advance had moved eastward, to be felt over the British Isles from the 17th to the 21st of the month, and after it a rapid fall of the barometer. The isotherm of 32° reached from the southern coast of North Carolina well offshore, thence northward to the coast of Maine, and from central Maine eastward across Cape Breton Island and southern Newfoundland. From the south-eastern to the north-western portion of the chart, the shades of color showed a difference of temperature of more than 80° (from above 70° to below—10°); but such great differences of temperature and pressure could not last long, and the normal conditions were gradually restored.

ELECTRICAL SCIENCE.

Atmospheric Electricity.

THE *London Electrician* contains an abstract of a paper by Prof. L. Weber which is of interest. He erected two insulated conductors on the top of the Riesengebirge; but he says, that, curiously enough, since they have been put up, they have never been struck by lightning, although before their erection lightning-flashes were continually occurring. He also made some kite and balloon experiments, in connection with which he goes at considerable length into the question of the effect of the conducting-string in altering the electrical condition of the circumjacent air layers, and also considers the effects due to a long conductor completely insulated from the earth, and without discharging-points; a similar conductor, with slight power of discharge along its whole length; an insulated conductor, with strong discharge-power (e.g., a flame) at the upper end; and other similar and more complicated cases. His kite-string was really a steel wire. The discharge-points of the kite consisted of 400 needle-points. In other cases he had the tails of the kite made of silver paper for the same purpose. The potential was measured by the length of sparks; the current, with a galvanometer. The latter varied in general from .07 to 2.5 micro-ampères. The potential varied generally from 3,000 to 10,000 volts. When thick clouds were overhead, there were no appreciable sparks, the strongest sparks being obtained when the zenith was either quite clear, or when cumulo-stratus clouds appeared. With potentials of 11,000 and 20,000 volts, currents of 4 and 8 micro-ampères were obtained.

INCANDESCENT LAMPS WITH ALTERNATING AND DIRECT CURRENTS. — Professors Ayrton and Perry have carried on a series of experiments to determine whether the efficiency of incandescent electric lamps is the same when supplied with alternating currents and with direct currents. The following table gives the results of measurements on four different lamps: —

Lamp.	No. of Experiments made.	Watts per Candle. White Light.			
		Continuous.		Alternating.	
1	20	3.053		3.033	
		Green Light.		Red Light.	
		Continuous.	Alt.	Continuous.	Alt.
2	19	2.597	2.534	3.100	3.100
3	20	2.935	2.966	3.254	3.164
4	16	2.900	3.073	3.504	3.477
Mean of last three experiments..		2.811	2.857	3.286	3.247
		Continuous.		Alternating.	
Mean of all results............		3.049		3.0497	

These results show, that, as far as the economy of the lamp is concerned, the efficiency of the two systems is about the same. What the life of the lamp would be with alternating currents is a matter which has yet to be decided. Considering the rapidity with which small wires respond in temperature to changes in current, it might be, when the period of the alternating current is not extremely rapid, that the filament of a lamp supplied by such a current would be at times at a much higher temperature than the average, at other times at a lower temperature. If this were the case, we would expect that the life of a lamp supplied in this way would be less than that of the same lamp fed by a continuous current. With 300 reversals a second, however, the temperature would vary but little, and there is no reason that the life of the lamp should not be the same with continuous and alternating currents.

POLARIZATION OF PLATINUM PLATES. — Mr. C. H. Draper has experimented on the electro-motive force of polarization between platinum plates immersed in dilute sulphuric acid, for different strengths of current passing between the plates, and with different temperatures. It is well known, that, if an electric current be sent between such plates, an electro-motive force of polarization is produced, in a direction opposite to that of the impressed electro-motive force, and of a value something in the neighborhood of one and a half volts. Mr. Draper tried to find if this opposing electro-motive force was independent of the current and temperature, and, if not, in what way it varies with them. The conclusions at which he arrives are as follows: 1. The opposing electro-motive force of polarization which arises in cells when at work depends on the value of the current passing through them when that current is below a certain value, increasing, but more and more slowly, with the current; 2. There is a maximum value of the polarization regarded only as a function of the current strength, beyond which any increase in the strength of the current has no effect upon it; 3. The electro-motive force of polarization varies with temperature, its value decreasing about one per cent for a rise of temperature of 40°.

ELECTRIC MINING ROAD AT LYKENS. — Among the interesting applications of electricity to mining-work, the electric road in the coal-mines at Lykens, Penn., is one of the most successful. It has been pointed out in this journal that electricity offers especial advantages for use at mines where fuel is scarce and water-power of easy access, as in the silver and other mines in our Western territory; but, besides the decreased cost of fuel, the ease with which electric motors can be used in almost any position, under conditions that steam-engines could not meet, makes electric transmission still more valuable. In coal-mines the cost of fuel is, of course, a small item; but the greater safety, efficiency, and flexibility of a system of electrical distribution, as compared with a number of steam-engines, give it an advantage which must soon be recognized. In the Lykens Valley Mines there has been used for some time an electric-motor car to take the place of mules for hauling cars from the mine. The length of the road is 6,300 feet; the weight of the locomotive, 15,000 pounds; the largest load it is capable of handling, 150 tons; the speed, 6 to 8 miles per hour. A second road on the same general plan is being equipped for the same company. The system employed is the Schlesinger.

DESIGNING DYNAMO-ELECTRIC MACHINES. — Until very recently the designing of dynamo-electric machinery was an empirical matter. The practice was to roughly guess, from the dimensions of some similar machine, about what the dimensions should be to give the required output, and, after the dynamo was built, to change the number of revolutions or the winding of the field-magnets until the required conditions were fulfilled. Sometimes even this would not suffice to bring the machine to its output, in which case another was built. In the last two years the papers of Mr. Kapp and Dr. Hopkinson, together with the growing habit of treating a magnetic circuit in the same way that ordinary electric circuits are treated, introducing the idea of magnetic resistance, have greatly increased the certainty with which dynamos may be designed. In fact, from experiments on one machine of a type, we can design another of the same type to give any required output, with considerable accuracy. While this is not generally recognized in this country, it soon will be, and a great deal of expense and energy will be saved; besides which, a consideration of the magnetic resistance of various parts of the magnetic circuit of a dynamo should improve the designs of machines now being built. The best dimensions to give the different parts of any dynamo is a perfectly definite problem, involving, besides questions of electrical efficiency, questions of the cost of the iron and wire and labor. However, the problem can be solved, and each maker of dynamos should have it solved. In a recent paper, Professors Ayrton and Perry have considered the magnetic circuit of dynamo machines, and have arrived at some important conclusions. Considering the resistance of the magnetic circuit, they find, that, when a machine is working at its best permanent output, its iron magnetic resistance plus the air magnetic resistance of the clearance is equal to the air magnetic resistance of the space on the outside of the armature occupied by the winding. The paper of Professors Ayrton and Perry, with those above mentioned, will greatly aid in the improvement of dynamo-electric machinery.

MENTAL SCIENCE.

The Relative Legibility of the Small Letters.

READING is one of the most widespread of modern activities, and the endless multiplication of books and cheap editions makes a study of the factors of this process of great importance. In the end the process reduces to the differentiation of black or colored marks on a white or colored surface. 'Black on white' is current as an expression for clearness, leaving the question of the shapes of the letters as the important one. Inasmuch as the Roman alphabet is in use for the chief languages of civilization, and a large majority of the characters are formed by the small letters, the investigation of the forms of these letters is naturally the point of prime value. If by any means we can make the reading of these letters an easier task, the improvement, however minute, when multiplied by the number of times the letter is read, will be very great. This is, however, not the only consideration. Tint and quality of paper, length of lines and spaces between them, the size of the letters and their distances from one another, — all affect the legibility. The end to be aimed at is to attain "the greatest legibility to the square inch," with due regard to taste and economy. The solution of this problem has been experimentally attempted by Dr. Javal and by Dr. Cattell, and has recently been again studied with improved apparatus by Mr. E. C. Sanford (*American Journal of Psychology*, May, 1888).

The first method of obtaining an order of legibility of the letters consisted in measuring the distances at which they could just be read. The letters were fastened to the edge of a rotating disk, and were viewed through a square hole of 2 centimetres, in a black screen placed in front of the disk. Test-type letters of a clear bold pattern were used, the short letters being about 1.8 and the long letters about 2.2 millimetres high. The whole apparatus was mounted on runners sloping upwards from the floor at an angle of about fourteen degrees, and could be moved to any distance from the eye by pulling an endless cord.

The first method of these distance-tests consisted in showing the letters at a fixed distance for the whole alphabet, and noting the number of times each letter was rightly and wrongly named, as well as the letters with which it was liable to be confused. Another fixed distance is then chosen, and the test repeated. The result, with five subjects and the letters at distances varying by 10 centimetres from about 1.5 to 3.2 metres, was as follows, the numbers expressing the percentage of cases in which the letters were correctly read : —

m, 90.9	*v*, 71.0	*x*, 63.0	*n*, 46.2
w, 88.1	*k*, 70.9	*a*, 60.8	*e*, 46.2
f, 84.4	*b*, 70.4	*i*, 60.6	*c*, 45.1
p, 84.3	*y*, 70.4	*l*, 58.6	*o*, 44.9
q, 80.9	*h*, 69.9	*u*, 55.2	*z*, 34.1
r, 78.7	*d*, 68.3	*s*, 53.0	
j, 77.6	*g*, 68.2	*t*, 46.5	

These percentages are based on about three hundred answers for each letter, the preferred letter being counted as the only answer in cases of doubt between two or more letters.

From the same record we can obtain an order of the liability of the letters to confusion and the chief causes of confusion. This order is substantially the same as the former, and would be still more closely like it were it founded on precisely the same data. The order, with the letters most likely to be confused with them, as well as the percentages of cases in which the confusion occurred, are given below : —

m	with	*w*, 52.	*h*	with	*b*, 51.
w	"	*v*, 53.	*x*	"	*n*, 19; *z*, 15.
p	"	*r*, 44.	*a*	"	*u*, 16; *n*, 14; *s*, 13.
f	"	*r*, 37.	*s*	"	*n*, 14; *cr*, 12.
r	"	*v*, 22.	*l*	"	*i*, 39; *j*, 36.
q	"	*g*, 30.	*u*	"	*a*, 18; *z*, 12.
j	"	*l*, 25; *f*, 21.	*i*	"	*l*, 58.
v	"	*r*, 33.	*t*	"	*i*, 40.
y	"	*p*, 61.	*n*	"	*a*, 41.
d	"	*ag*, 22.	*e*	"	*c*, 40.
g	"	*r*, 12; *t*, 10.	*z*	"	*e*, 19; *s*, 17; *a*, 16.
b	"	*h*, 45.	*c*	"	*e*, 34; *o*, 23.
k	"	*x*, 34.	*o*	"	*c*, 34; *e*, 23.

Mr. Sanford also tested the letters by setting them so far away that they could not be read, and then having the subject slowly draw them near until he could read them; in general, recording both the distance at which the subject would first hazard a guess, and the distance at which he felt confident that he had correctly read the letter. Here differences in eyesight of the subjects tested make average results meaningless, but the order for any one subject agrees fairly well with that obtained by the other test. If the letters be divided into three groups of eight, ten, and eight,— calling those in the first group good, those in the second fair, and in the third poor, — all the orders agree in making *w*, *m*, *q*, good; *b* and *x*, fair; and *z*, *o*, *c*, *s*, *e*, poor: and the balance of the evidence goes to make the good letters, *w*, *m*, *q*, *p*, *v*, *y*, *j*; the ten fair ones, *h*, *r*, *d*, *g*, *k*, *b*, *x*, *l*, *n*, *u*; and the eight poor ones, *a*, *t*, *i*, *z*, *o*, *c*, *s*, and *e*.

By an ingenious apparatus a dark box in which one of the letters was set could be illuminated for a very minute yet accurately measurable time, and the proportion of cases in which each letter could be correctly named when seen for a definite fraction of a second would again measure its relative legibility. The letters were exposed for times varying from .0013 to .004 of a second, and each letter was shown about two hundred times. A table comparable with that for distance is given below : —

m, 82.	*p*, 61.	*h*, 47.	*n*, 34.
w, 73.	*k*, 61.	*r*, 43.	*e*, 33.
d, 67.	*f*, 58.	*x*, 42.	*s*, 27.
q, 66.	*b*, 52.	*t*, 39.	*c*, 26.
v, 63.	*l*, 49.	*o*, 39.	*z*, 23.
y, 62.	*i*, 48.	*u*, 38.	
j, 61.	*g*, 47.	*a*, 35.	

The order of legibility by the two methods agrees very well, and yields the important conclusion that the letters read at the greatest distance are also the letters most rapidly recognized at an ordinary distance. The order for the two methods, as well as that found by Dr. Cattell by a different mode of time-measurements, are : —

Order for time,	*mwdqvyjp*	*kfblighrxt*	*ouanescz*
Order for distance,	*wmqpvyjf*	*hrdgkbxlnu*	*atizocse*
Order for time (Cattell),	*dkmqhbpw*	*uljtvzrofn*	*axyeigcs*

It so happens, that, of the eight letters most fully represented in a full font of type, three (*e*, *a*, *s*) are the very letters that all the tests agree in regarding as the worst, and six (*e*, *a*, *s*, *o*, *i*, *t*) are among those regarded as poor by two of the results.

Among the deductions formed from this study are, that the concentration of differentia is an important aid to clearness, while the lack of it leads to confusion. Thus, *b*, *d*, *p*, *q*, are all made of a straight stem and a loop, and yet are easily distinguished (except that *b* is confused with *h*); while *g* and *a*, though having few points in common with other letters, are confused with several. The group of confusables (*e*, *o*, *c*) should be differentiated, the *c* being left wide open, and some other form, such as the Greek ε, or an E with square corners, substituted for *e*: *u*, *n*, *a*, should be similarly treated; *u*, *a*, *n*, having their openings kept well open, and *a* changed perhaps to an inverted *v*; *s*, too, needs reform, and a shape