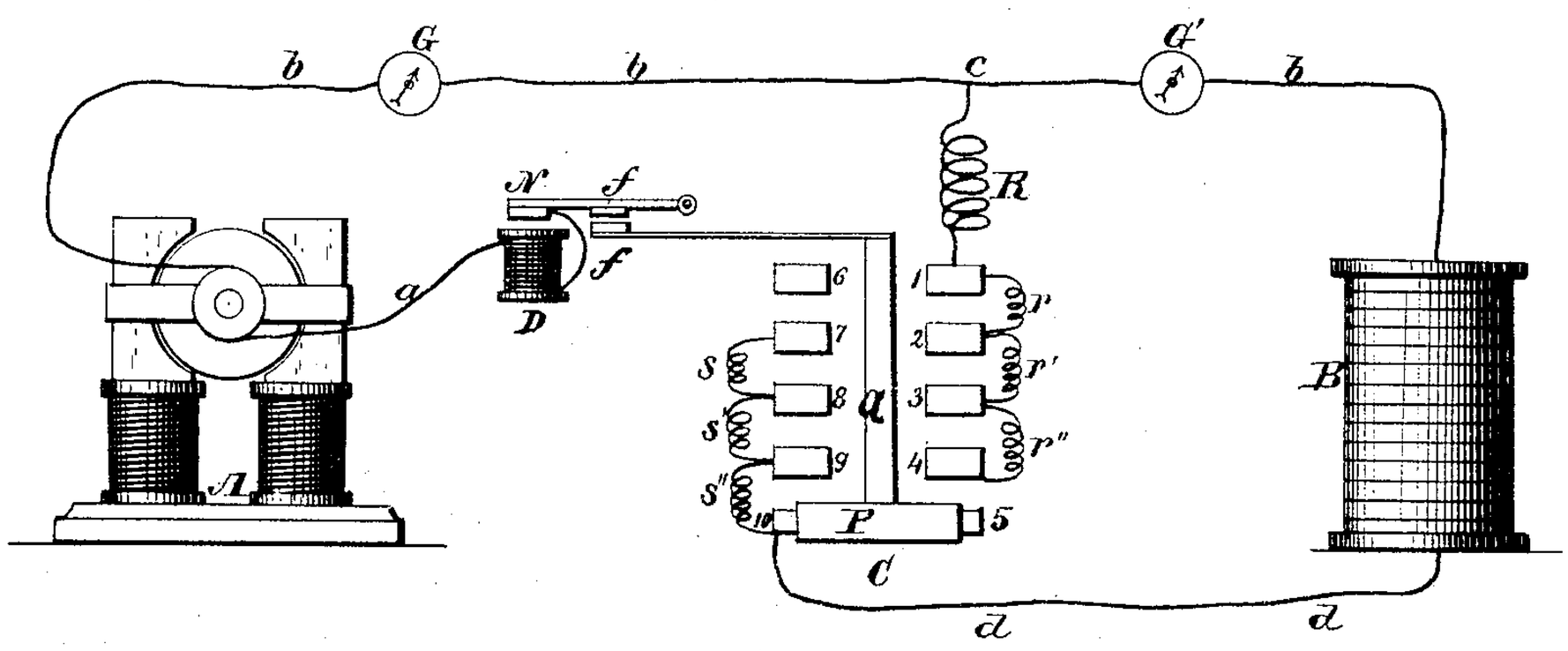
2 Sheets—Sheet 1.

E. THOMSON & E. J. HOUSTON.

Process and Apparatus for the Storage of Electricity.

No. 220,948. **Patented Oct. 28, 1879.**

Fig. I.



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2 Sheets—Sheet 2.

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Fig. 2.

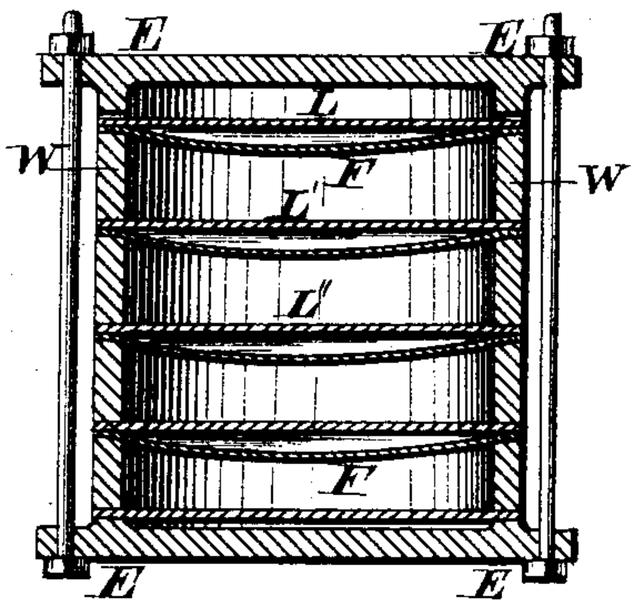


Fig. 3.

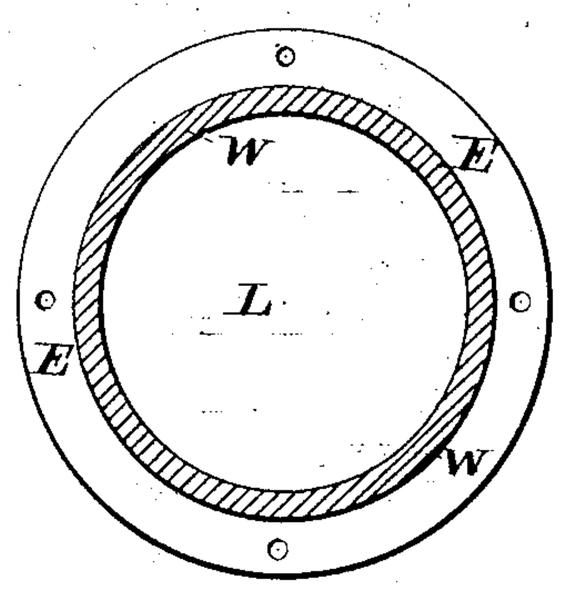


Fig. 4.

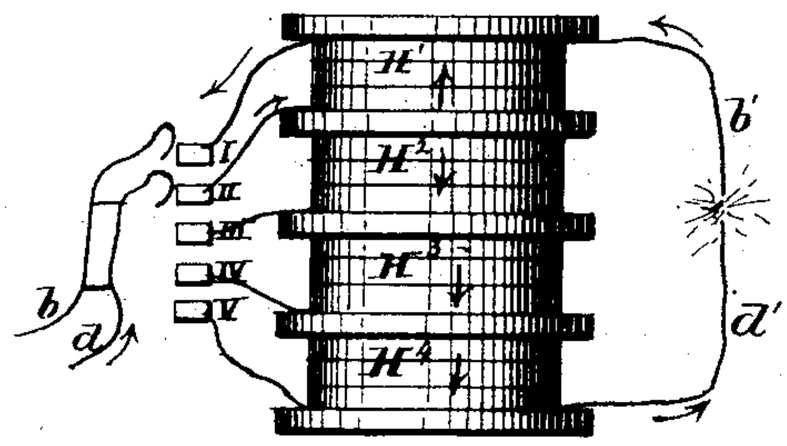


Fig. 5.

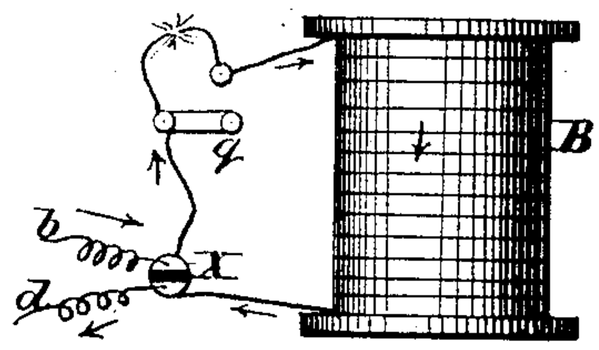


Fig. 6.

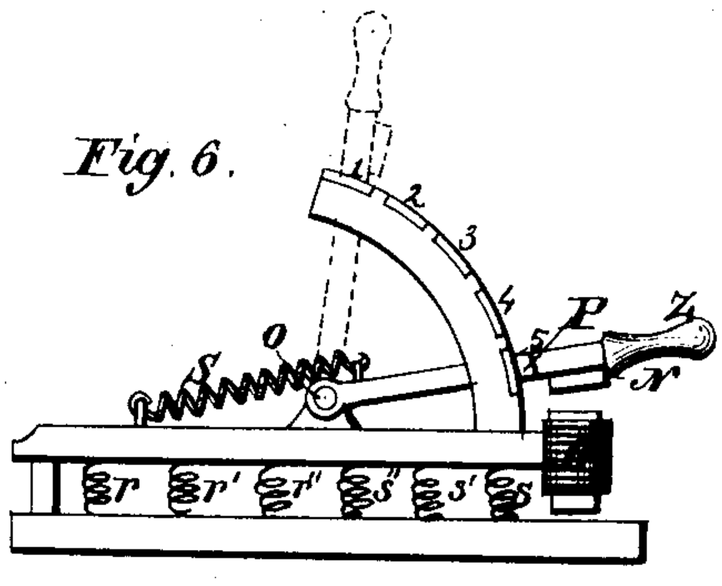
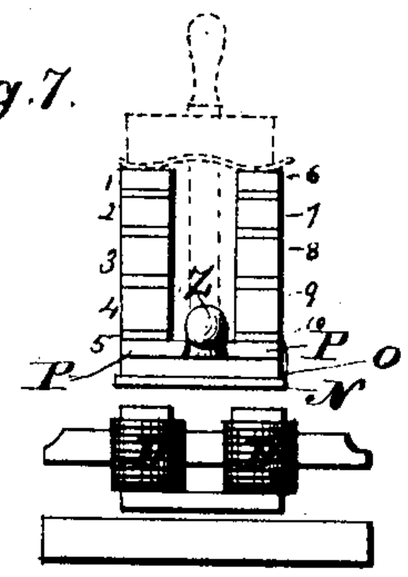


Fig. 7.



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UNITED STATES PATENT OFFICE.

ELIHU THOMSON AND EDWIN J. HOUSTON, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNORS OF ONE-THIRD OF THEIR RIGHT TO THOMAS H. McCOLLIN, OF SAME PLACE.

IMPROVEMENT IN PROCESSES AND APPARATUS FOR THE STORAGE OF ELECTRICITY.

Specification forming part of Letters Patent No. **220,948**, dated October 28, 1879; application filed May 21, 1879.

To all whom it may concern:

Be it known that we, ELIHU THOMSON and EDWIN J. HOUSTON, both of the city and county of Philadelphia, and State of Pennsylvania, have invented a certain Process and Apparatus for the Storage of Electricity, of which the following is a full, clear, and exact description; and we do hereby declare that the same is a full, clear, and exact description of our said invention, which will enable any person skilled in the art to which our invention pertains to use, make, and practice the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon.

The objects of our invention are to provide a means for storing electricity developed by dynamo-electric machines; to provide means for properly controlling the working of such machines, so as to prevent demagnetization or reversal of magnetic polarity both in starting and stopping said machine when used in connection with a storage-battery; to provide means to insure at all times the running of a dynamo-electric machine with its proper external resistance, and thus avoid damage to it and other parts of the apparatus that would otherwise result; to provide means for charging the storage-battery while said battery is furnishing current, and also to provide means, by the combination of a dynamo-electric machine and storage-battery, for procuring an electro-motive force greatly in excess of that which the machine alone is capable of producing.

The object of our invention may be stated, generally, to be to so employ a dynamo-electric machine under circumstances where the power used to drive the machine is intermittent or subject to fluctuations as to obtain an electrical current suitable to the performance of work requiring such current to be uninterrupted, or of nearly constant electro-motive force.

The purposes to which we apply our invention are chiefly as follows: In light-houses a dynamo-electric machine is provided, operated by suitable motive power at intervals during the day, the electricity from which is made, as provided by our invention, to charge storage-batteries, whose current is finally employed, either in conjunction with said dynamo-electric machine or separate therefrom, to operate suitable electrical-light sources.

In railroad-engineering a dynamo-electric machine is similarly run by the motion of the train, or the motive power derived from the locomotive-engine, to charge, as provided by our invention, storage-batteries placed under the train, and employed, when needed, for the operation of the head-light or other illuminating device, for electric-signal apparatus, or for other purpose.

In steamships part of the motive power is employed at intervals to drive a dynamo-electric machine, whose current is, as provided by our invention, employed to charge storage-batteries, the current from which operates the signal or other lights employed.

In manufactories, where the motive power is subject to interruptions, our invention provides a means of sustaining during said interruptions the illuminating power of the electric lamps employed therein.

Our invention is also applicable to the operation of dynamo-electric machines in conjunction with systems of telegraphic signaling.

In our system we employ a dynamo-electric machine in connection with a peculiarly-constructed switch and resistance-coils attached thereto, and a safety electro-magnetic circuit-opener, and in connection with a storage-battery embodying the principles of our Letters Patent for voltaic-battery cells, of even date herewith.

In certain cases we employ besides the above peculiarly-constructed commutators, to be hereinafter described.

We have found it necessary in charging a storage-battery by means of a dynamo-electric machine to bring said machine to its full normal condition as to developing current before making attachment to said storage-battery, since otherwise, should such storage-battery possess slight residual current-producing power, the slight magnetism of the dynamo-electric machine would be reversed, and the current obtained therefrom caused to flow in a direction contrary to that desired in the charging, or otherwise to defeat the object in view.

We also find that inconveniences arise when the dynamo-electric machine is placed upon closed circuit without external resistance, so that its magnets may become highly charged before its current is transferred to the storage-battery.

The inconveniences referred to are the excessive power required to move the machine when on closed circuit, the danger of injury by heating or burning, and the injury to the terminals of the machine resulting from the extra spark when said terminals are transferred to the circuit of the storage-battery. If, also, during the operation of the machine, any sudden stoppage of motive power occurs, as would be the case if the belt driving said machine should break or slip, the storage-battery being partly charged, a current would instantly flow through the machine, reversing its magnetism, giving its armature rotation in the opposite direction, and upon once more giving it motion in the proper direction the current, becoming the reverse of that required to charge the battery, would undo the work already accomplished in said charging. These and other disadvantages are overcome by means of our invention.

In the further description of the invention which follows, reference is made to the accompanying drawings, in which—

Figure 1 is an extended view of our complete apparatus. Fig. 2 is a section of the storage-battery. Fig. 3 is an end view of the same, one of the end plates being removed. Figs. 4 and 5 are exterior views of storage-batteries, showing special applications thereto, as hereinafter described. Figs. 6 and 7 are, respectively, a side and an end view of the switch.

Similar letters of reference indicate similar parts in all the figures.

A represents a dynamo-electric machine; B, a storage-battery; C, the switch and resistance; R, an electrical resistance, such as a coil of wire or a strip of some partial conductor equal to the proper external resistance for which the machine is normally used. A safety circuit-opener, D, is also provided, the function of which will be hereinafter described.

Galvanometers G G′ are interposed at convenient points in portions, respectively, of the circuit leading from the switch C to the machine A and to the battery B, as shown.

The switch C consists, essentially, of a movable rib of metal, P, in electrical communication with one of the wires leading from the machine A, said wire being marked *a a*. The other wire from said machine is led to one terminal of the storage-battery B, as shown at *b b b*, but is branched through the resistance R at *c*.

Metallic contact-plates 1 2 3 4 5, of any convenient number, are provided. Plate 1 is attached to that extremity of the resistance R not attached to the wire *b b b* at *c*, and also through a resistance-coil, *r*, to a second plate, 2, and this latter through a resistance, *r′*, to plate 3, plate 3 to plate 4 through *r″*, while the last two—viz., 4 and 5—are insulated from each other.

The terminal *d d* of the battery B has attached to it, in like manner, a set of conducting-plates, 7, 8, 9, and 10, and resistances *s*, *s′*, and *s″*, arranged in the inverse order to 1, 2, 3, 4, and 5, 10 being attached to *d d* and to 9, 8, and 7 through resistance-coils *s″*, *s′*, and *s*, while 6 and 7 are insulated from each other.

Plates 5 and 6 may be omitted when so desired.

To secure the best results, the resistances *r r′ r″* should be made unequal, *r* being less than *r′*, and *r′* less than *r″*, and should, together, be several times that of R. Similarly, the resistances *s″*, *s′*, and *s* should increase in the order named.

If the metallic rib P be placed so that its extremities rest on the plates 1 and 6, the battery B is cut out of the circuit of the machine A, and the resistance R is inserted. This position is given to the switch on starting the machine A, and the current it develops reaches that strength normal to it in passing through the resistance R, and thus the possibility of damage resulting from excessive current and from the excessive strain on the motive power, which would occur were the resistance R not employed, is avoided. The rib P is now moved so as to come into contact successively with the plates 2 and 7, with 3 and 8, with 4 and 9, and, finally, with 5 and 10. At this moment the resistance R is completely removed from the circuit of the machine A, and the resistance of the storage-battery B substituted; and while the gradual nature of the transfer has prevented any considerable change in the working condition of A, so also any burning of contacts in the switch C has been avoided. The necessity of these precautions in operating arises from the fact of the great intensity of the current flowing and the length of conductor through which it passes.

If, while the rib P is in contact with the plate 10, any accidental stoppage of the machine A should occur, as from the breaking or slipping of the belt, the battery B then discharges itself through the machine A, giving it motion and reversing its magnets.

To avoid such a discharge of the battery B, and consequent injury to the machine A, an automatic circuit-opener, D, Fig. 1, is provided, consisting of an electro-magnet whose coils are in the circuit of the machine, and the motion of whose armature N toward the magnet D closes the circuit *a a* by bringing into contact the conducting-points *f f*. A spring is provided, so that on the weakening, by any cause, of the currents developed by the machine, the armature of the electro-magnet D is released and the circuit broken at *f f*. When desired, the armature N of the magnet D, instead of breaking the circuit of *a a* at *f f*, moves instead, when actuated by a spring, the sliding piece P of the switch C, so as to cause said sliding piece P to rest in contact with plates

1 and 6, and thus remove the battery B from the circuit of the machine A. This modification of parts is hereinafter described in connection with Figs. 6 and 7.

When the storage-battery B is partially or wholly charged, and it is desired to stop the machine A, the sliding rib P is moved into contact with plates 1 and 6, thus taking the battery B out of the circuit and restoring the resistance R. The machine may now be brought to rest without detriment.

Galvanometers G G′ are preferably provided as indices of the direction and strength of the currents traversing the various circuits.

In order to secure compactness and simplicity of the storage-battery, we prefer to construct it as follows: A series of disks or plates, L L′ L″, Fig. 2, of copper or other suitable metal, are arranged one above another, and separated by rings W W, of earthenware, rubber, wood, or other properly-prepared substance not affording electrical contact between the copper plates. A convenient number of plates and rings are thus piled alternately and bolted firmly together between plates E E, as shown. The spaces between the copper disks L L′ L″, &c., are filled with a saturated solution of zinc sulphate, or similar salt. When the space between any two disks, L L′ L″, &c., is made small, we extend underneath said plates, and close to them, diaphragms F, of heavy felt. This is an improved construction of battery for which our before-mentioned Letters Patent, of even date herewith, are granted.

When the battery is subject to motion after or during charging—as, for example, in ships or cars—we fill the spaces between the plates with sand, broken pumice-stone, sawdust, or the like.

The new feature of the construction of the storage-battery, Fig. 2, consists in making the lower plate of one of the cells or divisions serve at the same time as an upper plate for the next lower cell or division in the series.

On connecting the lowest plate in the series with the positive terminal of a dynamo-electric machine, and the upper plate with the negative terminal, metallic zinc is, during the running of said machine, deposited on the under surfaces of the copper plates, except the lowest, and copper sulphate formed on the upper surfaces of said disks, except the uppermost. When this action has been carried on for a sufficient length of time the series of cells is charged, and then becomes a compact though powerful source of electrical current, the work of which may be recovered in the various forms of light, heat, mechanical motion, &c.

By combining a number of series, H′ H² H³ H⁴, Fig. 4, either alongside of or one above another, the operation of charging by the dynamo-electric machine can be effected contemporaneously with the discharge of the battery through its terminals *b′ d′*. In this case, at regular intervals in the series of cells, conducting-wires extend from the copper plates, the free extremities of which conducting-wires are placed in line upon an insulating support, and the terminals *b d* of the dynamo-electric machine, used for charging, are necessarily brought into contact with consecutive pairs of said terminals. The contact being effected, as shown in Fig. 4, between the terminal *b* of the dynamo-electric machine and I of the battery, and between *d* and II likewise, the current of the dynamo-electric machine passes upward through the section or series H′, thereby effecting those changes which we characterize as charging said section, and this charging operation is effected, moreover, without interfering with the strength of current being given out by the battery, for although the section H′ is not furnishing current, yet this deficiency is made up by the branching which occurs from the circuit of the dynamo-electric machine through the remaining sections that are active in generating current. Thus, while the section that is being charged is practically removed from action, yet its absence does not cause a decrease in the available current yielded by the battery. The charging operation is repeated for each of the sections H′ H² H³ H⁴ by simply changing the position of the terminals *b d* of the dynamo-electric machine.

Since by the method of charging above described but one portion of a series of cells undergoes the operation at one time, the electromotive force generated by the complete series may be very much in excess of that which the dynamo electric machine itself could produce. By this means we increase the light-producing capacity of any dynamo-electric machine, which may be run during the time that the light is not needed to partially charge the sections H′ H² H³ H⁴, &c., and may continue to be run during the use of said sections to prolong the duration of the charge.

The storage-battery B, Fig. 5, may, after the passage of the current of a dynamo-electric machine, be employed to furnish current either by itself or in conjunction with said machine. In the latter case the current of the machine, after having been made to traverse the battery B for charging it, is reversed by a commutator, X, and a light source or other working resistance introduced into the circuit at *q*. In this case the machine and battery intensify the effect of each other, and render possible the working through a higher resistance, as at *q*, than either alone could work through successfully.

Fig. 6 represents the construction of the switch C, Fig. 1, where P is attached to an arm pivoted at O, and the plates 1 2 3 4 5, Fig. 1, are arranged, as in Figs. 6 and 7, around the arc of a circle concentric with O.

The set of plates 6, 7, 8, 9, and 10, Fig. 1, are arranged parallel to 1 2 3 4 5, Figs. 6 and 7, separated from them by a slot, through which the arm carrying the sliding piece P, Fig. 7, passes. The resistance-coils *r r′ r″ s s′ s″* are placed below, as shown.

The electro-magnet D and its armature N, Fig. 1, are arranged as shown in Fig. 6, the armature being connected to the arm carrying the sliding piece P, so that when P is brought into contact with the pieces 5 and 10, Fig. 1, the armature N and magnet D hold it in that position. If, however, the current circulating through the coils of the magnet D becomes weakened, its armature N is released and the arm Z is moved by a spring, S, so as to bring the sliding piece P into contact with the pieces 1 and 6, Fig. 1, performing in this manner the functions of the circuit-opener described in connection with D and *f f*, Fig. 1.

Having described our invention, we claim as new and wish to secure by Letters Patent of the United States—

1. In a system of electrical storage, the hereinbefore-described method of bringing a dynamo-electric machine into circuit with a storage-battery, consisting in, first, bringing said machine to its normal condition of working by the interposition in its circuit of a resistance, R, and, secondly, in afterward transferring the current of the machine to the circuit of a storage-battery, substantially as set forth.

2. In a system of electrical storage, the combination of a normal working resistance, R, and a storage-battery, B, in the manner described, a gradual transfer of the current developed by a dynamo electric machine from the working resistance R to the circuit of a storage-battery, B, being effected by the successive addition to the resistance R of graduated resistances $r\ r'\ r''$ and simultaneous successive removals from the circuit of a storage-battery of graduated resistances $s\ s'\ s''$, substantially as set forth.

3. In a system of electrical storage, the combination of a normal working resistance, R, and a storage-battery, B, in the manner described, a gradual transfer of the current developed by a dynamo-electric machine from the circuit of a storage-battery to the working resistance R being effected by the successive introduction into the circuit of a storage-battery of graduated resistances $s\ s'\ s''$ and the simultaneous removal of graduated resistances $r''\ r'\ r$ from that branch of the circuit in which the resistance R is included, substantially as set forth.

4. In a system of electrical storage, for the purpose of preventing injury due to the discharge of a storage-battery, B, through a dynamo-electric machine on the weakening of the current-producing power of the latter from any cause, the combination of the electro-magnet D, placed in the common circuit of said machine and battery, with the sliding piece P, connected to the armature N of said electro-magnet, the whole being arranged to operate substantially as described.

5. In a system of electrical storage, a storage battery or reservoir consisting, substantially, of a series of metallic plates, L L′ L″, &c., placed one above another, and separated from one another by insulating material, W W, made in the form of rings or of other suitable figure, so that cellular spaces are provided between each pair of said plates L L′ L″, &c., for the introduction of a decomposable liquid substance, substantially as specified, and for the purposes set forth.

6. In a system of electrical storage, the method hereinbefore described of charging a storage-battery at the same time that said battery is furnishing an electrical current, or of equally charging said battery by a dynamo-electric machine whose electro-motive power is less than that yielded by the battery when charged, consisting in the division of said battery into sections $H'\ H^2\ H^3$, each of which sections is separately charged by the passage of the current from a dynamo-electric machine, and which sections act in conjunction with one another in furnishing current, substantially as set forth.

In testimony whereof we have hereto subscribed our names.

ELIHU THOMSON.
EDWIN J. HOUSTON.

Witnesses:
J. P. CHEYNEY,
S. CHADWICK.