literature renders it impossible to present a complete survey of so immense a field of labor in the address of an evening. What has been said is little more than a beginning of what has been done in this line of biochemical research—the promise of its future remains to be told.

Beside the great intellectual gain must be placed the immense practical benefits such investigations have secured for man—as witnessed in the saving of millions of lives of human beings, many times more of the lower animals, and large areas of plant life. They have ever made for the betterment and happiness of man, and for the highest progress of civilization, and so will they continue.

HENRY WINSTON HARPER.

AN ELECTROCHEMICAL LABORATORY AT THE UNIVERSITY OF PENNSYLVANIA.

THE great importance of electricity in chemistry is universally recognized. Universities and technical schools are rapidly adding appliances for the use of this agent to their chemical equipments. Here, at the University of Pennsylvania, the first work done in electrochemistry was in the year 1878. It consisted in the precipitation of cadmium from its salts, also the separation of this metal from copper, and the precipitation of uranium as protosesquioxide by the electric current. Since that time numerous other methods have been devised, and the practical work has been greatly amplified and incorporated in the course of chemical instruction designed for undergraduate and graduate students in chemistry.

The electric energy was, at first, derived from various types of primary batteries, but as the demand for powerful and steady currents grew, several storage cells of the Julien type were introduced, early in the year 1888, and constantly used until 1895, when the equipment was increased by the addition of twelve chloride accumulators (Type E), connected to a plug-board, by which any number of cells could be arranged in series or parallel, and attached to any one of three sets of terminals, conveniently placed on a working table. Fig. 1 represents a photograph of the table, showing the board in position. The storage cells were placed in the cupboard back of the distributing board. The arrangement of the plug-board with its connections is clearly indicated in Fig. 2, where the lettered and numbered squares represent brass blocks mounted on a slab of hard rubber, and the dotted lines indicate the electrical connections on the back. Provision was thus made for three students.

As this device and our present laboratory were installed at the writer's suggestion and under his direction by A. W. Schramm, of the Electrical Department of the University, it seems best, to insure accuracy and avoid uncertainty, to introduce the latter's own language in describing the two schemes:

"The brass blocks marked P are each connected to the positive terminal of a storage cell. These cells are marked in the figure by A, B, C, etc. The negative terminals are each connected to two blocks marked N, as shown. The upper line of blocks, numbered 1, are joined together, and, in fact, might be made of one strip except for economy of material. This row is attached to, and forms part of, the positive lead running to outlet No. 1 on the operating table. The negative lead for this same outlet is connected to the lower row of blocks marked 1. Thus: If the operator at outlet No. 1 wanted to use the two cells A and K in parallel it would only be necessary for him to insert plugs between the upper row of 1 blocks and the P blocks of A and K respectively, and between the N blocks of A and K, and lower row of 1's. Similarly, the upper row of blocks marked 2 are connected to the positive lead running to outlet No. 2, and the lower row of blocks marked 2 are connected to the negative lead of the same outlet. And so on with the blocks marked 3. It will be noticed that one of the two abovementioned N blocks is located in the same row with the P blocks, and this N block of one cell is adjacent to a P block of its neighbor. This is for the purpose of connecting cells in series.

"For instance, suppose that the operator at outlet No. 2 wanted to use cells B, C and D in series, he would connect the P block of cell B to 2, the P block of C to the N of B, and the P block of D to the N block of C, finally connecting the N block of D to its adjacent 2 block.

"In addition to the above, the operator at 3 could insert plugs so as to use the cells E, F, G, H, I, J in a combination of all in parallel, three in parallel two in series, two in parallel three in series, or all in series, just as occasion might demand.

"The cells were charged (generally at night) by connecting circuit No. 1 to the 110-volt lighting circuit by means of a small knife switch, conveniently located at the side of the operating table. Incandescent lamps placed in this charging circuit kept the current down to the desired value. The cells were then all connected in series and across the No. 1 leads. Making No. 1 leads the charging circuit also provided means for using the 110-volt current for electrolytic work where the solutions were of such high resistance that the twelve cells in series were insufficient to produce the desired results. Portable resistance frames were provided, consisting of wooden frames mounted on neat iron feet, having German-silver wire coils stretched between brass blocks on both sides. There were sixteen pairs of coils of one resistance, and ten pairs of one-tenth of that resistance, all joined in series between two binding posts, and so arranged that any number of coils of either denomination could be short-circuited by means of two plugs ; thus the resistance could be altered by small steps.

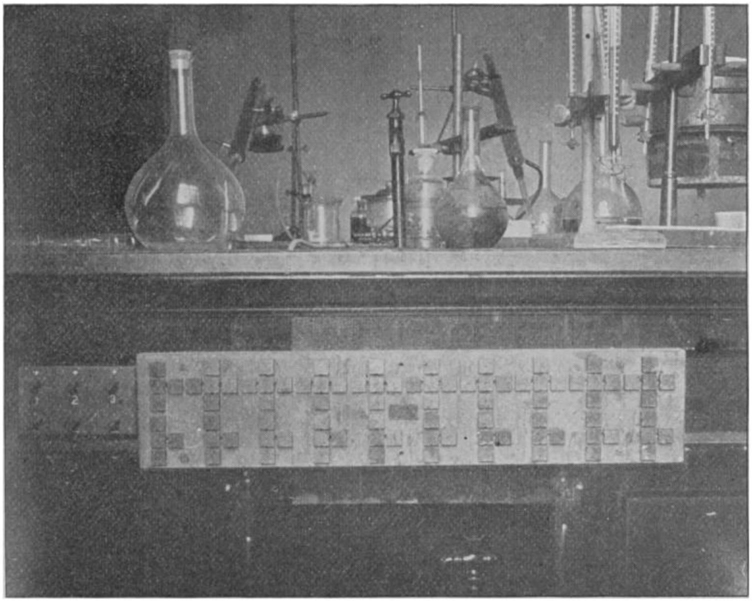

FIG. 1. Old Working Table.

A third plug was provided to prevent the necessity for opening the circuit when altering the resistance. The measuring in-

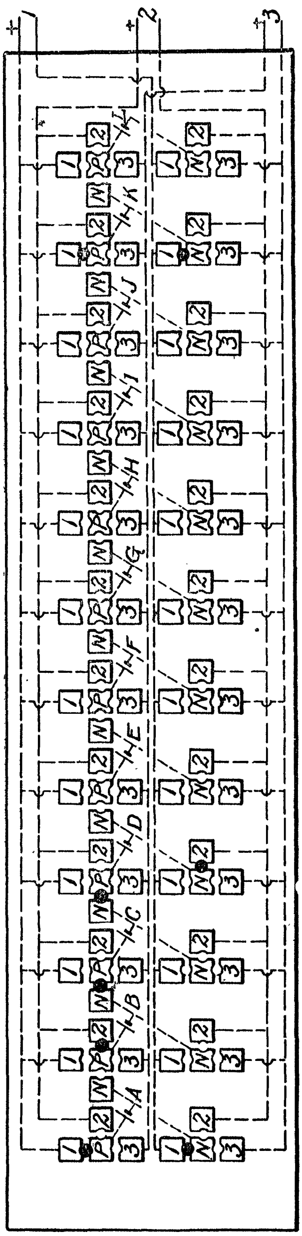

FIG. 2. Old Distributing Board.

struments were portable, Weston's and Hartman-Braun. This entire electrical equipment was fairly satisfactory and was duplicated later. It had many defects; for instance, it was possible to connect cells in parallel and series at the same time and the student sometimes preferred to make connections haphazard rather than work out and understand the whole scheme. And even though he did understand it, the chances for making a wrong connection were too great because of the confusingly large number of blocks on the boards. The resistance frames had the fault that the German-silver wire soon became so corroded as to break. Replacing the coils by tinned steel wire proved to be little or no improvement. The portable instruments, too, were in danger of being injured by solutions being spilled on them, and sometimes received rather rough handling, which soon decreased their usefulness.

"For these reasons, and the growing demand for training in electrochemistry, it was finally decided to provide a laboratory and installation sufficient to accommodate eighteen students. The effort was also made to overcome as fully as possible the defects of the previous arrangement. It will readily be seen that the matter of complication would be made indefinitely worse if the number of outlets were increased to eighteen and the number of cells to fifty, so an entirely different arrangement of switchboard had to be devised. The only room available was one fifteen feet by twenty-six feet, as shown in Fig. 3, and it soon became evident that this room would not accommodate more than sixteen students, allowing each individual three feet by twenty inches of table space.

"Storage cells were, because of their constancy, decided upon for this installation. Those in use have 120 ampère hours' capacity, with a normal discharge rate of 15 ampères and a maximum rate of 30 ampères. Two groups of twenty-four cells each were located in the compartments shown; they supply their respective sides of the room.

They are supported on racks of four shelves each, six cells per shelf. Each shelf is thoroughly paraffined and a half inch layer of ground quartz placed around the jars. Fig. 4 shows one of these compartments with the lead wires and cut-outs for each cell.

"The switchboards are three in number, two of them each controlling the six places on their respective sides of the room, and the third controlling the four places in the center. The face of one of these boards is shown in Fig. 5, the letters on the face referring to the working tables controlled.

"The switchboard on the east side of the room consists of a slab of enamelled slate

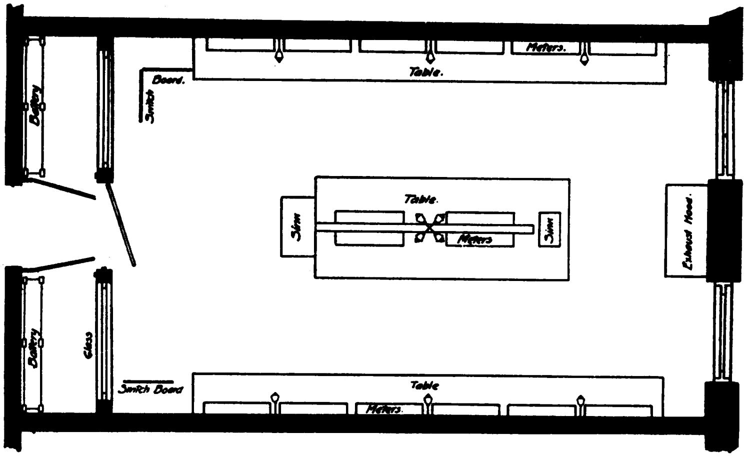

Fig. 3. Electrolytic Laboratory.

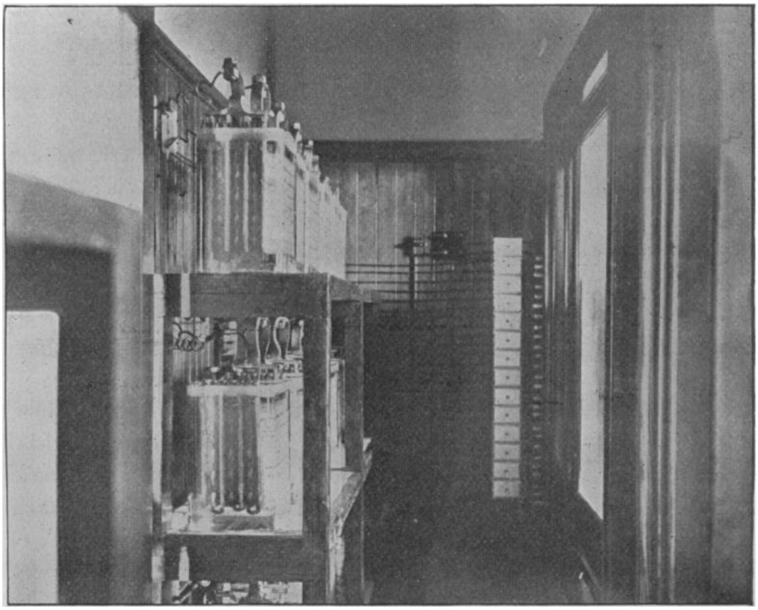

Fig. 4. Battery Room.

24 by 34 inches, one inch thick, and contains, for each of the six outlets to be controlled, one circle of twenty-five contact pieces, and has two spring levers, insulated from each other and moving about a common center, sweeping over them. The contact blocks are numbered consecutively from 0 to 24 and a stop is provided to prevent the levers from sweeping past the zero. Cell No. 1 is connected between blocks numbered 0 and 1 in each of the six circles, cell No. 2 between blocks numbered 1 and 2, and so on for the remainder of the twenty-four cells in that group, so that all blocks similarly numbered on the one board are connected together, and but a single wire leads from the six similarly numbered blocks to the junction between two cells. In this lead is provided the usual fuse. The circles are lettered A, B, C, etc., consecutively, corresponding with the letters at the outlets to be controlled.

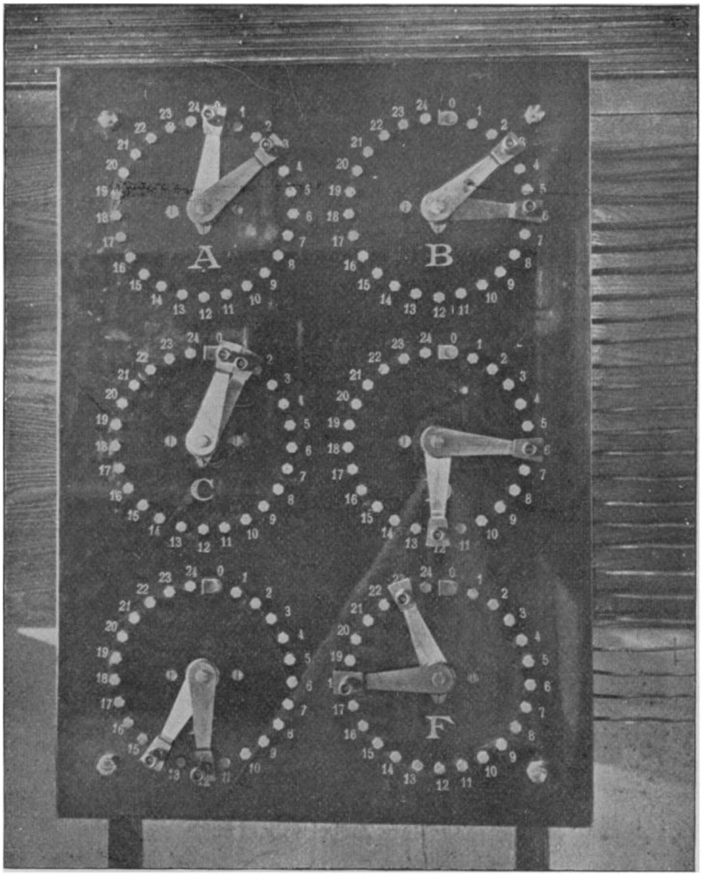

FIG. 5. Distributing Board.

"Should the operator at the outlet E, for instance, need two cells, he goes to this board, and finding that the cells from the twelfth cell forward are not being used in any of the circles, he places one of his levers on contact block No. 12 and the other one on No. 14. There is thus very little chance of doing anything wrong, or for persons to interfere with one another, because there is no necessity to use the same cells, and at a glance one can observe which cells are in use. Fig. 6 shows the electrical connections from one of these distributing boards to the cells and outlets on the working tables. The levers themselves are too narrow at their outer ends to reach across from one block to another, to prevent short circuiting the cells, so they are provided with fiber extentensions on each side to prevent their falling between the blocks, and also to prevent their making contact with each other. The switchboard on the west wall is exactly similar to the one just described, it containing the circles G, H, I, K, L, and M, while the third one, which controls the four outlets on the center table, is but twenty-four inches square, but has twenty-six contact blocks in each circle. They are numbered 0, 24, 25, 26, and so on to 48. Between the two blocks numbered 0 and 24 are connected the cells of the group on the east side of the room ; between the blocks 24 and 25 is connected cell No. 1 of the west side of the room, while cell No. 2 is connected between blocks numbered 25 and 26. This arrangement connects the two groups of cells in series, and permits the use of from one to forty-eight cells at the center table when necessity requires. It will, perhaps, have been noticed that there is no provision made for connecting cells in parallel, and this is not necessary, as the maximum discharge rate of the cells exceeds the greatest estimated current needed by one operator. All brass parts on the back of the board, as well as the bared ends of the wires, are thoroughly coated with P. and B. paint, while the brass parts on the front are heavily lacquered to prevent corrosion. The surface of the contact blocks can easily be cleaned with fine sandpaper.

"The measuring instruments, after some deliberation, were chosen of the switchboard type. While this necessitated procuring at least one-third more instruments, yet the initial cost was considerably lower than if portable instruments had been provided, and experience with portable instruments leads me to believe that a greater accuracy will be attained with switchboard instruments of a good form, if not immediately, yet surely after the first six months of use.

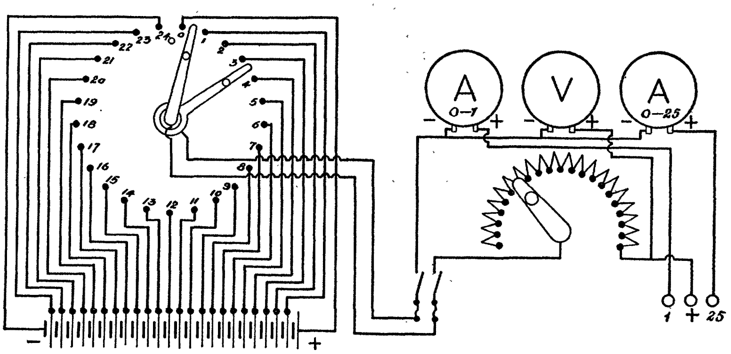

FIG. 6. Connections to Working Table.

"Each outlet is provided with a fused switch, a voltmeter, two ammeters, a rheostat and a terminal board. They are connected as shown in Fig. 6. The positive lead after passing through the variable resistance runs directly to the positive binding post. The wire coming from the negative binding post runs to the low reading ammeter and thence to the negative side of the switch, while the negative post marked 25 is connected to the same switch terminal, but through the ammeter of large capacity. The anode of the electrolytic cell is therefore always connected to the middle binding post and the kathode either to the post 1 or 25, depending upon the strength of current it is intended to pass through the cell. The voltmeter, being connected as shown, measures the potential differences at the terminals of the cell, except for the addition of the small fall of potential through the ammeters.

"The voltmeters on the side of the room have scales ranging from 0 to 50, and divided to 1–2 volts. Those on the center table range from 0 to 120.

"The ammeters ranging from 0 to 1 ampère are divided to 1–100 and those reading from 0 to 25 are divided to 1–5 ampères. The three instruments are mounted side by side on an oak backboard extending the whole length of the room and are covered by an air-tight case with a glass front, as shown in Fig. 7. The cases have neither doors nor a back, but are simply screwed against a backboard with a heavy felt gasket, making the joint. The wires come out through hard rubber tubes sealed at their outer ends by insulating tape. The rheostats are of the enameled type, chosen because of their being impervious to fumes. They have a total resistance of 172 ohms, divided into 51 steps in such a way that their resistances form a geometrical progression. The first step, and the sum of all the steps, being chosen in accordance with data of the resistances of the baths determined for the work done under the old system.

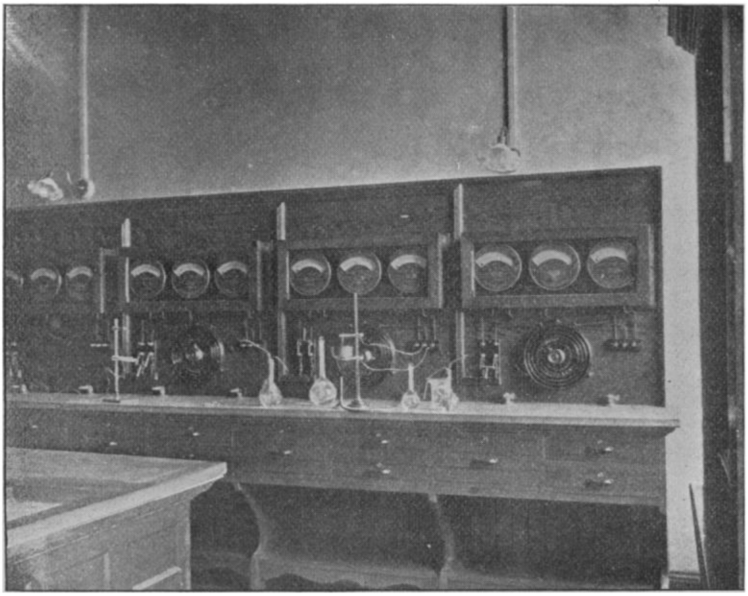

FIG. 7. Working Table.

"The wires, both those in the battery rooms and those in the laboratory proper, are covered with rubber, and those in the laboratory are further encased in oak molding, but this rather for appearance's sake than for protection. The whole installation, as well as the other fittings of the room have a very neat and finished appearance.

The problems investigated by students in this laboratory are the study of the influence of current density and concentration upon the course of chemical reactions, the application of gas analysis to the study of the latter (in the formation of hypochlorites and chlorates), ion transference (in the electrolysis of dilute sulphuric acid or sodium hydrate) with a diaphragm, formation of persulphuric acid (influence of concentration, of current density, of temperature), metal precipitations with soluble and insoluble anodes, the introduction of aid-reactions, experiments with molten electrolytes, experiments with multipolar electrodes, the determination and separation of metals, the electrolysis of a series of organic compounds (reduction and synthesis), etc.

The writer is indebted and under many obligations for this installation to Provost Harrison who provided the necessary funds.

In conclusion it may be said that in a second room close by there is also provision for work at high temperatures. A Moissan and two Borscher's furnaces are used for this purpose. They are in direct connection with a 50-horse-power dynamo and are furnished with satisfactory resistance and measuring instruments. They are applied in the reduction of oxides, in the electrolysis of fixed salts, the production of alloys, etc.

The two laboratories afford all that is essential to acquaint the student with the fundamentals of electrochemistry, and give him also ample facilities for research in this domain of chemical science.

EDGAR F. SMITH.

LEGISLATIVE RECOGNITION OF SCIENTIFIC WORK.

IT is not often that SCIENCE has the opportunity of chronicling an event such as happened at Madison, Wis., on March 27th, when the Legislature of the State in open session presented to Dr. S. M. Babcock, of the University of Wisconsin, a beautiful bronze medal 'recognizing the great value to the people of this State and the whole world' of his inventions and discoveries, 'and his unselfish dedication of these inventions to the public service.'

Governments such as ours are not prone to recognize deeds of scientific men, but the service rendered in this connection was of such value that the State has honored itself by paying honor to the man who refused to take out a patent on his invention, but gave it freely and willingly to the people.

Dr. Babcock's discoveries in the field of agricultural science have been many,