Newman, (R.)

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ACCUMULATORS

AND THEIR MEDICAL USE.

BY

ROBERT NEWMAN, M.D.

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ACCUMULATORS

AND THEIR MEDICAL USES.

BY ROBERT NEWMAN, M.D.

Synonymous terms of accumulators are storage batteries and secondary batteries, and will be used so in this paper.

These names convey only a vague idea of the nature of these batteries, without really explaining their characteristics. The accumulator is a battery, which first must be charged with electricity by a primary battery, before it can be used, thereby becoming a secondary battery. It is not exactly correct to say that the electricity is stored up; but the fact is, that by changing accumulators, they become reservoirs for electric energy, which can be used at will, and last till the electric energy is exhausted. A secondary battery consists of one or a series of accumulators, each accumulator representing one cell.

To make this paper more complete, some terms and electric units used in modern electricity will be explained as adopted at the Electric Congress in Paris, 1881.

Electric Units. A *Volt* is the unit of electro-motor force, the measure for pressure of difference of potential. It is nearly equal to one cell of Daniell's Battery.

The *Ohm* is the unit of resistance, or rate of velocity, the standard of which is a column of pure mercury one square millimeter in cross-section, and 106 centimeters in length, at the temperature of ° C. "An ampere is the unit of current strength or volume; the standard measure of the electric current. An *ampere* is equivalent to the strength furnished by an electro-motive force of one volt, passing through a resistance equal to one ohm" $\left\{ C. = \frac{E}{R} \right\}$

A coulomb is the unit of quantity. It is equal to one unit of current ampere passing in one unit of time (one second); or in other words a current of one ampere in a circuit will produce one coulomb in a second.

A Watt is the unit of energy or force, or equal to a combined volt and ampere.

$$\text{One horse power} = \frac{\text{Amp. x Volt.}}{746}$$

A Farad is the unit of capacity. It represents the storage of one coulomb of electricity in a condenser.

A Joule is the unit of heat; it also represents the work done by a watt in a second.

Cell. By a cell we understand the vessel with its contents complete with liquid and elements (or plates) not the receptacle *per se.*

Primary cells used for Faradic and galvanic batteries, vary very much in their composition ; but all have one characteristic when exhausted, the whole or part of the chemicals employed must be renewed, and sometimes the plates also. Types of these are the Daniell, Bunsen, Grove, Leclanche, etc.

Secondary cells are such, which when exhausted, may be revived by simply passing a current through them from a battery of primary cells.

For each cell we have a fluid and plates. Cells proper are generally made of glass or hard rubber. The plates consist of positive and negative elements, made of some suitable substances.

FLUIDS.—The fluids used may be alkaline, acid or neutral, according to the plates employed, and other considerations. In the present storage batteries the fluid consists of diluted sulphuric acid covering the plates to the depth of half an inch above the upper edges of the negatives.

The theory of electric storage is that when water is decomposed by electrolysis the gases are collected in separate receptacles, if the connection with the battery be severed, and the wires leading to the gas tubes brought into contact, a current of electricity will flow through them in the reverse order to that of the original current, the gases at the same time recombining to form

water. Thereby the electric energy expanded in decomposing the water is stored up in the gases, and recovered when they recombine, Oxygen accumulates at the positive pole and hydrogen at the negative. The oxygen unites with the terminal, if composed of any of the baser metals, and appears in the combined form of an oxide instead of a gas. But experiment proves that electric energy is also stored up in the oxide, when so formed, and may be recovered from it.[1]

As a primitive storage of electricity we may look to the Leyden jar in principle; which, however, differs considerably from the present accumulators; the Leyden jar becomes charged by induction, the secondary battery by chemical action. The Leyden jar, when used, liberates all the electricity contained in it, as one discharge, while in our present accumulators the electricity can be used in quantities to suit our purpose, commenced, stopped, interrupted at will instantaneously, and even the strength of such current can be regulated.

The principle of our present accumulators was discovered by Planté, 1860. A modification of Planté's system was made by Faure in 1880, whose storage battery was the first exhibition of a

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[1] Atkinson: The elements of electric lighting.

practical appliance, which promised to be used for different purposes. At the present time the best cells in use are in reality only improved Faure's cells,and come under three heads: One has plates composed of lead in a spongy or granular state; the second has lead plates, or some alloy of lead, perforated with holes which are filled with lead compounds. The third type has lead and zinc plates. All lead-plate accumulators are based on the principle of Planté,s invention, which represents, also, the type of the first class mentioned.

Planté's system is as follows:

Two sets of lead plates prepared with a view of making them porous are rolled into each other; at the start both sets are identical, and only afterwards become positive and negative respectively. They have luggs either cast on them or put on afterwards to project above the level of the electrolyte, so that the plate itself may be completely immersed. A strip of lead is then soldered to the luggs of all the negatives, and the same is done with the positives destined for one cell. The two sets of plates are pushed into one another, so as to form a compact block, positive and negative, alternately, every plate being insulated from the next one by some non-conductor, for which India-rubber bands are mostly used; but they remain joined by the lead strips de-

scribed above. The block of plates is firmly held together and constitutes a section. The two poles of a primary battery are connected with the accumulator, and by a series of charges and discharges with reversible properties the forming takes place. For charging, a battery is used consisting of a series of Daniell's or Bunsen elements. The principle is to form an oxidation at the positive pole, thereby converting the plates into a peroxide of lead and the positive plate will accordingly become brown, while the negative plate will remain gray. The battery is fully charged when gases are formed at the positive pole (brown color) and escape in small bubbles. If a so-charged battery is left to itself without being used it will deteriorate, by a reduction of the peroxide of lead, and it becomes a sulphate of lead, which can be observed by the brown color at the positive pole changing into a yellow. The chief drawback to this type of accumulator is that frequent reversals are necessary to obtain a good storage capacity, and just when that point has been attained, the plates shortly fall to pieces; that is the limit of the accummulator and its end. The objections, therefore, are that such batteries are troublesome, expensive, and too heavy for portability.

The Second Type (lead plates perforated with holes which are filled with lead compounds) is unquestionably the

most useful, and it is those which are most in use at the present day.

Pasted plates are made in many ways, but the object in all is to produce an efficient support of lead for carrying the paste. Several companies prepare plates which are almost identical. They consist of lead, or an alloy of lead, cast in plates full of small square holes, pyramidal in form, with their bases on the surface of a plate minute-glass shape in section, with a lugg to attach the connecting strip of lead, when built up in sections. Now they use an alloy of lead to obtain a better plate of grid, as it is called, the alloy being far stronger than the lead. The plates intended for positives are pasted with red lead, or minimum, and sulphuric acid; the negatives with yellow lead, or litharge and sulphuric acid; the latter is used to make the paste more coherent.

They are now built up in sections by soldering the luggs of a number of positives to a strip of lead. The negatives are treated in the same way. These two sets of plates are pushed into one another, so that positive and negative alternate, and every plate is insulated from the next one. A plate of thick glass is then placed at each end of the section, and two stout rubber bands are made to encircle the whole, one near the top, and one near the bottom, of the section, horizontally. The number

of negative plates always exceeds the positives by one, so that a negative is seen at each end; of the remaining plates the edges only are in sight, the plates being about a quarter of an inch apart, positive and negative alternately. There is no connection between the positives except through the leaden strips at the end of the luggs, this being left long enough to join to the next cell; the ends of the luggs with the strip always remain above the liquid of the cell. These remarks also apply to the negatives. The section is now ready for forming. In the foregoing description of the manufacture of the plates I have followed mostly Sir David Salomon's management of accumulators.

Many experiments have been made to improve the Planté's system, and we find accumulators exhibited by the following scientists; Meritens, Pezzers, Sellon & Volckmann, Changy, Kabath, Faure and Schulze.

Next come the accumulators with only one lead plate by Arsonvals, Boettcher, Sutton; and last, the experiments of accumulators without lead plates by Houston & Thompson, H. Aron, Varley and Dumoncel. The latter belong to the third type mentioned above.

All support plates belonging to the first type were founded on the principle of the oxidation of the positive plates or their conversion into peroxide,

so that they soon fell to pieces, which is the objection. The type of the second class differs from the first in that the plates are already prepared in its make, so that the cell is ready for immediate use. Our present useful accumulators belong to this class, and are all modifications and improvements of the Faure system.

The importance of a reliable accumulator will be appreciated best when it can be utilized in all practical appliances of electricity. It has already been extensively used for the following purposes:

1. Electric lighting of buildings.
2. Lighting of railway trains, street cars, and omnibuses.
3. The traction of all vehicles, more especially street cars.
4. The propulsion of yachts, launches and pleasure boats.
5. The lighting of steamers.
6. Running motors of all kinds.
7. Telegraphy, signaling.
8. Medical use.
9. Electro-plating.
10. General laboratory, etc.

Each of these uses plays a very important part in our domestic and public economy; but most interesting is "Electric Lighting." It is here that its functions as a reservoir of energy become utilized to the greatest advantage; and after a retrospect of not so many years, in which the light for houses and

our studies was a tallow candle, we can appreciate more fully the progress of an enlightened community, which has given us electric light as a comfort and a luxury. While this subject is so very interesting, its pursuit is not within the scope of this paper, and we must restrict the further consideration of accumulators to MEDICAL USES;" which are:

1. Galvano cautery.
2. Incandescent light for general examination and especial illumination of cavities of the body.
3. Motors, and operating induction coils.

Among the many advantages of the accumulators are:

A. In regard to Light.

1. The greater superiority and steadiness of the light.
2. It does not heat the instruments, and its surroundings.
3. The light is concentrated and does not flicker or smoke.
4. The freedom from smoke and deleterious gases.

B. In regard to Cautery.

5. The cleanliness in contrast with the acid plunge batteries, which often have ruined clothes, carpets and furniture.
6. The battery is always ready for use.
7. It gives a uniform strength of current from beginning till the energy

of electricity is completely exhausted; thereby a platinum burner can be kept at the same intensity of heat during any operation; whereas, the primary batteries polarized and the heat diminished during an operation.

8. The amount of heat desired can be regulated by the rheostat.

9. The accumulators are more portable than a battery filled with acid fluid.

10. It saves time and work, being always ready; there is no necessity of making fluid, filling, refilling and cleaning the elements.

DISADVANTAGES.

1. The constant care and use.

2. If out of order, the cell must be renewed; it cannot be repaired.

These may be considered by some drawbacks; just as well, as it needs to be an expert to handle the instruments. The accumulators must be used often, and it must be charged and discharged at certain intervals. One or a few days intervals will not make much difference; but if a charged cell will be left standing without being used, it may be found entirely useless after a certain time; just as well, as if the cell is left exhausted of energy and not charged again. Therefore, the general practitioner, who, perhaps, uses a galvanocautery once in a month will not find the accumulator practical; but the ex-

pert and specialist will not complain; on the contrary, will find that he saves time and work. I use the accumulators almost daily, and find the care needed not burdensome, on the contrary, pleasant, and saving time and labor in comparison with the old method. All these disadvantages are reduced to a minimum by constant improvements which inventors make.

PRINCIPAL ACCUMULATORS FOR MEDICAL USE.

In America several types of batteries have appeared, all having as foundation the Planté's system; the plates of all are a modification of Faure, all plates are in cells, filled partially with diluted sulphuric acid. The difference consists in preparing the plates, in which the principal point and secret is to prepare a suitable alloy of lead, instead of lead itself.

Here in New York we have three systems in use, all protected by letters patent, viz.: The Gibson's, the Julien, and the Black Giant. The latter two will be considered here, and introduced to your special attention. I have used them side by side for comparison for some time past, and both have given so much satisfaction that I feel justified in recommending both and showing them to you here in orperation.

THE JULIEN ACCUMULATOR

Is manufactured by a powerful and en-

terprising company, called "The Julien Electric Company," doing business on a very large scale; having the patronage of the Vanderbilt, Pennsylvania and other railroads, and also using their batteries as motors for railroad cars. The inventor is Edmond Julien, a Belgian engineer. His specific claim is that the grids or supporting plates are made of a special metallic composition which prevents oxidation and buckling, giving the battery much greater durability than can be obtained by the use of lead grids. The nature of this composition is a business secret, but some knowing ones say it consits of 94.5 lead, 4.2 antimony, and 1.3 mercury. In commercial circles it is known as "L'Electrique." The company calls it a new principle, that of an *inoxidizable support plate.* The Julien accumulator is guaranteed to render efficient service for a period of at least two years, and the company considers it the most duable battery. An instrument of this make I have used for some time, and it has given me perfect satisfaction. It consists of three cells in one case, and can be used for cautery as well as for electric light. It is charged by a series of ten Watson cells. The Watson cell is an improved gravity cell, each six by eight inches in size. This primary battery is stationary below in the basement, and two wires running up, representing the positive and negative poles, respec-

tively, are connected with the same poles of the accumulator, when the latter wants to be charged. As a rule the battery is charged during one night. The instrument is also provided with a rheostat, by which the strength of the current may be increased or diminished or regulated for the work to be done. One charge will hold a two-candle power lamp in a state of incandescence for ten hours. I believe that this battery has sufficient power to do all galvanic cautery work for surgical purposes, while the use of the rheostat will regulate and diminish the power to such a degree that the smallest burner can be applied without the risk of melting the platinum. I have used this accumulator for my galvanic cautery sound, also for heavy work. If the operator is attentive and uses the rheostat with care, he will never melt the platinum and ruin his instrument, while he can hold the same heat for any length of time without any polarization. This and other advantages over the primary cautery battery have been mentioned above. Another additional advantage is that this battery can be arranged for quantity, as well as for intensity, by plugs inserted in the holes you see here. If the battery is used in three consecutive cells at once, heat in the burner used immediately gives a flash to its fullest extent, which is important for some uses, particularly in

the application to the prostate with my galvano-cautery sound ; this is the intensity or volt current. On the other hand, if the three cells are converted into one cell, the heat comes gradually up to its fullest power, where it will remain during an operation. In the latter case the battery is set for quantity. To a certain extent this battery is portable, that means, one strong man can carry it to the place of operation, if he holds it "this side up." Its weight is about forty pounds. It cannot be laid on its side or upset, in which case the fluid would run out and injure the upper part of the cells.

THE BLACK GIANT ELECTRIC ACCUMULATOR

Is the invention of Dr. Flick of Brooklyn, and has come more recently to the notice of the public. Each cell is a sealed receptacle, has 8 plates, and is encased in an exterior of hard rubber. On top is a small hole in which a $\frac{3}{4}$ inch high tube is placed, which has the function as a ventilator to allow the free escape of gases. This opening can be closed by any kind of plug or cork, which prevents any leakage during a transportation. In the middle of the top are two projecting arms, nickel-plated, which are the two poles, with binding posts used for storing as well as for discharging. The cell is round, $8\frac{1}{2}$ inches high, 4 inches in diameter, with a circumference of 13 inches,

and weighs 10 pounds. It can be used single or in combination. A battery of two such cells is powerful and sufficient for almost any surgical galvano-cautery operation.

From trials made, I believe that two cells give nearly as much heat as three cells of the Julien accumulator. One cell, when fully charged, is equal to 2½ volts, and can be discharged at the rate of from 5 to 20 amperes, according to the use desired, and has a capacity of at least 30 ampere hours.

This battery has also a rheostat attached.

The plates are made of an alloy of lead, the composition of which is also the secret of the inventor. It is a very neat battery and has given me entire satisfaction. A particular advantage, which would make it useful to the general practitioner, is that in the Black Giant accumulator no local action takes place, and there is no loss of power when standing unused; and it may be allowed to stand many months empty and will readily charge again. How long it will retain its power I cannot say; but from experiments made myself I know that this accumulator was discharged and idle for nearly three months without losing anything in its power, was charged readily again and to-day is just as good as ever in its start. These accumulators are now manufactured in New York, and are for

sale at B. Blum & Co., 5 and 7 Dey Street, New York, and other dealers.

The inventor claims that the Black Giant excels all other accumulators in the following points:

1. Its electrodes or plates are non-corrosive and consequently indestructible.

2. The composition of its plates and its method of manufacture prevent local action and consequent loss of capacity to receive, retain and develop a high tension and a great quantity of current.

3. It is durable, reliable and constant. The plates do not enter into the chemical action involved in the operation of the cell, but remain non-disintegrable conductors.

4. Its capacity is greater in proportion to weight of cell than that of any other.

5. Its mechanical construction and appearance is superior to any other. The cell does not leak, the terminals or plates are thoroughly protected from corrosion, and consequently permanent.

6. The cells in transportation can be placed in any position or upset without being injured or leaking.

Both instruments, Julien as well as the Black Giant, are good practical accumulators which I can recommend. Both claim their instruments are the best and most durable. Progress is constantly made, and while we discuss here the merits of each, an im-

provement may greet us on awakening in the morning.

In determining the degree of intensity of a current required to heat a platinum wire to a point sufficiently hot for the purpose of operation with galvano-cautery, it is impossible to say how many degrees Fahrenheit are necessary, obviously, since for some time operations, a wire heated to a dark red is sufficient, while, for others, the wire must be brought to a white heat, yet not carried to such a degree as to melt the wire. The intensity of an electric current being measured only by electric units, it is but the sign of dense ignorance of electric laws to ask how many degrees Fahrenheit are necessary to produce a given result in electricity, because the thermometer is not a measure of electric force.

All operations can be made with the accumulators where galvano-cautery can be used, with platinum burners or with the galvano-cautery ecraseur with platinum wire. For most operations of the latter kind a No. 22 wire is used; while a No. 20 or 24 may be indicated, according to the work to be done.

II. INCANDESCENT LIGHTING

Is one of the most interesting applications of the storage battery. It is here that its functions as a reservoir of energy become utilized to the greatest advantage. Electric illumination is

carried on upon a large scale by dynamo, accumulator or both combined. Lights supplied direct from a dynamo are unsteady, uncertain and flickering, and the wires of such a current are dangerous to life by its large electro-motive force. A type of this is the Brush system, which flickering, unsteady lights can be observed in our streets, and the newspapers report many cases of death by loose wires coming in contact with a human body. On the other hand, the light furnished by accumlators is perfectly steady, and the current can be regulated with great certainty, so that we are enabled to use it for medical purposes. The Edison light is the type of this, which is used for illuminating our houses, and has 100 to 110 volts. The storage battery is, in fact, an equalizer and regulator to the dynamo, besides acting as a reservoir of accident, which is liable to happen with the best machinery. It is evident that in incandescent lighting for medical instruments, we can use the accumulator only.

Lighting apparatus for surgical instruments do not require so much room, and an electric lamp can be brought into nearer proximity with the parts of a human body under examination than any other lamp, and it also permits the eye of the operator to get nearer the point of observation, by which means a closer and more thorough examination becomes possible. By the aid of lenses,

pictures can easily be enlarged, and finally very fine photographs of the cavities of the human body can be obtained. H. Fenwick, in London, has improved now his apparatus to take photographs of the interior of the bladder. The best instruments of illuminating the cavities of the body by incandescent light are now made by J. Leiter, of Vienna. We find among his instruments the following:

Lamp for the forehead.

The lamp used for these instruments gives a light equal to from ten to twenty standard candles. It can be removed from its holder and connected with a handle, so as to be used as a hand lamp. It never becomes heated.

Laryngoscope; can also be used for dental operations.

Rhinoscope.

Tongue-depressor.

Gastroscope, after Mikulicz-Leiter, to examine the stomach.

Speculum, with incandescent lamp.

The lamp is carried on a spring, which can be clamped to any speculum.

Leiter's panelectroscope, for male and female urinary organs, ear, nose, œsophagus, rectum and vagina, is a universal lighting apparatus. The same apparatus will illuminate either of the organs mentioned, if an appropriate tube for the purpose is attached to the end of the instrument. As you see here, on removing the metal plate and screw-

ing on a mirror in its place, we have a laryngoscope, and in turning the same, it can be used for lighting up the nasal cavity. The panelectroscope differs from other endoscopic instruments in the mirror being placed behind the lamp, and its concavity permitting of concentration of the rays of light coming from the lamp upon the object. The operator looks over the upper edge of the mirror in though the respective tube. The lamp stands here free, not encased or obstructed above, which has the advantage that the instrument will not be heated, even if the lamp is kept burning for hours.

The most important novelty is Leiter's improved *Cystoscope*. This excels all former apparatus by superior workmanship and finish, has a far greater illuminative power, can be used in a bladder full of fluid, will burn steadily a long time and in every way gives the greatest security. Two instruments are made, one for examining the posterior part, and the other the anterior surface of the bladder, the light being respectively on the concavity and convexity of the instrument. By aid of the cystoscope a surface of the interior of the bladder of 100 to 200 millimeters can be very distinctly seen at once.

The size of the tube is No. 22 French; but it is also made of a calibre of No. 40, which is very useful in the examination of the female bladder.

Cystoscopes must not be left burning for any length of time in the open air, as in that case they become heated. If, however, that part of the apparatus containing the lamp is surrounded by water, the cystoscope may be kept burning for hours before it becomes perceptibly heated. To be examined with such instruments, the bladder always ought to contain 5 to 8 ounces clear water.

I have here a phantom bladder filled with six ounces of water, in which I have placed some objects which are for your inspection with the cystoscope, which is now lighted up with the accumulator. We need 3 to 4 cells to produce a brilliant light, which is regulated with the rheostat, according to the resistance of the lamp. The latter is placed near the curve of the instrument, by which the light is introduced directly into the bladder and not by reflection through mirrors, as was the case with all former instruments. Leiter furnishes a plunge battery with acid and bichromate of potassa for the generation of the electric current; but our demonstration here will prove that the accumulators do the work perfectly, and once adjusted give a steady light uninterruptedly for hours, while a plunge battery, with acids, necessarily will polarize and must constantly be readjusted. There is no question that the incandescent light, including the Mignon lamp, is an Ameri-

can invention. Yet we are unable to procure any incandescent lamp made in this country that is of any practical value, though many are made here, yet all are defective in one way or another, some bursting without warning and without apparent cause save defective workmanship, and all fail to give light sufficient for the required purpose.

It has fallen to the hands of skillful instrument makers of Europe to furnish us with a lamp yielding the best light with a greater resistance, thereby making the lamp more durable and less liable to breakage.

Among good lamps are some manufactured by J. Leiter in Vienna, P. Hartwig, of Berlin, and K. Schall, of London.

Leiter furnishes with his cystoscope a longer tube, for deeper inspection; but as he thereby alters the arrangement of the lenses, he also disturbs the focus, so that the point to be examined is not shown as distinctly as in the regular tube.

We have also in the market Nitze's cystoscope, which is nearly identical with Leiter's. Yet Nitze's has this advantage over Leiter's that the instrument, while in the bladder, may be turned around so as to make examination of posterior and anterior surfaces, while with Leiter's a different instrument must be used for each examination. Notwithstanding this disadvan-

tage, many prefer Leiter's instrument, myself being among those.

The cystoscope possesses nearly the same disadvantage that existed in Desormeaux endoscope, viz.: an abrupr curve which is sometimes difficult fot the operator and painful for the patient in introducing it into the bladder. Could the fenestrum be arranged in a gradual curve, like the steel sound, much disadvantage would be overcome.

The cystoscope in the present condition can only be used in examination and for diagnosis.

Could it be modified so as to enable the physician to make a diagnosis and operate at the same time, the instrument would be the ideal of perfection. We sincerely hope that this instrument may shortly be brought to this state of perfection.

New York, 68 West 36th Street.