertained. It is worthy of notice, however, that this is the first representative of a class of disubstituted pyromucic acids which must be either structurally isomeric with the two forms formerly observed or geometrically isomeric with one of them.

By experiments conducted under the direction of Prof. Hill upon the so-called dioxymaleic acid, it was found that pure dibrommaleic acid yielded nothing but acetic acid and carbonic dioxide under the conditions described by Bourgoin.

The pyromucic acid used in these investigations was made from a crude furfurol found among the products of the dry distillation of wood. The higher boiling portions of the oil have also been studied, and although the experiments have not yet been completed, the presence has been established of a methylfurfurol boiling at 186° to 187°, which can readily be converted into a methylpyromucic acid by oxidation.

A few years ago, I sought, with the assistance of Dr. T. W. Richards, to determine accurately the ratio between the atomic weights of oxygen and hydrogen, with the view of testing the hypothesis that the atomic weights are in many cases the exact multiples of that of hydrogen.

In the course of this investigation, the glass globe holding the gas contracted when exhausted, producing an unexpected correction, which so greatly reduced the value of the atomic weight of oxygen below that previously obtained as to suggest the idea that in former experiments this correction had been compensated for by some constant error still undetected. Owing to the fact that the atomic weight of oxygen referred to hydrogen must have, very nearly, the same value as the specific gravity of oxygen gas referred to hydrogen gas, it seemed advisable to redetermine this last constant by a process not involving the exhaustion of the globe in which the gases were weighed.

I devised a method for this purpose, and I have been engaged this year in working out the details which the new method involved. This work has resulted in verification of the low value of the atomic weight of oxygen previously obtained.

A series of interesting observations were conducted by Dr. O. W. Huntington, on certain features of crystalline growth, which bear an important relation to the subject of the origin of meteoric bodies. Previously he had shown that a continuity could be traced between ordinary octahedral and so-called cubic irons, and this led to the inference that both had the same structure, and that they differed only in having a more or less coarse grained structure, depending on the rapidity of the cooling of the originally molten mass. Later observations have confirmed this inference, and it is now evident that while the outer portions of the large Cohahuila meteorites have all the characters heretofore associated with a cubic structure, the interior of these masses is filled with Widmanstattian plates, and when exposed breaks into small octahedral plates. The transition from rapid to slow crystallization is shown on the face of a large slab cut through the center of one of the masses. From these observations it would seem that there is a certain individuality in the masses and that the meteors were launched into space in a molten condition and cooled each by itself.

The above is a brief outline of what has been accomplished at Harvard in the direction of original research in the science of chemistry. And this was accomplished in spite of the requirements in the way of active teaching. Moreover, the cost of the material and apparatus and in some instances of the salaries of private assistants was borne by the teachers conducting the experiments. And in this connection I would say that one of our greatest needs is a small endowment to defray the expenses of chemical investigation. I say it in no boastful mood, but it is nevertheless a fact that among the English-speaking people there is not a single university which can show as good a record. And in Germany, of which so much may be said regarding the encouragement of original research in chemistry, it is at only two or three centers of activity that this record has been greatly surpassed.

The functions of a university are to act as an educator of youth and to serve as a source of knowledge. These functions are mutually dependent yet essentially distinct. Until recently an idea was current that in most departments teaching was the only occupation for which the professors were paid. This idea had its origin in the circumstance that the teachers were mainly supported by the fees of students. I do not for a moment question that in an American college a prime condition of the institution's success is the best of thorough teaching; and that we have not neglected our duty in this respect is evident from the large number of students now studying at our desks.

But the officers of a university should be actuated by a higher spirit than that of a mere pedagogue, and in this respect there has been a noticeable change during the last few years in the attitude of the university toward original research. The value, material and moral, arising from the discovery of truth is universally admitted. Scholars in a university are properly engaged only when searching for abstract truth; that is in searching for truth for truth's sake, rather than for devices for industrial appliances. That this value of pure scientific truth is not appreciated fully in the United States is a lamentable fact; and it is often the case, even in the reading of a paper before a scientific society, that the technical forms in which results are stated are often received with a smile. But the abstract truths of one generation is the practical knowledge of the next.

The magneto-electric machine, a purely philosophical instrument made by Faraday in 1831, has developed into the dynamo of to-day. The discovery by Oersted in 1819, that a needle is deflected by an electric current, became the basis of Wheatstone's telegraph in 1838. And so in chemistry purely theoretical investigations of the products of the distillation of coal tar have created new branches of industry and revolutionized the old arts of dyeing and printing. Undoubtedly, theoretical study is the necessary condition of industrial progress. Oersted, Ampere, and Faraday were the necessary forerunners of Wheatstone, Morse, and Gramme. One hundred years ago Galvani published a description of certain phenomena, which were the first indicators of the mode of energy now known as electricity. And a century hence, when our successors look back on our work of to-day, what will most engage their attention is not the great industrial achievements of which we boast, but the conscientious following out of some mysterious hints of nature, as mysterious as were the twitchings of the frog's legs suspended from an iron balcony in Bologna in the year 1787. The enthusiasm of the true-hearted scientific investigator has also an immediate value. It has an important reflex action on education. Certainly direct teaching has its legitimate place in the details of college discipline, but education is not solely a question of instruction, but fully as much, if not more, a question of enthusiasm.

The highest inspiration can come only from the teacher who is himself a student ever searching for the underlying and vivifying truth at its original sources, which, for the student of science, must be the ever-open book of nature. Compared with this overruling spirit, the number of courses of study is a matter of secondary importance.

If, then, it is true that the function of the university is to serve as a pioneer in original investigation, no cost can be too great which is required to facilitate these studies. But while the colleges of this country have vied with each other to increase the facilities for instruction, they have done almost nothing to encourage the higher work of their professors, and what has been accomplished for science and scholarship is due solely to the untiring efforts of devoted men working under adverse circumstances and against great odds.

A college professor cannot successfully conduct any of this work unless his occupation of teaching leaves him sufficient leisure of energy as well as of time. No original work can be expected of a teacher whose energy has been exhausted in the class-room. Moreover, in conducting scientific investigation, it is all important that the attention should be engrossed with the work. To secure the best result whole days or weeks should be left otherwise unoccupied, and if this object were regarded as of primary importance, the colleges might easily conform their exercises to meet this requirement. On the other hand, however, a limited amount of teaching is a help rather than a drag to the investigator.

But in the distribution of work, a far greater economy of resources might be used than is usual in our colleges. To employ trained veterans to do drill work which could be done equally as well by younger men is as great a waste of skill as it would be to set a cabinet maker to frame a house. If the administration of our colleges relieved their experienced professors from drudgery by transferring elementary instruction to young men, the efficiency of these institutions as sources of knowledge would be greatly augmented. But, even if relieved from the irksome work of elementary instruction, our college professors cannot secure the largest results as producers of knowledge, unless they are provided with the assistance required to carry forward with success the work of investigation. In all departments of experimental science original research involves an immense amount of purely mechanical labor. Mechanical difficulties have to be overcome, and the resources of every art and trade are called into requisition. To those who are accustomed to secure a return proportionate to the labor expended, as in most literary enterprises, such work would be utterly discouraging. We spend days and weeks to find the cause of an anomaly in our results, and discover at last only an impurity in our materials or a leak in our apparatus. Thus it is that the mere physical labor in a chemical experiment becomes so great. As well expect an architect to build with his own hands the house he had planned as to expect the experienced chemist or physicist to do the mechanical work which his investigations require. The productiveness of our universities as centers of thought can never be brought up to the higher interests of the community until provision is made for supplying with necessary assistance those who are capable of directing scientific investigation. We should never have been able to accomplish the work that has been done in our laboratory had we not been able in a more or less irregular or spasmodic way to secure a limited amount of excellent assistance. Some advanced students have been willing to give their labor for such small pecuniary remuneration as will enable them barely to live at the university. This mode of securing assistance is objectionable for several reasons. No dependence can be placed upon it, and the assistance is constantly wanting when most needed. A large university should provide and organize the assistance required by its working professors just as efficiently as it actually does its instruction. Of course, to do this requires endowments. The only department where the endowments are adequate for the purpose is the observatory, and its large contributions to astronomical science is the natural result of the large amount of assistant labor it employs. There are just as large problems in physics and chemistry, and just as important ones for the advancement of knowledge as in astronomy, but these have to wait for the want of such endowments as the older and more popular science readily secures. At this moment there is a very important problem in chemistry which corresponds to the great problem of mapping out the stars, with which so many astronomical observatories are occupied, and that is the determination of the accurate values of the atomic weights. A great deal of work has been done on that problem in our laboratory, and a plan has been devised for carrying forward the investigation, which cannot fail to bind the results obtained into a consistent whole, but the plan lags for want of laborers. Our laboratory has actually no endowments, and the cost of all scientific work, except actual instruction, must be borne by those who seek to extend the boundaries of knowledge.

Some years ago a plan to endow research was drawn up and submitted to the criticism of several prominent men of science in this country. The plan contemplated supporting with large endowments a body of trained experts wholly devoted to scientific investigation, and the interest which it aroused plainly indicated the national importance which was attached to such work. It seems to me that the chief defect of the plan was to connect the endowments with the universities or other existing educational institutions. It is not possible to secure by any system of competition first-class investigators, and endowments distributed on such a basis would lead only to commonplace results. Like the poet, the investigator is born, not made, and the higher educational institutions are the places where such powers are naturally discovered and developed, and they afford the best field for its exercise. I believe that the most effective method of endowing research would be to multiply at the larger universities professorships, with strict limitations as to the amount of teaching that could be required, and with an income sufficient to pay for assistance and defray all other costs of investigation. I should recommend that such professorships be open at large to any one who had special aptitude for investigation.

Another condition of successful investigation is freedom from anxiety in regard to means of support. The divine afflatus is rarely accompanied by wealth, and the investigator must live, and live decently. The average salary of the schoolmasters of the country is better than that of the professorships in most of our colleges, and it seems strange that recruits can be had for such positions; but, in fact, they are eagerly sought, and by a class of noble and devoted men. Students who in our laboratory acquire an enthusiasm in the pursuit of truth will constantly give up every chance of pecuniary gain and take a position where they can devote their life to study, provided only it promises a bare support. Their first question in regard to an opening is not what is the salary, but what are the facilities for investigation. The world would profit from the labor of such men if they were relieved of all pecuniary anxiety.

Large salaries are not expected, indeed are not desirable. It is not best that men should be led into such a career who have not so marked a call that they are willing to sacrifice to it the larger emoluments of professional success.

(Further talks with professors of Harvard and other universities will follow.)

MISCELLANEOUS NOTES.

To what extent may mechanical designs be copied? From a legal standpoint the answer would be: Only up to the point of infringement. But in the current practice in the machinery trades, unless the design be wholly novel, little, if any, objection is made to infringement in the line of improvement. Hammers, saws, chisels, files, and the like are constantly undergoing changes in design; he whose design is improved upon borrowing the improvement, adding something to it, and selling it as his own; another taking it from him by similar means, and so on. A large manufacturer of machinery said to the writer recently: "It doesn't pay to bring suit save where the interference is very clear. Saws and planers and drills and the like have been made time out of mind, their principles having been utilized in a thousand and one ways. Even where one of our draughtsmen leaves us and goes to a rival house, carrying many of our ideas with him to be worked out with close resemblance to our own designs, it scarcely pays to fight. We take the result and make as much improvement as we are enabled to and let it go at that. The machinery trade generally is doing the same, the result being as usual—the man with the longest pole gets the most persimmons."

Too much cavalry, so it is claimed, is a serious defect of the German war establishment. Indeed, a suggestion of reducing the present force of 64,162 troopers and 62,469 horse one-half is now being seriously considered by the general staff. "Cavalry armed with sword and lance, like the uhlan," says a general of division, writing on the subject, "is more likely to encumber an army than to advantage it." He reviews the history of recent wars to prove the utter fatuity of pitting mounted men against infantry, citing the failure of the cavalry at Milaslaw, Wiesenthal, Balaklava, Solferino, Worth, Mars la Tour, Beaumont, etc., to prove his point. His mention of Balaklava, it is evident, refers to the charging of the Light Brigade upon a Russian battery, this having always been regarded as a great blunder, the result of a misunderstanding of orders. On the other hand, the charge of 500 men of the heavy brigade, under Col. Scarlett, was a remarkable triumph for the trooper, but not, however, over infantry. "The improvement in small arms," continues the general, "has led to the abandonment of the old bayonet drill. A man who started at a distance of 1,000 paces to attack an enemy with fixed bayonet would be regarded as a candidate for a lunatic asylum. What, then, of the cavalryman, who offers six times the front to marksmen, who cannot take advantage of the protection afforded by the contour of the country, but who is expected to advance in solid array on an enemy 3,000 paces distant?" He believes it to be the province of cavalry to reconnoiter and force an unestimated enemy to show his strength, and would have wagons carrying infantry to storm fortified places during aggressive reconnoitering. As to opposing cavalry with cavalry, he does not believe in it; insisting that infantry fire is the best physic for charging troopers.

Electricity for passenger service, steam for freight trains. That, so some good authorities declare, will be the apportionment of the rival energies on the railroad of the future. Steam at high speed requires quantities of coal and water, thus largely increasing the weight to be carried, while the wear and tear of the generating apparatus is thought to be almost doubled when continuously forced. With electricity, on the other hand, it is quite otherwise. The faster you go, the greater is the economy over steam. Indeed, as the speed increases the relative value of electric propulsion increases enormously, an expert before a recent meeting of the Institute of Electrical Engineers declaring that at 120 miles an hour it is something like six times more economical than steam. "If," said he, "you can get 90 per cent efficiency out of your electric service and have a frequent service at 20 miles an hour, electric propulsion is even then slightly more economical than steam propulsion." One of the best known electric motor manufacturers recently declared it to be his belief that in the future express trains between populous centers like New York and Philadelphia would consist of two electric cars, to be started every ten minutes, and running at a speed of a mile a minute.

The Electric Transmission of Power.

Switzerland seems to have taken the lead of all countries in adopting the system of electric transmission of power in a large way and for all purposes. Mr. Gasper Kapp, in a recent lecture before the British Society of Arts, gives some most interesting details, including cost, of the principal installations, as follows:

Distance in Miles.	Horse Power Delivered.	Speed of Machines.	Cost in £.			Total Cost.*	Cost per Horse Power.
			Generator.	Motor.	Line.		
						£	£
1·870	85	450	640	560	440	188C	22·2
0·280	195	500	760	680	132	1800	9·7
0 280	51	600	320	280	·60	720	14·1
0·375	90	550	520	480	80	1240	13·8
0·560	71	600	440	400	60	1040	14·6
0·280	40	700	260	240	20	640	16
0·375	75	600	480	440	68	1120	15
0·500	87	500	520	480	100	1260	14·5
1·560	150	600	760	720	330	2050	13·7
0·220	93	450	440	420	232	1270	13·7
6·250	11	900	132	110	480	960	87
2·200	51	600	360	320	300	1140	22·4
0·187	60	900	240	220	18	600	10
5·000	41	750	240	200	344	1020	24·8
3·750	220	600	1040	960	640	2960	13·5
0·002	15	600	112	104	8	252	16·8
0·250	19	700	160	160	20	390	20·5

*This includes regulating apparatus, instruments, posts, insulators, lightning arresters, erection, and supervision.

At the Schaffhausen Spinning Mills a larger plant than any of the above is being erected, to have five turbine wheels of 350 horse power each, of which three are in position and two are in use. Four cables are employed, each having 0·437 of a square inch section, and they are carried on towers across a river span of 336 feet. At the power station there are two dynamos of 300 horse power over-compounded, and there are three motors at the mill, one a twin machine of 380 horse power, and two of 60 horse power in different parts of the premises. The commercial efficiency of the plant at full load is 78 per cent; it is guaranteed to have a capacity of 20 per cent in excess of the normal for 1½ hours; the brushes wear 2,000 hours, and the commutator 20,000 hours. The cost of the installation was $68 per horse power delivered, and the cost of power is $14 per horse power per year at the rope pulley of the turbine.

The Iron Port of the World.

Escanaba is the county seat of Delta County, Michigan. It lies at the foot of the great pine forests, and overlooks Little Bay de Noquet, the headwaters of Green Bay. Five years since it was practically a village in the wilderness. To-day finds it a city with a population of 8,000, lighted by electricity, having a well equipped fire brigade, waterworks with a capacity of 4,000,000 gallons per day, a high school and three other schools, six churches, three newspapers, a railway station where 216 trains arrive and depart daily, and it will shortly have an electric street railway in full work. Its annual retail trade is estimated at $3,000,000, and its wholesale trade, including iron ore, pig iron, lumber, and coal, at about $25,000,000.

According to Mr. Nursey's carefully written report, capable of the fullest verification, Escanaba is the greatest iron port of the world. He tells us that during the navigation season of 1890 it shipped 3,700,000 tons of iron ore, or nearly double that of all the ore ports of Michigan, Wisconsin, and Minnesota combined. Its lumber output amounted to about 120,000,000 feet, while the freight capacity of the vessels entering and clearing from its port exceeded 8,000,000 tons. This compares with the tonnage of the greatest seaports of the world, which are: (1) London, 19,000,000; (2) Liverpool, 14,000,000; (3) New York, 11,000,000; and next comes Escanaba with 8,000,000 tons.