future, and got from God whatever he asked. This procured him great renown. In consequence, however, of his prevarication, God was offended with him, and left him to himself, so that he fell into infidelity. It is generally supposed that the words in the Koran (§ Al-Araf) refer to him:—"The history of him unto whom we brought our signs and he departed from them; wherefore Satan followed him, and he became one of those who were seduced. And if we had pleased, we had surely raised him thereby unto wisdom; but he inclined unto the earth, and followed his own desire. Wherefore his likeness is as the likeness of a dog, which, if thou drive him away, putteth forth his tongue; or if thou let him alone, putteth forth his tongue also."

It has been conjectured with much probability that the Arabic wise man, commonly called Lokman, is identical with Balaam. The two names coincide in meaning, *devourer, swallower*;[1] and the names of their fathers are also alike. The Jews suppose Balaam to have been a Nahorite, and so Lokman is regarded by many Arabic authors, though the more general opinion is that he was an Abyssinian slave who lived in the time of David, and was renowned as a Hakim. The proverbs or fables attributed to him are of Greek origin.

Modern critics are divided in opinion respecting him. Three leading views embrace the varieties of belief as to his true position, viz., that he was an idolater and soothsayer, whose soul was uninfluenced by true religion—a sorcerer who had acquired reputation by his insight into the force of nature and his incantations; that he was a true prophet of God, a pious man who fell through covetousness; and that he was a heathen soothsayer and a prophet of Jehovah at the same time, occupying an intermediate position, with an incipient knowledge and fear of God, needing but to be developed, though checked by the love of gain. It appears impossible to arrive at a definite or comprehensive view of one who is described in different sources inconsistently. Bishop Butler, not recognising that the history of Balaam has poetical elements, and that different traditions are given respecting him, considers him a very wicked man under a deep sense of God and religion, persisting still in his wickedness, and preferring the wages of unrighteousness even when he had before him a lively view of death. His mind was distracted by contradictory principles of action. All we know about him amounts to very little. After admitting that a heathen soothsayer of this name existed in Mesopotamia, and had acquired some renown in the regions adjoining, and that he was employed in some way as a medium for uttering eulogiums upon Israel, of whose pre-eminence and permanence he is fully conscious, nothing else can be affirmed with certainty. (Davidson's *Introduction to the Old Testament*, vol. i. p. 328, &c.; Ewald's *Geschichte des Volkes Israel*, zweyter Band, p. 298, &c., 3d edition, and his *Jahrbücher*, part 8, p. 1, &c.; Kurtz's *Geschichte des alten Bundes*, zweyter Band, p. 454, &c.; Hengstenberg's *Die Geschichte Bileam's und seine Weissagungen*, 1842; Winer's *Realwörterbuch*, *s.v.* "Bileam;" Knobel's *Die Bücher Numeri, Deuteronomium, und Josua erklärt*, p. 121, &c.; Schenkel's *Bibel-Lexicon*, *s.v.* "Bileam;" and Hamburger's *Real-Encyclopædie fur Bibel und Talmud*, *s.v.* "Bileam.")

BÁLÁGHÁT, a British district in the Central Provinces of India, situated between 21° and 23° N. lat. and 80° and 81° E. long.; bounded on the N. by the district of Mandla; on the E. by the district of Chhattisgarh; on the S. by Chhattisgarh and Bhandárá; and on the W. by the district of Seoní. Bálághát forms the eastern portion of the central plateau which divides the province from east to west. These highlands, formerly known as the Ráigarh Bichhiá tract, remained desolate and neglected until 1866, when the district of Bálághát was formed, and the country opened to the industrious and enterprising peasantry of the Waingangá valley. Geographically the district is divided into three distinct parts:—(1.) The southern lowlands, a slightly undulating plain, comparatively well cultivated, and drained by the Waingangá, Bágh, Deo, Ghisrí, and Son rivers. (2.) The long narrow valley, known as the Mau Táluká, lying between the hills and the Waingangá river, and comprising a long, narrow, irregular-shaped lowland tract, intersected by hill ranges and peaks covered with dense jungle, and running generally from north to south. (3.) The lofty plateau, in which is situated the Ráigárh Bichhiá tract, comprising irregular ranges of hills, broken into numerous valleys, and generally running from east to west. The highest points in the hills of the district are as follows:—Peaks above Lánjí, 2300 or 2500 feet; Tepágarh hill, about 2600 feet; and Bhainsághát range, about 3000 feet above the sea. The principal rivers in the district are the Waingangá, and its tributaries, the Bágh, Nahrá, and Uskál; a few smaller streams, such as the Masmár, the Máhkárá, &c.; and the Banjár, Hálon, and Jamuniá, tributaries of the Narbadá, which drain a portion of the upper plateau. Bálághát contains very extensive forests, but they do not produce timber of any great value. They teem with wild animals, from the great bison to the fox; 470 beasts and venomous snakes were killed in 1867-68, a total reward of £156 being paid under this head. The district contained in 1868 an assessed area of 1462·08 square miles or 935,731 acres, of which 214,587 acres were under cultivation; 488,510 grazing lands; 116,938 culturable, but not actually under cultivation; 115,696 unculturable waste. The census report of 1872 returned the area at 2608 square miles. The census of 1866 showed a population of 170,964. This had in 1872 increased to 195,008, residing in 37,192 houses and 781 villages; average number of persons per square mile, 74·77; per village, 249·69; per house, 5·24. Of the total population, 131,176 or 67·27 per cent. were Hindus; 2934 or 1·50 per cent. Mahometans; 39 Buddhists; 11 Christians; 60,848 or 31·20 per cent. of unspecified religions of aboriginal or imperfectly Hinduised types.

Since 1867 considerable encouragement has been given to the cultivating tribes of Ponwárs, Kunbís, Marárs, &c., of the low country to immigrate, and take up lands in the upland tracts. By this means a large quantity of jungle lands has lately come under cultivation. The acreage under the principal crops grown in the district is returned as follows:—rice, 188,312 acres; wheat, 585; other food grains, 8770; oil-seeds, 3436; sugar, 505; fibres, 100; tobacco, 638; total, 202,346 acres. Iron is smelted by the Gonds; gold exists in the beds of some of the rivers, but not in sufficient quantities to repay the labour of washing. There are no regularly made roads in the district. Five passes lead from the low country to the highlands, viz., the Bánpur Ghát, the Warai Ghát, the Pancherá Ghát, the Bhondwá Ghát, and the Ahmadpur Ghát. For revenue purposes the district is divided into two subdivisions, the Búrhá Tahsíl and the Paraswárá Tahsíl. In 1868–69 the total revenue of the Bálághát district amounted to £11,746, of which £6754, or 57 per cent., was from land. For the protection of person and property, Government maintained, in 1868, 115 policemen, at a total cost of £1156, 16s. In 1868 only two towns in the district had upwards of 2000 inhabitants, viz., Hattá, population, 2608, and Lanjí, population, 2116. About 60 years ago the upper part of the district was an impenetrable waste. About that time one Lachhman Náik established the first villages on the Paraswárá plateau, on which there are about 30 flourishing settlements. But a handsome Buddhist temple of cut stone, belonging to some remote period, is suggestive of a civilization which had disappeared before historic times.

[1] בִּלְעָם from בָּלַע, with the formative letter ם. It has been derived from בלע–עם (Sanhed. 105), *destroyer* or *corrupter of the people*, so that the name has passed for a typical designation of Israel's enemy; and this is reflected in the Greek word Νικολαΐτης (Rev. ii. 6), from νικᾶν and λαός, as if the Nicolaitanes were essentially Balaamites, or seducers. But this etymology of the name Balaam is improbable.

BALANCE. For the measurement of the "*mass*" of (*i.e.*, of the quantity of matter contained in) a given body we possess only *one* method, which, being independent of any supposition regarding the nature of the matter to be measured, is of perfectly general applicability. The method—to give it at once in its customary form—consists in this, that after having fixed upon a *unit mass*, and procured a sufficiently complete set of bodies representing each a known number of mass-units (a "set of weights"), we determine the ratio of the *weight* of the body under examination to the *weight* of the unit piece of the set, and identify this ratio with the ratio of the *masses*. Machines constructed for this particular *modus* of weighing are called *balances*. Evidently the weight of a body as determined by means of a balance—and it is in this sense that the term is always used in everyday life, and also in certain sciences, as, for instance, in chemistry—is independent of the magnitude of the force of gravity; what the merchant (or chemist) calls, say, a "pound" of gold is the same at the bottom as it is at the top of Mont Blanc, although its real weight, *i.e.*, the force with which it tends to fall, is greater in the former than it is in the latter case.

To any person acquainted with the elements of mechanics, numerous ideal contrivances for ascertaining which of two bodies is the heavier, and for even determining the ratio of their weights, will readily suggest themselves; but there would be no use in our noticing any of these many conceivable balances, except those which have been actually realised and successfully employed. These may be conveniently arranged under six heads.

1. *Spring Balances.*—The general principle of this class of balances is that when an elastic body is acted upon by a weight suspended from it, it undergoes a change of form, which, *cæteris paribus*, is the greater the greater the weight. The simplest form of the spring balance is a straight spiral of hard steel (or other kind of elastic) wire, suspended by its upper end from a fixed point, and having its lower end bent into a hook, from which, by means of another hook crossing the first, the body to be weighed is suspended,—matters being arranged so that even in the empty instrument the axis of the spiral is a plumb-line. Supposing a body to be suspended at the lower hook, it is clear that the point where the hooks intersect each other will descend from the level it originally occupied, and that it must fall through a certain height h before it can, by itself, remain at rest. This height, provided the spiral was not strained beyond its limit of elasticity (*i.e.*, into a permanent change of form), is proportional to the *weight* P of the body, and consequently has to the mass M the relation $h = cg\mathrm{M}$, where c is a constant and g the acceleration of gravity. Hence, supposing in a first case h and M to have been h' and M′, and in a second case, h'' and M″, we have $h' : h'' :: g'\mathrm{M}' : g''\mathrm{M}''$; and it is only as long as g is the same that we can say $h' : h'' :: \mathrm{M}' : \mathrm{M}''$. Spring balances are very extensively used for the weighing of the cheaper articles of commerce and other purposes, where a high degree of precision is not required. In this class of instruments, to combine compactness with relatively considerable range, the spring is generally made rather strong; and sometimes the exactitude of the reading is increased by inserting, between the index and that point the displacement of which serves to measure the weight, a system of levers or toothed wheels, constructed so as to magnify into convenient visibility the displacement corresponding to the least difference of weight to be determined. Attempts to convert the spring balance into a precision instrument have scarcely ever been made; the only case in point known to the writer is that of an elegant little instrument constructed by Professor Jolly, of Munich, for the determination of the specific gravity of solids by immersion, which consists of a long steel-wire spiral, suspended in front of a vertical strip of silvered glass bearing a millimetre scale. To read off the position of equilibrium of the index on the scale, the observing eye is placed in such a position that the eye, its image in the glass, and the index are in a line, and the point on the scale noted down with which the index apparently coincides.

2. *Chain Balances.*—This invention of Wilhelm Weber's having never, so far as we know, found its way into actual practice, we confine ourselves to an illustration of its principle. Imagine a flexible string to have its two ends attached to the two fixed points C and D (fig. 1), forming the terminal points of a horizontal line CD shorter than the string.

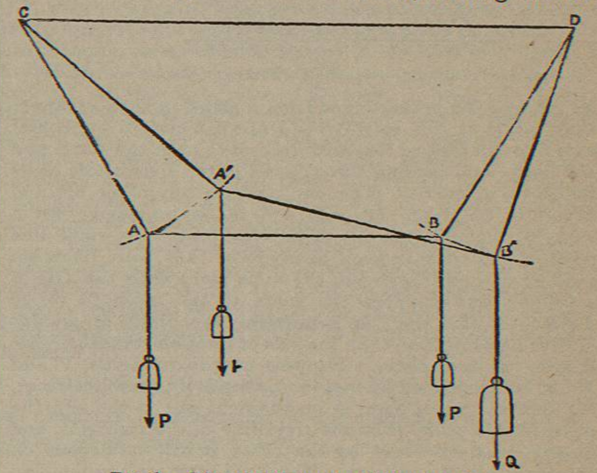

FIG. 1.—Diagram illustrating Chain Balance.

Suppose two weights to be suspended, the one at a point A, the other at a point B of the string; the form of the polygon CDBA will depend, *cæteris paribus*, on the ratio of the two weights. Assuming, for simplicity's sake, CA to be equal to DB, then, if the weights are equal, say, each = P units, the line AB will be horizontal. But if now, say, the weight at B be replaced by a heavier weight Q, the point A will ascend through a height h, the point B will descend through a lesser height h' in accordance with equation $\mathrm{P}h = \mathrm{Q}h'$, and the angle between what is now the position of rest of the base line A′B′, and the original line AB will depend on the ratio of P : Q. The exact measurement of this angle would be difficult, but it would be easy to devise very exact means for ascertaining whether or not it was horizontal, and, if not, whether it slanted down the one way or the other; and thus the instrument might serve to determine whether P was equal to, or greater or less than, Q; and this obviously is all that is required to convert the contrivance into an exact balance.

3. *Lever Balances.*—This class of balances, being more extensively used than any other, forms the most important division of our subject. There is a great variety of lever balances; but they are all founded upon the same principles, and it is consequently expedient to begin by summing up these into one general theory.

Theory of the Lever Balance (fig. 2).—In developing the "theory" of a machine, the first step always is and must be that we substitute for the machine as it is a *fictitious* machine, which, while it closely corresponds in its working to the actual thing, is free from its defects. In this sense what now follows has to be understood. Imagine

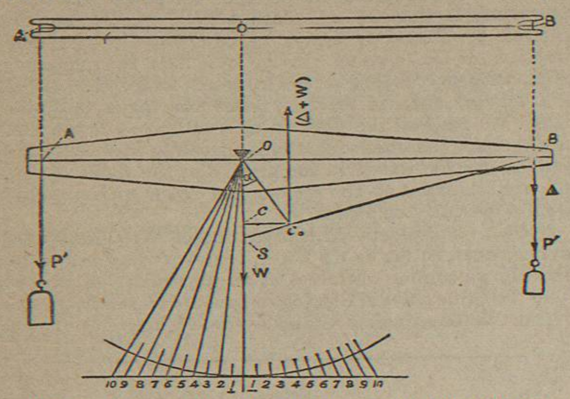

FIG. 2.—Diagram illustrating the theory of the Lever Balance.

an *inflexible beam* suspended from a stand in such a manner that, while it can *rotate freely* about a certain horizontal axis fixed in its position with respect to both the stand and the beam, and passing through the latter somewhere *above* its centre of gravity, it cannot perform any other motion. Imagine the beam at each end to be provided with a vertical slit, and each slit to be traversed by a rigid line fixed in the beam in such a situation that both lines are parallel to, and in one and the same plane with, the axis of rotation; and suppose the mass of the beam to be so distributed that the line connecting the centre of gravity S with its projection O on the axis of rotation stands perpendicular on that plane. Suppose now two weights, P′ and P″, to be suspended by means of absolutely flexible strings, the former from a point A on the rigid line in the left, the other from a point B on the rigid line in the right slit, and clearly, whatever may be the effect, it will *not* depend on the length of the strings. Hence we may replace the two weights by two material points situated in A and B, and weighing P′ and P″ respectively. But two such points are equivalent, statically, to one point (weighing P′ + P″) situated somewhere in D within the right line connecting A with B. Suppose the beam to be arrested in its "*normal position*" (by which we mean that position in which AB stands horizontal and the line SO is a plumb-line), and then to be released, the statical effect will depend on the situation of the point D, and this situation, supposing the ratio $l' : l''$ to be given, on the ratio P′ : P″. If $P' l' = P'' l''$, D lies in the axis of rotation; the beam remains at rest in its normal position, and, if brought out of it, will return to it, being in *stable* equilibrium. This at once suggests two modes of constructing the instrument and two corresponding methods of weighing.

First Method.—We so construct our instrument that while l' is constant, l'' can be made to vary and its ratio to l' be measured. In order then to determine an unknown weight P′, we suspend it at the point pivot A; we then take a standard weight P″ and, by shifting it forwards and backwards on AB, find that particular position of the point of suspension B, at which P″ exactly counterpoises P′. We then read off $\frac{l''}{l'}$, and have $P' = P''\frac{l''}{l'}$. But, practically, the body to be weighed cannot be directly suspended from A, but must be placed in a pan suspended from A, and consequently the weight p_0 of the pan and its appurtenances would always have to be deducted from the total weight P′, as found by the experiment, to arrive at the weight of the object $p = P' - p_0$. Hence, what is actually done in practice is so to shape the right arm that its back coincides with the line AB, and to lay down on it a scale, the degrees of which are equal to one another, and to l' (or some convenient submultiple or multiple of l') in length, and so to adjust p_0 and number the scale, that when the sliding weight P″ is suspended at the zero-point, it just counterpoises the pan; so that when now it is shifted successively to the points 1, 2, 3 . . . p, it balances exactly 1, 2, 3 . . . p units of weight placed in the pan. This is the principle of the common *steel-yard*, which, on account of the rapidity of its working, and as it requires only *one* standard weight, is very much used in practice for rough weighings, but which, when carefully constructed and adjusted, is susceptible of a very considerable degree of precision. In the case of a precision steel-yard, it is best so to distribute the mass of the beam that the right arm balances the left one + the pan, to divide that arm very exactly into, say, only 10 equal parts, and instead of one sliding weight of P″ units to use a set of standards weighing P″, $\frac{1}{10}$ P″, $\frac{1}{100}$ P″, $\frac{1}{1000}$ P″, &c. The great difficulty is to ensure to the heavier sliding weights a sufficiently constant position on the beam. To show the extent to which this difficulty can be overcome it may be stated that in an elegant little steel-yard, constructed by Mr Westphal of Celle (for the determination of specific gravities), which we had lately occasion to examine, even the largest rider, which weighs about 10 grammes, was so constant in its indications that, when suspended in any notch, it always produced the same effect to within less than $\frac{1}{3000}$th of its value.

Second Method.—We so construct our instrument that both l' and l'' have constant values, and are nearly or exactly equal to each other, and provide it with pans, whose weights p_0' and p_0'' are so adjusted against each other that $p' l' = p_0'' l''$, and, consequently, the empty instrument is at rest in its normal position. We next procure a sufficiently complete set of weights, *i.e.*, a set which, by properly combining the several pieces with one another, enables us to build up any integral multiple of the smallest difference of weight δ we care to determine, a set, for instance, which virtually contains any term of the series 0·001, 0·002, 0.003 . . . . 100·000 grammes. In order now to determine an unknown weight p', we place it, say, in the left pan, and then, by a series of trials, find that combination of standards p'' which, when placed in the right pan, establishes equilibrium to within $\pm\,\delta$. Evidently—

$$p' = \frac{(p'' \pm \delta) l''}{l'} \quad . \quad . \quad . \quad . \quad . \quad (1).$$

In the case of purely *relative* weighings, there is nothing to hinder us from adopting $\frac{l''}{l'}$ units $\left(e.g., \frac{l''}{l'} \text{ grammes}\right)$ as our unit of mass, and simply to identify the relative value of p' with the number p''. But even if we want to know the absolute value of p' in true grammes, we need not know the numerical value of $\frac{l''}{l'}$. All we have to do is, after having determined the value of p' in terms of $\frac{l''}{l'}$, to *reverse* the positions of object and standards, and, in a similar manner, to ascertain the value p_1'' which *now* counterpoises the unknown weight p' lying in the *right* pan. Obviously $p' = p''\frac{l''}{l'} = p_1''\frac{l'}{l''}$ whence $(p')^2 = p'' p_1''$, and $p' = \sqrt{p'' p_1''}$, for which expression, if the two arms are very nearly of equal length, we may safely substitute $p' = \frac{1}{2}(p'' + p_1'')$. Or, instead of at once finding the counterpoise for p' in standards, we may first counterpoise it by means of shot or other

material placed in the opposite pan, and then find out the number of grammes p'' which has to be *substituted* for p' to again establish absolute equilibrium. Evidently $p' = p''$. This (in reference to the ideal machine meant to be realised) is the theory of the *common balance* as we see it working in every grocer's shop, and also that of the modern *precision balance*, which, in fact, is nothing but an equal-armed beam and scales refinedly constructed. In the case of the latter class of balances the inconvenience involved in the use of very small weights may be avoided (and is generally avoided) by dividing the right arm of the beam, or rather the line AB, into 10 equal parts, and determining differences of less than, say, 0·01 gramme by means of a sliding weight possessing that value. But evidently, instead of dividing the whole length of the right arm, it is better to divide some portion of it which is so situated that the rider can be shifted from the very zero to the "10," and so to adjust the rider, that when it is shifted successively from 0 to 1, 2, 3 . . . n it is the same as if 1, 2, 3 . . . n tenths of its weight were placed in the right pan. The rider in this case must, of course, form part and parcel of the beam. It is singular that none of our precision-balance makers have ever thought of this very obvious improvement on the customary system. In the very excellent instrument made by Messrs Becker and Company of New York, this, it is true, is realised partially in a rider weighing 12 milligrammes and a beam divided into 12 equal parts (instead of 10 and 10 respectively); but this does not enable one to shift the rider to where it would indicate from 0 to say $\frac{3}{10}$ or $\frac{4}{10}$ of a milligramme. Whichever of these modes of weighing we may adopt, we must have an arrangement to see whether the balance is in its normal position, and it is desirable also to have some means to enable us, in the course of our trials, to form at least an idea as to the additional weight which would have to be added to the standards on the pan (or to be taken away) in order to establish equilibrium. To define the normal position, all that is required is to provide the beam with a sufficiently long "needle," the axis of which is parallel to the line OS, and which plays against a circular limb fixed to the stand and constructed so that the upper edge of the limb coincides very nearly with the path of the point of the vibrating needle, and to graduate the limb so that, as fig. 2 shows, the zero point indicates the normal position of the beam. In order to see how the graduation must be made to be as convenient as possible a means for translating deviations of the needle into differences of weight, let us assume the balance to be charged with P′ grammes from A and with P″ + Δ grammes from B, and P′ and P″ to satisfy the equation $P' l' = P'' l''$. The two weights P′ and P″ being equivalent to one point P′ + P″ in the axis of rotation, the effect is the same as if these two weights did not exist and the beam was only under the influence of two weights, viz., the weight W of the beam acting in S and the weight Δ acting in B. But this comes to the same as if both W and Δ were replaced by one point weighing W + Δ, and situated somewhere at C_0 between, and on a line with, B and S. Hence, supposing the beam to be first arrested in its normal position and then to be left to itself, the right arm will go down and not be able by itself to remain at rest before it has reached that position in which C_0 lies vertically below the axis of rotation. *Cæteris paribus* C_0 will be the nearer to B, and consequently the angle α, through which the beam (and with it the needle) has to turn to assume what now is its position of stable equilibrium, will be the greater the greater Δ is, and for the same Δ and W the angle of deviation will be the greater the less the distance s of the centre of gravity of the beam S is from the axis of rotation. The former proposition enables one in a given case to form an idea of the amount Δ which has to be taken away from the right pan to establish equilibrium. To find the exact mathematical relation between Δ and the corresponding angle α, let us remember that the position of C_0 is the same whatever may be the direction of gravity with regard to the beam. Assuming gravity to act parallel to OS, we have $(W + \Delta)\,\overline{CC_0} = \Delta l''$, where C stands for the projection of C_0 on $\overline{OS}$. Assuming, secondly, gravity to act parallel to the line $\overline{OB}$, we have $(W + \Delta).\,\overline{CO} = W.\,\overline{OS}$;

$$\therefore \frac{CC_0}{CO} = \tan\alpha = \frac{\Delta l''}{Ws} \quad . \quad . \quad . \quad . \quad (2).$$

Obviously, the right way of graduating the limb is to place the marks so that their radial projections on the tangent to the circle at the zero-point divide that line into parts of equal length. In the ordinary balance where l'' is a constant, the factor $\frac{l''}{Ws}$ has a constant value, which can be determined by *one* experiment with a known Δ—always supposing that in the instrument used the requirements of our theory were exactly fulfilled. In good precision balances they *are* fulfilled, to such an extent at least, that although the factor named is not absolutely constant, but a function of P, it can be looked upon as a *relative* constant, so that by determining the deviations produced by a given Δ, say Δ = 1 milligramme, for a series of charges (*i.e.*, values of P″), one is enabled to readily convert deviations of the needle, as read off on the scale, into differences of weight. This method is very generally followed in the exact determinations of weights as required in chemical assaying, in the adjusting of sets of weights, &c. Only, instead of letting the needle come to rest and then reading off its position, what is done is to note down 2, 3, 4 . . . n consecutive excursions of the needle, and from the readings ($a_1, a_2, a_3, a_4 \ldots a_n$) to calculate the position a_0 where the needle *would* come to rest if it were allowed to do so. It being understood that the readings must be taken as positive or negative quantities according as they lie to the left or to the right of the zero-point, a_0 might be identified with *any* of the sums—

$$\tfrac{1}{2}(a_1 + a_2),\ \tfrac{1}{2}(a_2 + a_3), \ldots\ldots \tfrac{1}{2}(a_{n-1} + a_n),$$

but clearly it is much better to calculate a_0 by taking the mean of these quantities, thus—

$$a_0 = \frac{a_1 + a_n + 2\,(a_2 + a_3 \ldots + a_{n-1})}{2\,(n-1)};$$

and it is also easily seen that to eliminate as much as possible the influences of the resistance of the air and (let us at once add by anticipation of what ought to be reserved for a subsequent paragraph) of the friction in the pivots of the balance, it is expedient to let n be an *odd* number. Theoretically this method is, of course, *not* confined to small Δ's, and it is easy to conceive a balance in which the limb is so graduated that it gives directly the weight of an object placed in the right pan; this is the principle of the *Tangent Balance*, a class of instruments which used to be very generally employed for the weighing of letters, parcels, &c., but is now almost entirely superseded by the spring balance.

After having thus given a general theory of the *ideal*, let us now pass to the *actual* instrument. But in doing so we must confine ourselves mainly to the consideration of that particular class of instruments called precision balances, which are used in chemical assaying, for the adjustment of standard weights, and for other exact gravimetric work.

The *Precision Balance* being, as already said, quite identical in principle with the ordinary "pair of scales," there is no sharp line of demarcation between it and what is usually called "a common balance," and it is equally