A current is sent along the wire *a* (Fig. 2) from the observatory. It traverses the coils, issuing by wire *b*, and, during the first instant of time, takes its course along the conductor *o*, passing through iron wire and carbon, and by *d*, *f*, back to the battery. The needle, however, is immediately deflected (in the direction shown by the arrow) pulling down the little lever *s s*, which, oscillating on the edge of a small vessel of mercury, and bearing a branch from the wire *b*, completes a circuit of low resistance with the return wire *f*, a branch from which communicates with the mercury in the vessel. A current is now flowing free of the carbon. It may be balanced at D (Fig. 1), and the second operation commenced. This consists in switching the current by a commutator, so that it arrives by wire *f*, and returns by wire *a*. The current on arrival tends to restore the needle to the horizontal, pressing it against the stop P. This, also (being the best position for deflection), is designed to be its position of equilibrium; the counterpoise *s*, being utilised to this end. The needle being horizontal, the low-resistance circuit is open, and the current must pass through the carbon to return to the battery. It is then again balanced at D, and the resistance of the carbon accurately determined.

Turning to Fig. 3 we find that the instrument used at D (Fig. 1) consists of a deep vessel of mercury *a a*, communicating with a flexible reservoir A, which is under the control of the screw *s*. A scale is mounted on the vessel carrying a marker, *m*, which is movable on the screw attached to knob *k*; to the marker a thread of carbon, similar to that in the distant barometer, is attached, it is kept vertical and rigid by a small varnished platinum weight *n*, beneath the surface of the mercury. The marker is of ivory, and a binding screw, B, keeps the carbon in circuit, the circuit being completed through the mercury and iron wire I.

For equalising the resistances in the bridge, when the barometer is out of circuit, the screw S is turned, and the mercury thus raised or lowered on the carbon, till the galvanoscope returns to zero. This being effected, and the barometer restored to circuit, the galvanoscope is once more brought to zero by turning the knob K. The marker M now reads the height of the distant barometer.

The scale, in Fig. 3, may not really be one of inches and fractions of inches; it may have to be divided by experimentally comparing the two carbons. Probably it would be hopeless to expect them to be exactly similar in section throughout their entire lengths.

There are many ways of rendering this method of determining the height of a barometer by resistance more sensitive. It was suggested to me, for example, to double the effect on the resistance of any movement, by replacing the iron wire in the barometer by a second carbon. With this arrangement, moreover, if we still retain but the one carbon for equalisation (Fig. 3), the range is doubled, and the chances of errors correspondingly diminished.

Other meteorological instruments may also be read by this method. J. JOLY

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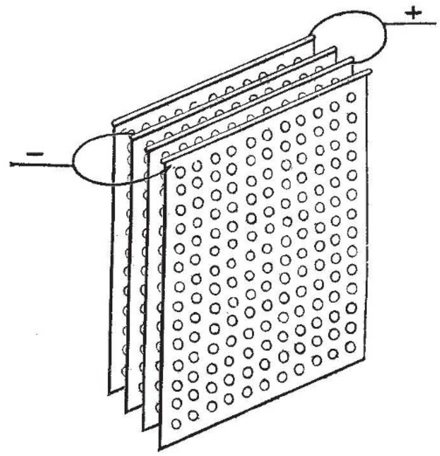
ELECTRICITY AT THE CRYSTAL PALACE

IV.—*Electrical Accumulators.*

THE new accumulator of Messrs. E. Volckmann and J. S. Sellon, exhibited at the Crystal Palace Electrical Exhibition, in connection with the Lane-Fox system of electric lighting in the Alhambra Courts, has already been announced, but its construction has hitherto been kept a secret for reasons of patent right. The storing-power of this new secondary battery may be gathered from the fact that 33 cells feed 201 Lane-Fox incandescent lamps, nominally of 20-candle power for 7 hours at a time, if the battery is fully charged to start with. The actual light of each lamp, however, is nearer 30 candles; and it is found that these lamps, which are designed to bear a 20-candle current from the generator, will stand a 30-candle current from the accumulator owing to its more uniform flow.

Each cell is stated to contain 5 horse-power of energy acting for an hour, or 1 horse-power for 5 hours, and so on. It consists of a series of metal plates of some alloy, each plate being $\frac{5}{16}''$ thick, and perforated with round $\frac{1}{2}$ inch holes, as close as they can be punched or cast. These plates are connected alternately in series like the plates of a condenser, as in the figure, and joined to two



stout terminals, which are the poles of the cell. The holes are filled with a metallic paste, the composition of which is not yet divulged, but may readily be guessed, from the fact that metallic lead is reduced on the negative plates, and peroxide of lead on the positive plates. The spaces between the plates, which are placed nearly an inch apart, are filled up with water mixed with one-tenth part of sulphuric acid, to give good conduction. The whole is contained in a wooden trough about 30 inches square and 8 inches in thickness. The weight of each cell is about 375 lbs., including 295 lbs. of the metallic composition which is the storing agent. The sparks given off on connecting several cells of the charged battery by a stout copper wire are remarkably violent, the deflagrated wire flying off in a perfect shower of red-hot sparks of copper accompanied by loud cracks. On examining the wire afterwards, it is found to be literally torn asunder in small pieces by the force of the discharge. A considerable quantity of hydrogen is evolved from the cells.

The exhibition of Lane-Fox lamps fed from this battery is without doubt the most beautiful display of incandescent lighting which has yet been made in this or any other country. This, however, is chiefly due to the designs of the ornamental lamps employed to show off the rich architecture of the Moorish courts. The arches of the courts are picked out with rows of lamps having bulb or opal glass, which give a very pleasing light, not in the least dazzling to the eye, but at the expense of 25 or 30 per cent. of the light. A crystal chandelier of the same kind of bulbs hangs in the Lion Court, and it is a moot point whether these opal globes, or globes of clouded glass are not best adapted for incandescent lamps in dwelling-rooms and studies. It is certain that the naked lights, though absolutely steady, have a dazzling effect on the eyes if looked at, which cannot but be injurious to the sight. The gems of the display are, however, three Mauresque electroliers designed by Mr. E. R. Johnson for Messrs. Verity Brothers, Regent Street. These large pagoda-like lanterns are hung in the inner courts, and the lights contained inside are only visible through the stained glass of the sides and bottom. The power of the lamps is ingeniously graduated by simply switching on or off more cells of the battery.

Rumours of at least two other secondary batteries of great promise are in the air; but it is not yet known what these are, and they have not been exhibited in action yet before the public. They are doubtless modifications of some or other of the ordinary voltaic batteries by which their action can be conveniently reversed, and the alteration patented. For it is obvious that the old combination pure and simple cannot be patented for a new purpose. It must be changed in some way or other, though the essential action may be pretty much the same.

The well-known Faure battery, which is exhibited by La Force et la Lumière Company, in the Western Corridor, still continues to excite a good deal of debate amongst the Faurites and anti-Faurites. The construction of the battery has already been described in NATURE, vol. xxv. p. 461; but some recent experiments by a group of French *savants* have contributed some further matter to the discussion of its merits, and as their results must be considered free from bias (which is perhaps more than can be said for all that has been written on the subject in this country) we shall give them in a condensed form.

The experiments were made at the Conservatoire des Arts et Métiers, Paris, by MM. Allard, Le Blanc, Joubert, Potier, and Tresca, in continuation of experiments begun during the latter part of the Paris Electrical Exhibition. The results were communicated by the authors to the French Academy of Sciences, on March 6. The battery consisted of thirty-five cells, of the new pattern, with plates rolled up together. Each cell weighed 43·7 kilograms, including the liquid. The lead plates were covered with minium to the amount of 10 kilograms per square metre. The solution was formed of distilled water, mixed with one-tenth of its weight of pure sulphuric acid. It will be seen that the cells were in the most favourable condition for experiment.

They were charged by a Siemens' machine, of which the armature resistance was 0·27 ohms, and the resistance of the inducing magnets was 19·45 ohms. The latter were excited by the current in a derived circuit from the main current in the armature. A species of voltameter was used to regulate this exerting current, so as to keep it between 2 and 3 ampères.

The object of the experiments was to measure—

1. The mechanical work expended in charging the battery.
2. The quantity of electricity "stored" during the charge.
3. The quantity of electricity yielded up during the discharge.
4. The electrical work actually done during the discharge.

It was also necessary to know, at each instant of the experiments, the electromotive force and the resistance of the battery; and further, as the discharge should make itself through a series of Maxim incandescent lamps, to study the variation of the resistance, and the luminous power of these lamps, according to the intensity of the current.

The mechanical work was measured by a totalising dynamometer, constructed for the French Society of Agriculture by Messrs Easton and Anderson, after the model belonging to the English Royal Society of Agriculture. The luminous intensity was measured by a Foucault photometer, such as was employed in the Exhibition experiments. As to the electric measures they were made by means of a Marcel Deprez galvanometer which measured the total current generated, and sometimes the exciting current on the magnet; a Siemens' electro-dynamometer which measured only the charging current; and a dial electrometer arranged according to a plan of M. Joubert, which gave the difference of potentials between the two poles of the battery. The indications of all the instruments were read off every quarter of an hour, sometimes at closer intervals.

The following table gives the principal results:—

TABLE I.—*Charge of the Battery*

Date.	Duration of experiments. h. m.	Speed of the dynamo.	Indicated work in kilogrametres.	Mean E.M.F. of the battery in volts.
January 4	5 30	1079	2,414,907	82·21
,, 5	7 0	1072	2,772,292	91·08
,, 6	7 30	1083	3,246,871	92·91
,, 7	2 45	1085	1,135,728	92·06
	22 45		9,569,798	
		Deduct	808,750	
			8,761,048	

(The work deducted was lost in the transmission of the indicated power to the dynamo.)

Date.	Duration of experiments. h. m.	Mean intensity of charging current in ampères.	Mean intensity of exciting current in ampères.	Quantity of electricity furnished by the battery in coulombs.
January 4	5 30	10·93	2·46	216,400
,, 5	7 0	7·97	2·81	200,800
,, 6	7 30	7·94	2·33	214.300
,, 7	2 45	6·36	2·18	63,000
	22 45			694,500

Date.	Duration of experiments. h. m.	Electric work of the charge in kilogrammetres.	Electric work of excitation in kilogrammetres.	Electric work of the ring in kilogrammetres.
January 4	5 30	1,814,600	408,400	94,400
,, 5	7 0	1,947,100	676,300	79,100
,, 6	7 30	2,028,800	596,100	76,800
,, 7	2 45	591,600	202,800	19,500
	22 45	6,382,100	1,883,600	269,800

The same determinations have been made during the discharge, observing at the same time the power of 12 Maxim lamps in a derived circuit. The light of a Carcel lamp was obtained from this experiment with an expenditure of 5·8 kilograms of electric work per second.

The following table gives the results for the discharge of the battery:—

TABLE II.—*Discharge of the Battery*

Date.	Duration of the experiment. h. m.	Mean E.M.F. of the battery in volts.	Mean resistance of the current in ampères.	Quantity of electricity in coulombs.	External electric work in kilogrammetres.
Jan. 7	7 19	61 39	16·128	424,800	2,608,000
,, 9	2 20	61 68	16·235	194,800	1,201,000
	10 39			619,600	3,809,000

The conclusion from these results is that between the quantity of electricity put into the battery (694,500 coulombs) and that got out (6,196,000 coulombs) there is a difference of only 74,900 coulombs, corresponding to a proportional loss of 10 per cent. (0·108). This refers, however, to the *quantity* of electricity, not, be it remembered, to the power stored. The electric work during the entire discharge was 3,809,000 kilograms. The mechanical work expended was 9,570,000 kilograms, but only 6,382,000 kilograms was really stored by the battery. It follows that the work recuperated or given back by the discharge of the battery is to that stored up, as 3,809,000 is to 6,382,000: that is to say, about 60 per cent. of the energy of the current was rendered up by the battery. If we compare the work recuperated with that indicated by the dynamometer, the percentage given back is still less, namely, 40 per cent.

This considerable loss of power, whilst the quantity of electricity is nearly the same in the charge and discharge, is due to the fact that there is a marked loss of electromotive force in the battery. Thus the charging current had 91 volts, while the discharging current had only 61·5 volts. It follows, from a consideration of the theory of the battery and the formula—

$$a = \frac{I'(E' - R'I')t'}{I(E - RI)t}$$

that the efficiency must always be less than unity, but may be greater as the intensities and resistances are less. In the formula, E is the E.M.F. of the battery, R its internal resistance, I and t the intensity of the current and its duration during charge, while the same letters marked serve for the corresponding quantities during discharge. It is therefore advantageous to charge the battery with a feeble current flowing for a long time. It was observed also, that the resistance of the battery was lower during discharge than charge.

To sum up, the charge of the battery requires a total mechanical work of 1·558 horse-power during 22h. 45m., which is equivalent to a horse-power during 35h. 26m. The battery only received 66 per cent. of the total work expended, the rest being lost in overcoming passive resistances, and exciting the field magnets. Only 60 per cent. of this power stored was yielded back by the battery, and there is reason to believe that the same result will be forthcoming in all applications similar to lighting by Maxim lamps.

THE WILD SILKS OF INDIA[1]

THE laudable efforts of the Indian Government to utilise the various products of which these wild silks form a class will tend, by the immediate production of wealth, and yet more by the spirit of intercommunication and enterprise thus created, to overcome the great difficulty of poverty and still greater difficulty of isolation, which so tasked its efforts in the last famine. And this work is the more desirable because, as the last census shows, the peaceful, firm rule of the British in India has removed that natural check to population which was found of old in the mutual internecine wars of its peoples; and numbers have increased to such an extent that the failure of a crop over any wide district is invariably followed now by a famine.

The principal varieties of wild silks found in India are the Tusser, or Tasar, the Eria, and the Muga, or Moonga, silks, besides several others, at present of little commercial importance.

Silk differs from all other materials used in textile fabrics in the nature of the thread as originally produced. Hemp, flax, cotton, wool, and many other threads are produced by the twisting tightly together of the short but very fine fibres of the raw material, the untwisting of which reduces the thread again to short loose fragments. The long fibre of the best Sea-Island cotton does not much exceed 1½ inches in length. Silk, on the other hand, is spun by the silkworm (except that it is not a worm, and does not spin it!) in one long thread: three-quarters of a mile is quoted by Mr. Wardle as the length of the thread of a Tusser worm. There is no "spinning" in the process at all, but two fine threads come from the spinnarets of the grub as from the spinnarets of a spider in such a glutinous semi-liquid condition that they coalesce into one thread, which, in the best kind of silkworms, can be wound without a break from the outside of the suspended cocoon to where the grub left off spinning and turned into a chrysalis. The silk-reeler does not, even in the coarse Tusser variety, reel off a cocoon of this singly, but from four to six together, whose gummy surfaces make them combine into a single thread still fine.

[1] "Handbook of the Collection Illustrative of the Wild Silks of India in he Indian Section of the South Kensington Museum," by Thomas Wardle. (Eyre and Spottiswoode, 1881.)

The Eria cocoon is not found practically so available for this treatment, but, in addition to the beautiful continuous thread of the Bombyx or Tusser silkworm, the waste part of their cocoons can be treated like the vegetable fibres (cotton, &c.) of which we spoke with equally good results as a textile material, and with nearly all the beauty of the perfect silk thread. For this purpose the whole of the cocoon of the Eria is specially available, and, instead of being carefully reeled off, it is cut up or torn into shreds by the carding machine, and then treated as a long staple cotton. This is known as spun silk, or by the more recent name of Schappe. If, however, the surface of such a thread is examined, even with small magnifying power, it will show the loose ends of the fibres sticking out in every direction; and although they are individually too fine to attract the attention of the naked eye, in combination they are quite patent to the finger and to the ear, a soft deadness resulting instead of the sharp whistle of the natural silk, on which are no fibres except the ends left by careless throwsters.

Another inferiority of spun silk, though not a great one in the ever-changing fashionable world of England, is that it has not the durability which distinguishes the continuous silk thread. Yet in India garments made from the former are handed down from mother to daughter!

The Tusser or Tusseh larva, whose coarse, strong thread is available for thrown silk, is a monster compared with the larva of the *Bombyx mori*, or common silk-worm, It measures 7 inches in length and 1 inch in diameter; the wings of the moth—a very handsome one—are 7 inches across, and the thread also is three times as coarse, and three times as strong as that of the China silkworm. Here, however, comes an objection to it in the eye of the manufacturer. While the thread of the Bombyx is almost round, the extra coarseness of the Tusser thread all consists in its extra width: it is, in fact, three times as broad as it is thick. Like any thread of this shape compared with a round one, it has a great tendency to split, and consequently become rough in working. Another difficulty to both reelers and dyers is caused by the substantial way in which the Tusser grub forms its cocoons. Major Coussmaker observes that—

"As the chrysalis remains in the cocoon as long as eight months, exposed to the hottest sun and occasional thunderstorms, the cocoon had need to be made a hard impenetrable material; so indestructible is it, that Bheels and other tribes which live in the jungles, use the cocoon as an extinguisher to the bamboo tube in which they keep the 'falita' or cotton tinder used by them for lighting their tobacco and the slow matches of their matchlocks. The cocoon is also cut into a long spiral band, and used for binding the barrel of matchlocks to the stocks, being, as the natives say, unaffected either by fire or water. . . . . After the caterpillar has spun a layer of silk thick enough to conceal itself, it discharges some kind of gum or cement, thick like plaster of Paris, and with its muscular action it causes this secretion to thoroughly permeate the whole cocoon and solidify the wall. In this manner it goes on spinning layer after layer of loops, and cementing them altogether until the whole of its silk is exhausted, and the wall of the cocoon becomes so hard that it requires a sharp penknife to cut through it" (pp. 18, 19).

Again, in a later report (February 21, 1880), Major Coussmaker writes:—

"One of the most interesting, and I think important, facts that I have this year been able to prove, is with regard to the composition of the cement with which the caterpillar hardens its cocoon. Former analyses of this agent made for me, in England by Dr. Taylor, and in Bombay by Dr. Lyon, had shown that it contained the acid urate of ammonia, that it was in fact excrementitious; and this year, by opening the cocoons at various intervals, I was able to convince myself of the fact that when the caterpillar has left off feeding and begins to spin, it voids