The *a priori* theory of the constant temperature of the crater is so attractive, that the author is inclined to attribute this phenomenon, not to any actual change of the luminosity of the crater, or to any wandering of the luminous area, as is seen with a long, unsteady arc, but to the refraction of the light by heated vapour. All experiments, such as enclosing the arc in a small chamber of transparent mica, or the use of magnets, or an air blast, have failed to produce any effect. A distortion of the image of the crater while the patch revolves, has been looked for, but nothing distinguishable from changes of luminosity has been seen.

An unexpected difficulty is thus introduced in the use of the arc as a standard of light, and one which may interfere with its use under some circumstances as a steady and continuous source of light. The author is further examining this phenomenon, with the view of ascertaining its nature, and of finding practical conditions under which it is absent or negligible.

VIII. "The Electric Strength of Mixtures of Nitrogen and Hydrogen." By Miss P. G. Fawcett. Communicated by Professor J. J. Thomson, F.R.S. Received June 21, 1894.

The experiments described in this paper were undertaken at Professor Thomson's suggestion, and have been carried out with the advantage of his advice and help.

The immediate object of the experiments was to determine the electromotive force required to produce a spark between two flat parallel metal plates in a mixture of hydrogen and nitrogen in different proportions and at different pressures.

The hydrogen used was obtained by electrolysis of water, as it was found that that obtained in the ordinary way from zinc and hydrochloric acid was liable to contain impurities which seriously affected its electric strength.

The two gases were collected over water in a graduated cylindrical gas-holder, and were allowed to stand for some hours to give them time to mix before being put into the apparatus. The mixture was passed through sulphuric acid, and also through cotton wool to remove dust.

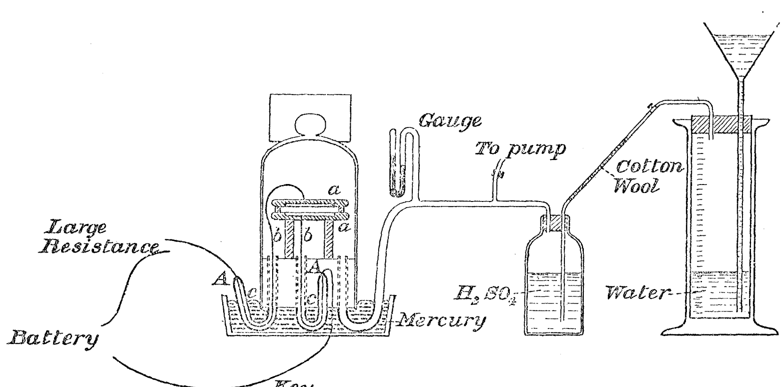
The electromotive force was supplied by a battery of storage cells, each of about 2 volts, and was measured simply by counting the number of cells. The strength of the cells was measured by a quadrant electrometer.

At very low pressures it was found that, unless special precautions were taken to prevent the discharge passing anywhere except between

the opposed faces of the plates, it would take a longer path, and pass between the connecting wires on the backs of the plates. When the distance was 0·047 in., the discharge began to pass between the backs of the plates when the pressure was reduced to about 2 mm.

In the later experiments this was prevented by using plates embedded in ebonite discs, only leaving exposed the faces between which the spark was intended to pass, and by making the connexions with indiarubber covered wires. Even then, after the plates had been used for some time, the indiarubber showed signs of giving way, and a discharge occasionally passed partly between the wires and partly between the plates.

The plates were kept at the right distance apart by placing between them small flat pieces of ebonite of the same thickness (0·047 in.). In the earlier experiments, the plates were in an ordinary bell-jar standing on a flat surface, the rim being greased with a mixture of bee's-wax and vaseline. Thinking it possible that there might be some vapour given off by the grease, I arranged the apparatus so that it could be made air-tight without grease. For this purpose I used a rather narrow bell-jar, closed at the bottom by an indiarubber stopper, through which passed three glass tubes for conveying the connecting wires, and for communicating with the air-pump and the gas-holder. The jar, with its stopper, was placed in a vessel containing mercury, so that the junction of the glass and indiarubber was immersed, the tubes being bent so that their ends came above the mercury. The arrangement is shown in the accompanying figure; *a*, *a* are the ebonite discs in which the plates are embedded; the wires,



b, *b*, pass through the ebonite, and are covered with indiarubber throughout their length until they come out into the open air at the ends, A, A, of the tubes, *c*, *c*, which are sealed with sealing-wax.

1 : 0.		2 : 1.		3 : 2.		1 : 1.		2 : 3.		1 : 2.		0 : 1.	
Pr.	E.M.F.	Pr.	E.M.F.	Pr.	E.M.F.	Pr.	E.M.F.	Pr.	E.M.F.	Pr.	E.M.F.	Pr.	E.M.F.
24	586	15	466	$17\frac{1}{2}$	508	$14\frac{1}{2}$	432	$18\frac{1}{2}$	480	27	536	25	488
$15\frac{1}{2}$	480	10	388	12	436	10	396	$14\frac{1}{2}$	444	17	476	17	456
$9\frac{1}{2}$	406	$7\frac{1}{2}$	368	8	400	7	378	$11\frac{1}{2}$	424	11	450	$10\frac{1}{2}$	442
$5\frac{1}{2}$	366	$5\frac{1}{2}$	370	5	396	5	382	$9\frac{1}{2}$	404	7	428	$7\frac{1}{2}$	460
$3\frac{1}{4}$	366	$3\frac{1}{2}$	386	$2\frac{3}{4}$	774	3	428	$6\frac{1}{2}$	380	4	440	$4\frac{1}{2}$	700
$1\frac{1}{2}$	1400	$2\frac{3}{4}$	470	$2\frac{1}{4}$	1200	2	560	4	462	2	720	$1\frac{1}{2}$	980
$13\frac{1}{4}$	460	$1\frac{3}{4}$	800			22	500	2	above 1600	$1\frac{1}{2}$	940	$17\frac{1}{2}$	440
10	426					16	458					$9\frac{1}{2}$	420
7	370					10	416					$5\frac{1}{2}$	500
$4\frac{1}{4}$	366					$3\frac{1}{2}$	520						
2	1400					$14\frac{1}{2}$	452						
						8	416						
						$2\frac{1}{2}$	552						
						2	above 1180						

The figures at the top give the ratio of the volume of nitrogen to that of hydrogen.

The results (p. 265) were obtained when no grease* was present, and the spark was not able to pass except between the opposed surfaces of the plates.

Distance between the plates = 0·047 in.

These results are represented by the continuous curves figs. 1—7, in which the abscissæ represent the pressure in millimetres of mercury, and the ordinates the E.M.F. in volts. The dotted curves in the same figures represent the means of the results of several series of observations with the earlier arrangement of the apparatus, in which grease was present, and no precautions were taken to prevent the discharge passing otherwise than between the plates.

FIG. 1.

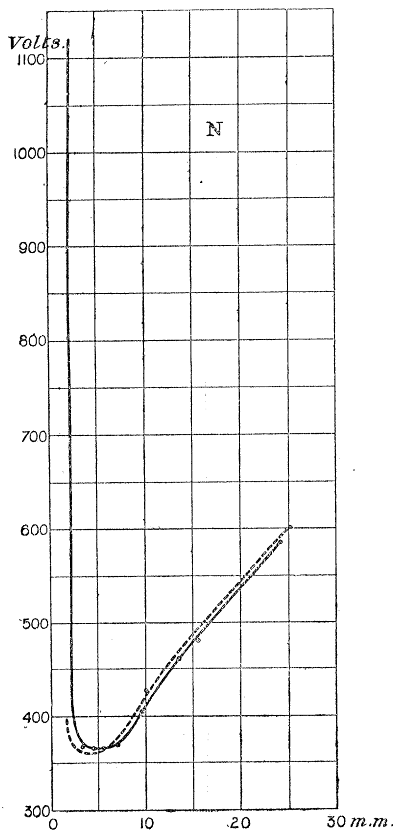
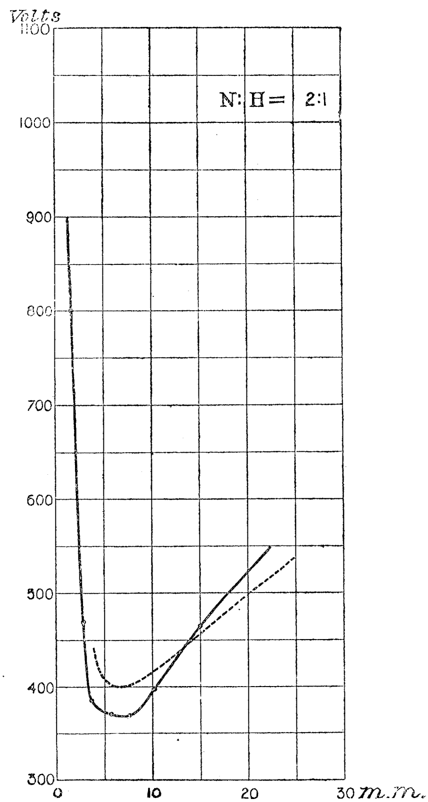


FIG. 2.



* There was always a small amount of grease on the stop-cock of the air-pump, but it does not seem probable that such a small quantity would have an appreciable effect.

Fig. 3.

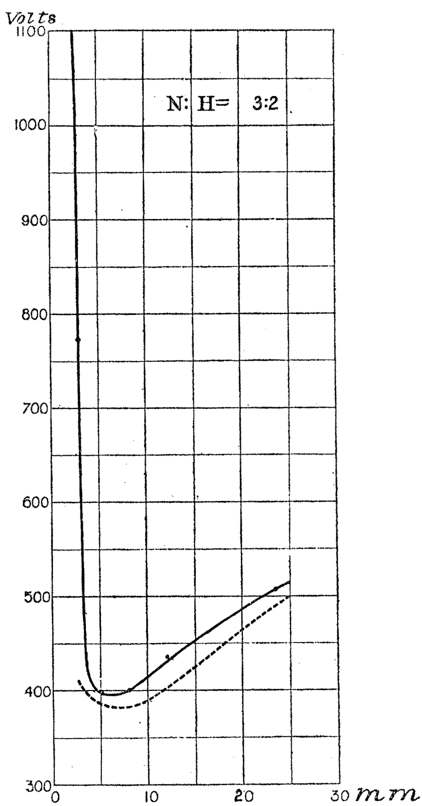

Volts
1100
1000
900
800
700
600
500
400
300
N: H= 3:2
0
10
20
30 mm

Fig. 4.

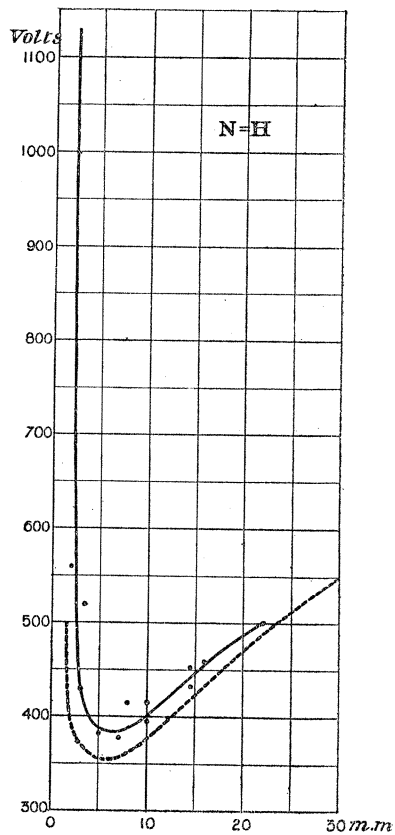

Volts
1100
1000
900
800
700
600
500
400
300
N=H
0
10
20
30 m.m

Fig. 5.

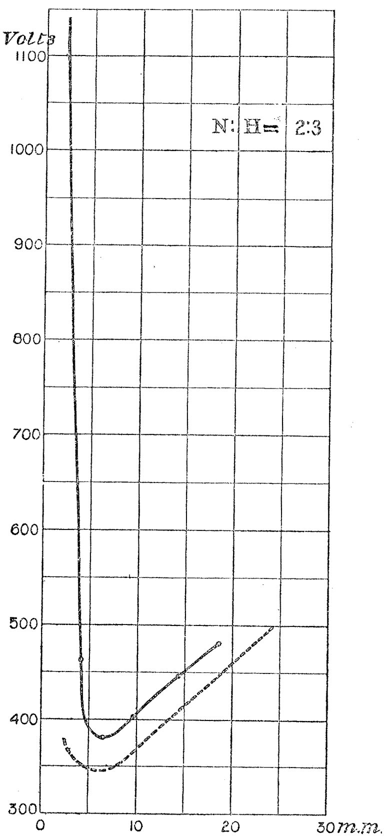

Volts
1100
1000
900
800
700
600
500
400
300
N : H = 2:3
0
10
20
30 m.m.

Fig. 6.

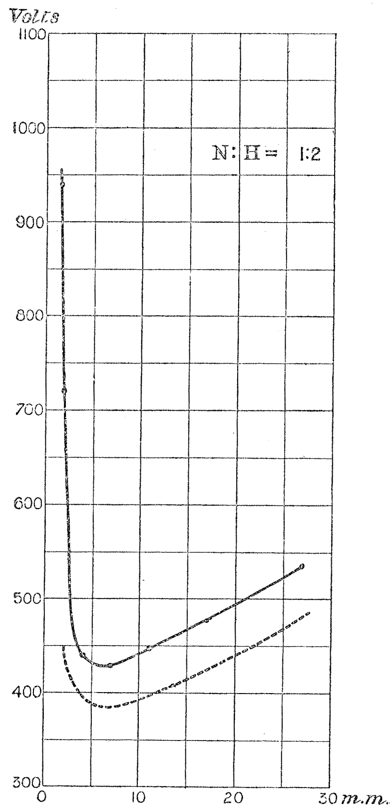
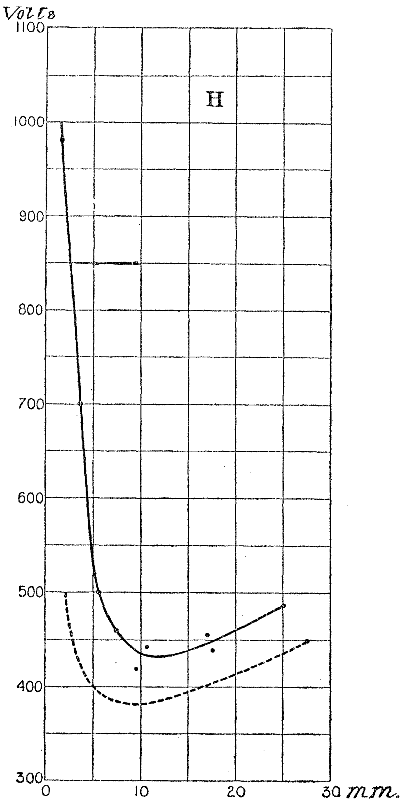

Volts
1100
1000
900
800
700
600
500
400
300
N : H = 1:2
0
10
20
30 m.m.

FIG. 7.



These curves are not traced for pressures lower than about 2 mm. The two curves are nearly identical in the case of pure nitrogen; in the other cases, with one exception, that of N : H = 2 : 1, the discharge seems to pass more easily when grease is present.

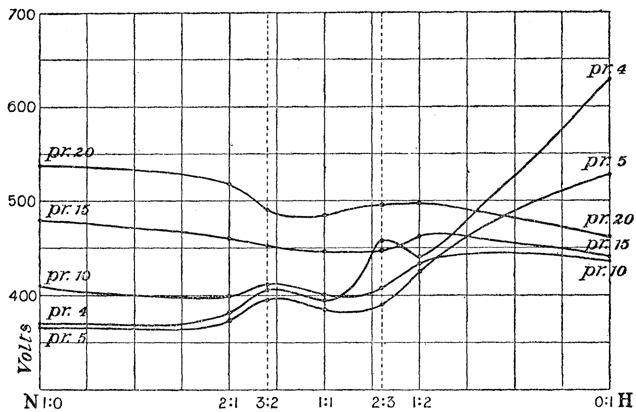
It will be noticed that at fairly high pressures the E.M.F. required to produce a spark diminishes nearly uniformly as the pressure diminishes, but that there exists for each mixture a critical pressure at which the E.M.F. is a minimum, and that as the pressure diminishes from the critical value the E.M.F. continually increases. When the pressure is slightly less than the critical pressure the E.M.F. increases with remarkable rapidity as the pressure diminishes. In fact, as the pressure falls by about $\frac{1}{2}$ mm. the E.M.F. may increase by several hundred volts.

The critical pressure diminishes as the proportion of nitrogen to

hydrogen is increased. With spark length 0·047 in. it varies from about 11 mm. in pure hydrogen to about 5 mm. in pure nitrogen.

At high pressures the E.M.F. required to produce a discharge at a given pressure diminishes continually as the proportion of hydrogen to nitrogen is increased. At low pressures the relation between the composition of the mixture and the E.M.F. required to produce a spark at a given pressure is less simple. It is represented by the curves in fig. 8, where the ordinates give the E.M.F. in volts, and the ratio in which the ordinate divides the line NH is equal to the ratio of the volumes of nitrogen and hydrogen in the mixture.

FIG. 8.



The curves are given for pressures of 20, 15, 10, 5, and 4 mm. They could not be considered accurate for lower pressures, owing to the extreme steepness of the curves (1—7), in consequence of which the E.M.F., which will produce a spark at a given low pressure, cannot be determined with any precision.

It will be seen that at the pressures 15 and 20 mm. the general slope of the curves is downwards from the nitrogen end to the hydrogen end, but that at pressures 10, 5, 4 the slope is the other way, showing that at low pressures the effect of introducing more hydrogen is in general to increase the electric strength of the mixture.

But as the proportion of nitrogen to hydrogen increases from 0 : 1 to 1 : 0, the electric strength does not diminish uniformly, but it may pass through one or more maxima and minima.

It is, perhaps, hardly necessary to say that the curves in fig. 8 cannot be regarded as accurate for strengths of mixture intermediate between those at which the observations were actually made. The

curves, especially at low pressures, must be considered rather as a convenient way of showing which dots in the figure correspond to any given pressure than as an attempt at interpolation.

IX. "The Asymmetrical Probability Curve." By F. Y. Edgeworth, M.A., D.C.L. Communicated by Sir G. G. Stokes, F.R.S. Received June 14, 1894.

(Abstract.)

The asymmetrical probability curve is the second approximation—the symmetrical probability curve being the first approximation—to the law of frequency which governs the set of values assumed by a function of numerous independently fluctuating small quantities. The curve may be written

$$y = \frac{1}{\sqrt{\pi}c} e^{\frac{-x^2}{c^2}} \left[\quad - \frac{2j}{c^3}\left(\frac{x}{c} - \frac{2}{3}\frac{x^3}{c^3}\right)\right];$$

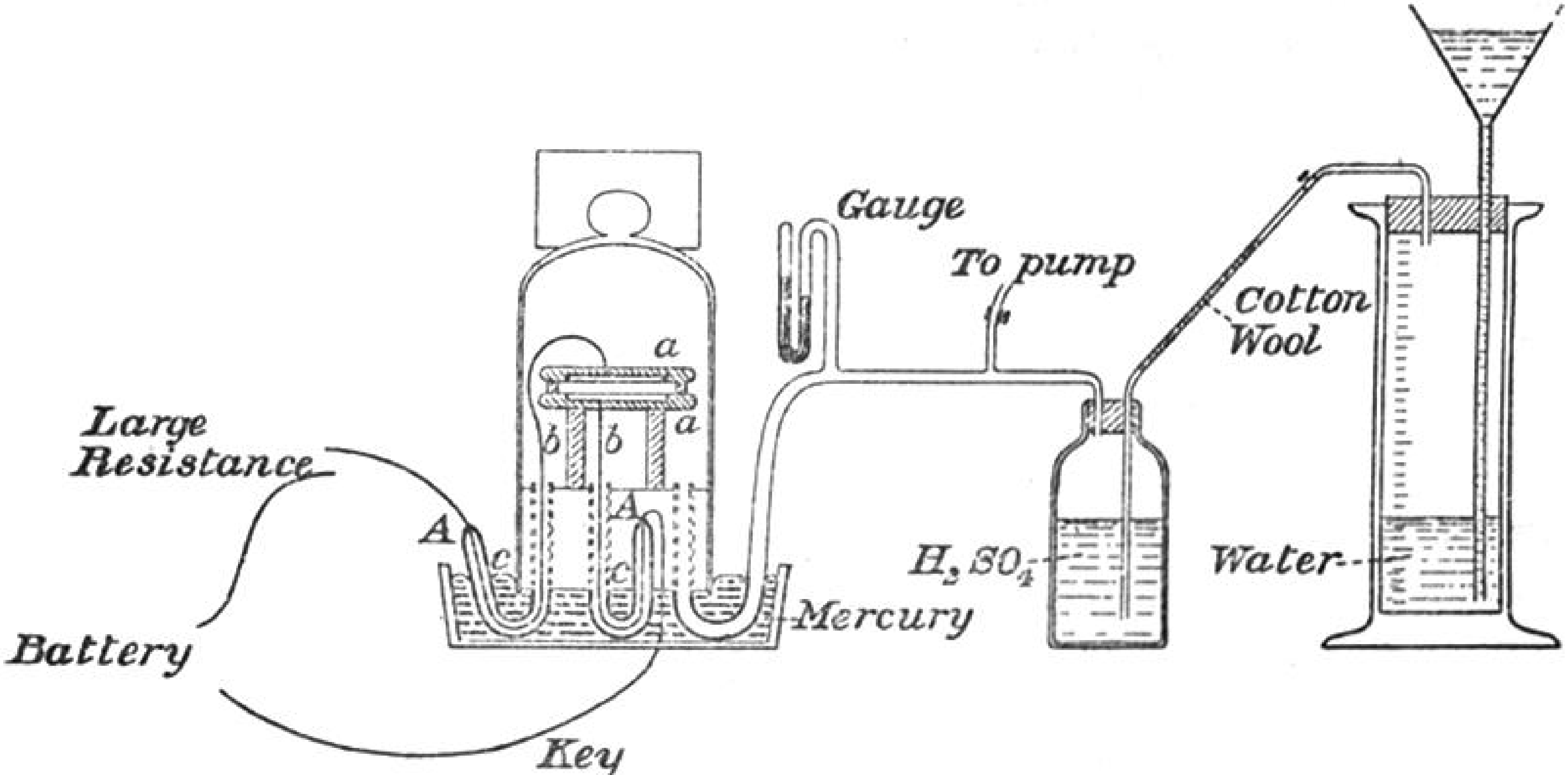
where $y\Delta x$ is the number of errors occurring between x and $x+\Delta x$, $c^2/2$ is the mean square of errors, and j is the mean cube of errors—errors measured from the centre of gravity. This form is obtained by completing the analysis which Todhunter, after Poisson, has indicated ('History of Probabilities,' Art. 1002); and independently by obtaining a general form for the asymmetric probability curve, and deducing therefrom the Poissonian formula in the case when the asymmetry is slight—the only case to which that formula is applicable.

Among the peculiarities of the asymmetric probability curve are the want of coincidence between the arithmetic mean and the position of the greatest ordinate, and the descent of the curve at one extremity below the abscissa—the ordinate appearing to denote *negative* probability.

An important case of the general curve is afforded by the *Binomial*, for which each of the independent elements admits of only *two* values. The approximate form of the Binomial, obtained directly by Laplace (Todhunter, 'History,' Art. 993), is deducible from the general theory. The general, or multinomial, probability curve can always be represented by a binomial.

The principle of the asymmetric probability curve affords an extension of the theory of *correlation* investigated by Messrs. Galton and Hamilton Dickson ('Roy. Soc. Proc.,' 1886, p. 63). The symmetrical probability surface

$$z = \frac{1}{\sqrt{\pi}\sqrt{1-r^2}} e^{\frac{-(x^2-2rxy+y^2)}{1-r^2}}$$


Gauge
To pump
Cotton
Wool
a
a
b
b
Large
Resistance
A
A
c
c
H, SO4
Water
Mercury
Battery
Key