IMPROVEMENTS IN THE STORAGE OF ELECTRICITY.

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It is only within a comparatively recent period that electricity has taken a foremost position for lighting, motive power and general use in chemico-metallurgical operations; still the very great advances which have been made and which are continually in progress have rendered it certain that electricity is the agent of the future, and that the part which it will play in the industrial economy of the world will ever be an increasingly useful and advantageous one. The discovery of the principles of the dynamo by Faraday, and its working out into actual practice by a long series of able inventors, have dispensed with the old and cumbersome methods of the generation of electricity by chemical means, and rendered its production a simple and thoroughly reliable process.

Notwithstanding this, however, the energy is essentially a dynamical one, and the continuance of the current is entirely dependent on the continuous motion of the generating machinery; and hence, whenever the machine stops, the current stops with it. More than this, any fluctuation in the regularity of the power supplied to drive the dynamo produces a more than corresponding fluctuation in the quantity and intensity of the current; and hence it it is necessary to have all the parts of the generating machinery duplicated, which increases the expense of the production of the current. Water power can be stored in reservoirs so that the winter's rain may be made available for summer's drought, and a constant flow of water thus obtained. Gas, which is generated intermittently in retorts, can be stored in suitable holders, and delivered out in regulated quantities throughout any given number of hours; and until it was possible also to store electricity the economical use of it was somewhat restricted, or perhaps it would be better to say that the possibility of its application to a larger number of cases and with more perfect regularity was secured by the method of electrical storage.

It had been noticed in certain experiments with primary chemical batteries that if a current from a battery was sent into another cell, the two elements of which were lead plates in an acid solution, a portion of this energy could be stored up in the elements of this cell, so that when the current was cut off from the charging battery and a connection between the plates of the charged battery completed, a current was obtainable, but flowing in an opposite direction from that in which it had entered the charged battery. This charged battery had its efficiency very much increased by being continuously charged and discharged when the currents sent into it were not so strong as to destroy these effects. The difference, therefore, between a primary battery and an accumulator may be simply stated as follows: In the primary battery the two plates are made of different materials, such as zinc and copper or zinc and platinum, and a current is generated by chemical action upon one of these plates, the other remaining unaffected; whereas in the accumulator both plates are of the same material, namely, lead; and neither of them wastes with the action of the current, the current derived, when the connection is made, being entirely due to the chemical action which has been set up in these plates by the current which was sent into them. It was soon found that, by a proper modification of the elements of the accumulator, the capacity to store the energy could be largely increased, and could also be retained for a considerable period of time without loss. Since the days of Ritter, Planté and Faure, to whom we owe the primary discoveries, very great improvements have been made in these accumulators. The early accumulators, like the early dynamos, were very ineffectual machines, very liable to get out of order, and easily destroyed by local action, and they were very irregular in their power to retain the electric energy; but the improvements which have been introduced into them have done away with many of these difficulties, and the most modern accumulators have an efficiency which but a few years ago would have been considered absolutely impossible.

The earliest form of practical accumulator was devised by Planté, and consisted of two thin sheets of lead, which were separated from each other by a piece of flannel of the same size as the plates. These plates were rolled round in a cylindrical form so as to occupy the least possible space, and then placed in a jar or other suitable vessel containing dilute sulphuric acid. The plates were charged by connecting them respectively with the two poles of a dynamo. The current from the dynamo decomposed the acidulated water, and oxygen was accumulated on one of the plates, and thus a store of chemical energy was provided which could be expended in the generation of an electric current when the charging was complete. The oxygen attached itself to the plate by entering into combination with the lead, thus forming a lead oxide, and the action on the other plate was to remove any oxygen which might be accumulated on the surface of that plate in the form of oxide, and reduce it to a pure metallic form. It will thus be seen that the electric current from the dynamo had accomplished work by tearing asunder the atoms of the acidulated water in which the plates of the accumulator were immersed and storing up the oxygen in combination with the material of one of the plates. A chemical strain is thus induced between the two plates, which increases in intensity as long as the charging current is sent into the acccumulator until a certain point is reached, which point is that at which the whole of the available surface of the oxidized plate has been completely changed into the lead oxide. After that the oxygen is given off from the surface of the plate, and no further storage takes place. When the charging current is taken off and the two poles of the accumulator reconnected, the strain tends to equalize itself, a portion of the oxygen from the oxidized plate passing by electrolitic action to the unoxidized plate until complete chemical equilibrium is restored, when the action ceases. When this process is continued for a length of time, which is necessary, in order that an efficient accumulator may be obtained, this alternate oxidizing and deoxidizing causes the surface of the plates to become more porous, or spongey, and thus it presents a larger surface to the oxidizing agent than would otherwise be the case; and at the same time, the surface of the lead being in a more granular or finer state of division, the alternate oxidization and deoxidization takes place with greater ease and rapidity, and thus not only is the quantity of energy which can be stored greater, but the time required for charging and discharging becomes less. This is a most important matter, because it not only enables a smaller number of cells to be used for the storage of a given quantity of electricity, but it also enables that which is drawn out to be obtained at a more rapid rate, since it is found that the power to receive the charging and to give it out are almost proportional.

The formation of this spongey surface on the plates of the accumulator by the alternating action of an electric current extends over a considerable period of time, and is a most expensive process, because it requires a large expenditure of electric energy to extend the spongey surface to any depth in the plates. To get over this difficulty in the more modern forms of the accumulator, devices were employed to obtain this sensitized surface in a more efficient and cheaper manner, such as dipping plates in oxidizing acids so as to chemically prepare the surface, scoring the plates, corrugating them, or giving them star-like or other sections, so as to present a larger surface for the same weight, filling perforated cylinders or other hollow forms with finely divided lead. The greatest advance, however, was made when it was discovered that by punching holes in the plates so as to give them the form of a collander and filling them up with an acid paste of red lead, or, better still, casting the plates in the form of a grid or grate and filling up the holes in the grid with an acid mixture of red lead for the positive plate and lithage, which is a lower oxide of lead, for the negative plate, plates in this form required much less forming and a much shorter time to charge, retained their charge for a longer period and gave out their discharge with greater regularity and in larger volume. This marked a distinct advance in the storage of electricity, and in the various forms of accumulators which are constructed in this manner very reliable and efficient results have been produced.

They have, however, one disadvantage: if they are either charged or discharged too rapidly a disintegration of the surface of the sensitised portions of the plate occurs. It probably arises from this cause. The acid paste of lead oxide consists of a mechanical aggregation of molecules of lead oxide, which are neither perfectly homogeneous in their structure nor perfectly regular in the arrangement of the molecules. The interstices between the molecules, from the very nature of the irregularity in the mechanical structure, must also be irregular. When, therefore, either in the charging or discharging, there is an evolution of gas in the interstices of the sensitised portion of the plate, especially at the surface, the increase in volume by the change of the liquid portion of the electrolite into the gaseous form throws a pressure within the interior of the molecular mass; and, in consequence of the irregularity in the interstices, these gaseous streams conflict with each other, and hence portions of the surface of the plate are disintegrated and fall down into the bottom of the cells. When the current, either in charging or discharging, is small in quantity, this disadvantage does not appear in the same proportion as when the charge or discharge is great. In actual use also it is generally desirable to draw out the stored energy at a greater rate than to charge it, so that the accumulator during the period of charging is usually subjected to a much less strain than during the period of discharge. When, therefore, the charge requires to be drawn out very quickly, the plates suffer rapid deterioration, and this rapid deterioration very soon breaks up the sensitized portions of the plates, and, by causing unequal expansion and contraction, causes buckling and local action.

This is one of the greatest disadvantages which this form of accumulator possesses, and it is this fault which has rendered them, not only in inexperienced hands, very inefficacious, but also very costly to maintain. The most modern form of accumulator to-day has now almost entirely done away with this disadvantage. It is well known that in a crystalline form the molecules of matter are arranged in a different order from what they are in any mechanical mixture. In the mechanical mixture the aggregation of the atoms is strictly fortuitous, that is to say, it is a mere question of chance how they are arranged, and they have no cohesion amongst themselves beyond that which is given to them by the cementing mixture which holds them together. In the crystalline form, however, all this is changed; the molecules of the body are arranged in perfect symmetrical order, and they are held together by molecular affinities which regulate the order of their distribution and secure the coherence of the mass. It is quite true that the material is denser unless some means are employed to modify the density; but although this is the case, the molecular channels which exist in the interstices of the crystal are arranged in as regular order as the molecules of the crystals themselves. This property has recently been employed with very great success in the formation of accumulators, and has enabled the plates of which they are composed to have the greatest uniformity in structure, capacity in storage, rapidity in charging, and regularity in discharging. While all these objects have been obtained, it has been found, in addition, that there is a greater durability in the life of the accumulator and a greater power to retain the intensity of the voltage almost to the end of the discharge.

The active part of the plates is formed of chemically pure lead, which is obtained in the following manner: White chloride of lead, after being thoroughly washed and dried, is mixed with a certain portion of chloride of zinc. The proportion varies with the use to which the accumulators are to be put, as upon this mixture depends the degree of density or porosity of the reduced lead, and this method of manufacture secures a most complete control over the structure of the plates. The mixture of lead and zinc chlorides is then fused together into a molten state, and cast in blocks like small tiles in suitable moulds. The size and thickness of these tiles depend on the purpose to which the accumulators are to be put. The form of the tile also varies with the particular form and size of which the plates of the accumulator are to be made. These chloride squares are then placed in a bath of dilute hydrochloric acid, which removes all the chloride of zinc. They are then dried and placed in suitable moulds to receive the framework of lead into which they are cast. The plates of lead enclosing the tiles of dried lead chloride are then placed in a dilute solution of chloride of zinc along with alternate plates of zinc, and, a connection being made between these plates, an electric couple is obtained. The lead chloride in the tiles is thus reduced to a pure porous metallic lead. If a section is made of one of these chloride tiles which has thus been reduced to pure porous metallic lead, it is found that the direction of the pores is always at right angles to the surface of the plate, and this structure, therefore, enables the electrolite with which the accumulator has been formed to penetrate every portion of the porous lead, and the structure also offers very little resistance to the disengagement of the gas which is formed by the electrolitic decomposition; and thus there is no tendency to disintegration of the plate, because no pressure is thrown upon the molecular structure. In the first formation of these plates those which are intended for cathodes or negatives and those which are intended for anodes or positives are all treated alike; but it is found better to again treat those plates which are intended for positives in a further manner by placing them along with alternate plates of lead in acidulated water and exposing them to the action of a current of electricity which is sent into them from a dynamo. By these means a reduction of the lead is more completely performed, and the greatest efficiency of the accumulator secured. The formed plates can then be built up alternately with the negative plates into any size of accumulator which is required.

The construction of this type of accumulator has solved many of the difficulties hitherto experienced. It has produced an accumulator with every quality which is most desirable, viz., a high rate of charge and discharge without injury to the plate, a high capacity of storage, and the maintenance of the voltage through a very large percentage of the capacity. Along with this there is also a very greatly increased durability; and the fact that the same number of ampere hours can be stored in half the weight of plates as against every other previous system not only makes their introduction a distinct era in electrical science, but opens up an increasingly wide field for their use in every-day life. As accumulators built in this form have been working, notably in Paris, for several years, their durability and efficiency are placed beyond doubt. Not only will they be of the greatest service in connection with electric lighting installations, but their high efficiency and light weight render it probable that sooner or later, in some form or other, they will render electric traction over ordinary roads not only a possibility, but a commercial success. It is probable that along the lines of this discovery still further improvements may be made, and each step in advance will probably open up increasingly wide fields for electrical application.

LETTERS TO THE EDITOR.

⁂Correspondents are requested to be as brief as possible. The writer's name is in all cases required as a proof of good faith.

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The editor will be glad to publish any queries consonant with the character of the journal.

The Systematic Position of Diptera.

In connection with the discussion that has been had on this subject in the columns of *Science*, Prof. John B. Smith has suggested that I send you some ideas of my own, as expounded in a lecture before the Brooklyn Institute last February, which was substantially the same as one previously given before the Lowell Institute at Boston, in January, 1892. It was on the general subject of social insects, and after showing that the insects treated were among the more intelligent of the insect world, I concluded with a statement of my own views as to the nature of this intelligence, and urged that we can never properly appreciate or bring ourselves into sympathy with lower creatures until we recognize that they are actuated by the same kind of intelligence as we ourselves. I drew attention to the significant fact that, just as among the mammalia, the higher intellectual development, as in man, is found physiologically correlated with the longest period of dependent infancy, and that this helpless infancy has been, in fact, a prime influence in the origin, through family, clan, tribe and state, of organized civilization; so in the insect world we find the same physiological correlation between the higher intelligence and dependent infancy, and are justified in concluding that the latter is in the same way physiologically correlated with brain development, and, at the same time, the cause of the high organization and division of labor. I then alluded to the discussion as to the systematic position of the different orders of insects, and especially to the claims that had been made for the Diptera as being of the highest rank. I argued that such claims were not justified, and pleaded for the Hymenoptera, not only on some of the grounds indicated by Dr. Packard, but particularly on the ground that the highest degree of intelligence among insects is exhibited by the social species in this order. There is a great deal that is vague and unmeaning in the discussion as to what is "high" or "low" in the relations of organisms to each other. If specialization of external structural parts is to be looked upon as an index of high position, then very many animals must be admitted to outrank man, whose bodily characteristics are in many respects embryological and non-specialized; while the parasitic forms among insects would have to be placed among the very highest, since, in a majority of instances, they exhibit the most perfect adaptations and specializations. Yet these last are almost universally admitted to be degraded forms, while few men will willingly allow that the genus Homo does not stand at the apex of the mammalian class. His superiority, however, is just as uniformly conceded to be by virtue of his intellect.

In the same way I urged that the order Hymenoptera, containing, as it does, the more highly developed social and intelligent insects, should, by virtue of these facts, rank above all other orders. This question of rank is meaningless, except as an indication of relative complexity of structure, the organisms best deserving to be ranked above all others in development being those which have acquired the greatest complexity. Nor must this complexity be confined to mere external structure, but must include nervous organization and brain development—in other words, must include psychical as well as physical characteristics. There is probably no more complex animal organ than the human brain, just as among insects there is probably no more complex hexapod organ than the brain of the ant or of the bee.

Such are substantially the ideas I set forth, the plea being that intelligence should no more be omitted from any discussion of the question of development or rank among insects than among vertebrates.

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BOOK-REVIEWS.

Vagaries of Sanitary Science. By F. L. Dibble, M. D. Philadelphia, J. B. Lippincott Company. 462 p., 8 vo.

Impressed with the imperfections, misstatements and inconsistencies of vital statistics in general, and of the reports of boards of health in particular, the author of the above-named work undertook a systematic study of Sanitary Science as practised by its votaries, and from being a believer in the same he has become a bitter antagonist, raising a protest most bitter in tone against all the accepted rulings. The book is outrageous in its sweeping challenge of cleanliness, and the author has certainly laid himself open to criticism in his championship of dirt and filth; but yet there is a certain well defined point of value in that it sounds a note of caution at a time when we are all rushing headlong into an unscientific acceptance of sanitary promulgations. Attention, too, is called to the character of the men who have taken up this branch of work, and, though the general statements are a slur upon the many earnest and scientific workers, still the statements are too often true of the members of many of our city boards.

The origin of the movement is described in the "Introductory" chapter as "a kind of disorderly agitation that suddenly seized the people of Great Britain following an inquiry into the condition and manners of living of the poorer classes of that country." In our own country the origin is ascribed "more to a fondness and habit of imitating the English than to any other cause." The movement is likened to a fanatical religious awakening, and the science to a false religion, whose priests have held whole continents in terror, and who, to gain stability, persistently summon up some new danger to frighten the people, and then caress them into tranquility by the announcement of their discovery of the antidote. The book is recommended by the author—"not for those of life-long prejudice, or who fear to sink into depravity in listening to the innocence of nature's metamorphosis, but for those timid people who have been plagued for the past thirty years by the increasing procession of sanitary terrors, and for those who love truth for truth's sake."

In chapter I. the history of "Sanitarians—Ancient,