

specimens having the dorsal surface almost wholly covered with brown markings.

Length, 5 mm.; breadth, 2 mm.

Hab.—New Plymouth and Mount Egmont, in nests of *Amblyopone cephalotes* and *Huberia striata* (W. W. Smith); Rai Valley, in nests of ants (J. MacMahon). Probably widely distributed in the North Island and in the north-western portion of the South Island.

The specimens from Greymouth collected by Mr. R. Helms, which I had previously referred with hesitation to *T. otakensis*,* belong to the present species. I have specimens also from Swanson, Auckland (H. Suter), and one from Kapiti Island (E. A. Newson). The last specimen is much browner than those actually taken in ants' nests by Mr. Smith and Mr. MacMahon, and it is possible that it was not living in association with ants. There is the same doubt with regard to the Greymouth and Auckland specimens.

ART. XVII.—*The Cam-lever Balance.*

By J. CLEMENT CUFF.

[Read before the Auckland Institute, 22nd November, 1909.]

“CAM-LEVER balance” is the name given by the author to a modification of the bent-lever balance whereby the scale becomes regular throughout its whole length.

The bent-lever balance is more convenient in use than any other form of gravity balance because it indicates the weight by direct observation without having to slide a counterpoise, or shift the fulcrum, or put counterbalancing weights in a scale-pan. A spring balance also has these advantages, but a spring is not so reliable and constant as gravity. On the score of simplicity of construction and delicacy of action a bent-lever balance is better than a spring balance. The one great defect of the bent-lever balance is the irregularity of its scale; therefore this paper is written to explain clearly how this solitary defect of this otherwise excellent form of balance can be remedied in a very simple way.

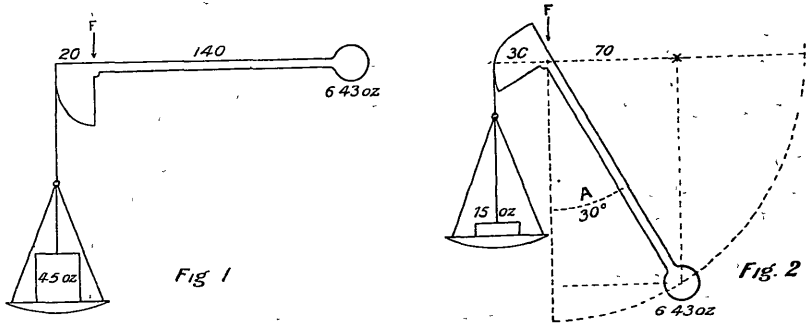
In the bent-lever balance the counterpoise arm is actually much longer than the scale-pan arm, and these lengths are constant, but the virtual lengths of the two arms change with every change of weight in the scale-pan. The virtual length of the arm is the horizontal distance between the fulcrum and a line drawn vertical to the centre of gravity of the arm and its attached or suspended weight. If the angle of deflection of the long arm from the vertical be called A , then the virtual length of the long arm will vary as the sine of A , and the virtual length of the short arm will vary as the cosine of A , exactly if the effective directions of the two arms are at right angles, otherwise approximately. This relationship gives a scale increasingly compressed in the direction of the higher readings.

* Trans. Linn. Soc., 2nd ser., Zool., vol. viii, p. 117.

This great defect is entirely removed by applying to the scale-pan arm a correctly shaped cam, which prevents the too rapid shortening of the virtual length of the scale-pan arm for any given increase in the deflection of the counterpoise arm. The scale-pan is suspended by a tape or cord which passes over the curved surface of the cam and is attached to it on its farthest side.

With any gravity balance the condition of equilibrium is attained when the product of the length (or the virtual length) of the arm multiplied by the weight on one side of the fulcrum is equal to the product of the length (or the virtual length) of the arm multiplied by the weight on the other side of the fulcrum. The product of the said factors on either side of the fulcrum is called the "moment of force" on that side.

As an example: Let the length of the counterpoise arm be 140 mm., and the limit of weight to be measured by the balance (including the weight of the scale-pan) be 45 oz., at a distance of 20 mm. from the fulcrum; then the moment of force on the scale-pan arm would be $45 \times 20 = 900$, and the counterpoise weight must be 900 divided by 140 (the length of its arm), or 6.4286 oz., or very nearly 6.43 oz. (See fig. 1.)



It is required that when the weight suspended at the end of the scale-pan arm be reduced to any given proportion—say, one-third of the maximum—then the counterpoise arm should rest in equilibrium at the same proportion of its total range—that is, at one-third of 90° (or 30°) from the vertical. In this position (see Fig. 2) it is seen that although the actual length of the counterpoise arm has remained the same, yet its virtual length for reckoning its balancing-power has been reduced to one-half, or 70 mm., and the moment of force on its side of the fulcrum has been reduced from 900 to $700 \times 6.4286 = 450$. Then, the length (or the virtual length) of the scale-pan arm must be 450 divided by one-third of the maximum weight—that is, one-third of 45 oz. (or 15 oz.). This gives 30 mm. as the required length of the scale-pan arm in this position, instead of 20 mm. as in the first position.

To make the scale regular, the scale-pan has to be suspended at a different distance from the fulcrum for every different angle of deflection of the counterpoise arm.

Let A = the angle of deflection of the counterpoise arm from the vertical, and L = the actual length of the counterpoise arm, which agrees with its effective length only in its horizontal position, or when $A = 90^\circ$: then $L \times \sin A$ = the virtual length of the counterpoise arm for any angle A . Let C = the weight of the counterpoise: then $L \times \sin A \times C$ = moment

of force on the counterpoise side for any angle A. Let W = the weight on the scale-pan side: then $\frac{L \times \sin A \times C}{W}$ = the required distance from the fulcrum at which the scale-pan must be suspended for any given angle A. Because the angle A must be in proportion to W, let $W = nA$: then $\frac{L \times \sin A \times C}{nA} = \frac{\sin A}{A} \times \frac{LC}{n}$ = the required distance from the fulcrum at which the scale-pan must be suspended for any given angle A. Hence it is evident that in a gravity lever balance, in order to make the angle of deflection (A) of the long arm proportional to the weight suspended from the short arm throughout the whole length of the quadrant, whilst the virtual length of the long arm varies as $\sin A$, the virtual length of the short arm must vary as $\sin A/A$.

The above relation is fixed for all balances of this class, but L, C, and n may have any values according to the desired dimensions of the balance. In the example given they are 140, 6.4286, and $\frac{1}{2}$ respectively. The value of n is $\frac{1}{2}$ because the number of ounces to be indicated by any angle of deflection happens to be one-half of the number of degrees in the angle. In this or in any other case n will equal 90 divided by the total number of units of weight (including the weight of the scale-pan) intended to be the full range of the balance.

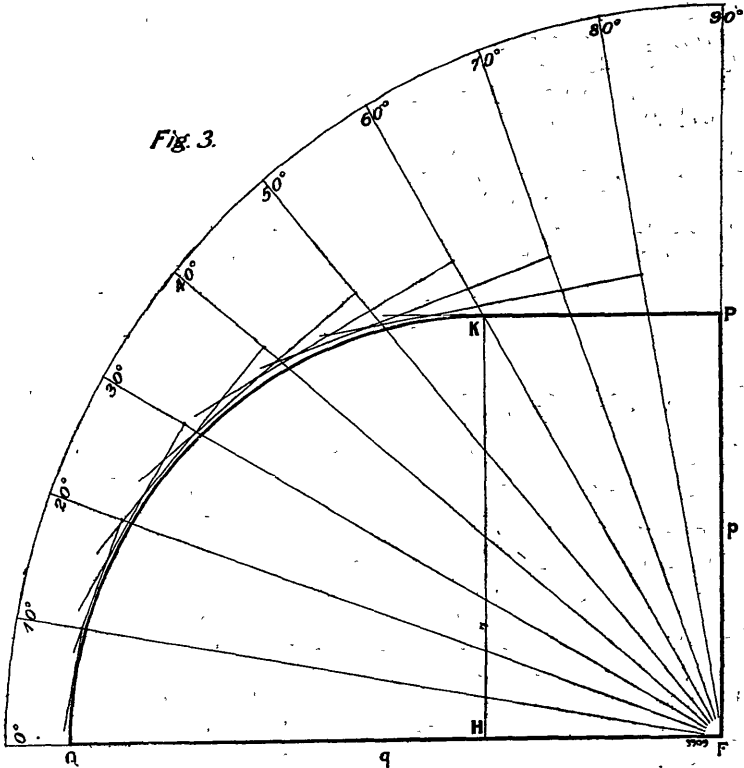
In the following table, column (1) gives A, the angle of deflection from the vertical of the long arm, in degrees. Column (2) gives $\sin A$. The virtual length of the long arm varies with the angle A as the figures in this column. Column (3) gives $\sin A/A$. The virtual length of the short arm, with the angle A, must vary as the figures in this column. Column (4) shows the application of column (3) to the particular example given, in which LC/n is equal to 1800. It gives, in millimetres, the various distances from the fulcrum at which the scale-pan must be suspended according to the angle A given in each case.

A. Degrees.		Sine of A	$\frac{\text{Sine A}}{A}$	
(1.)		(2.)	(3.)	(4.)
1	..	0.01745	0.01745	31.41
5	..	0.0872	0.01743	31.37
10	..	0.1736	0.01736	31.30
20	..	0.3420	0.01710	30.80
30	..	0.5000	0.01667	30.00
40	..	0.6428	0.01607	29.00
50	..	0.7660	0.01532	27.50
60	..	0.8660	0.01443	26.00
70	..	0.9397	0.01342	24.00
80	..	0.9848	0.01231	22.20
90	..	1.0000	0.01111	20.00

From the figures in column (3) a curve can be plotted which will give correctly the shape of the required cam (see fig. 3).

Taking the point F, which represents the fulcrum of the balance, as centre, describe the quadrant marked F, 0°, 90°. Draw eight intermediate radii, all at equal distances of 10 degrees, and number them accordingly. On each radius numbered as in column (1) of table, mark off the length indicated in column (3) according to any convenient scale of units. For instance, on the radius for 10 degrees mark off 173.6 mm., on the radius

for 20 degrees mark off 171 mm., and so on up to 90 degrees, 111.1 mm. At the point so marked in each radius erect a perpendicular inclining towards the side of lower magnitudes. These perpendiculars will intersect at several points. Draw a curve tangential to these perpendiculars on the inner side. This is the true curve required for the cam. The distance to be marked off on the radius F to 0° is very approximately the same as that given in the table for 1 degree—namely, 174.5 mm.—and this point marks the lower termination of the curve.



An examination of the true cam-curve reveals that a very close approximation thereto can be made in a much more simple way (see fig. 3). Call the distance F to P, on the vertical side of the quadrant, p ; and the distance F to Q, on the horizontal side, q : then the ratio of p to q must always be as $\sin 90^\circ / 90^\circ$ to $\sin 1^\circ / 1^\circ$. Taking 1 minute of arc, or $\frac{1}{60}$ degree, as being $= 1^\circ$, then p is to q as 0.01 is to 0.0174505098. These figures are almost perfectly in the ratio of 7 to 11. If p equal 7 units of length and q equal 11 of the same units of length, then q will be 0.0563 per cent. too long, or less than one part in 1776 too long.

Hence the simple and practical way to mark off the cam-curve, approximately, is as follows: (1) Draw two lines, FP and FQ, at right angles; (2) make the vertical line FP equal to 7 units of length, of any suitable size; (3) make the horizontal line FQ equal to 11 of the same units; (4) mark a point H on FQ so that the distance from Q to H equals FP;

(5) using H as centre, describe a quadrant HK of radius HQ; (6) join K to P by a straight line, thus completing the cam-contour.

This simple curve falls slightly within the true cam-curve for a portion of its length, but so slightly as to cause a maximum error of only about 1 per cent. in the virtual length of the short arm of the balance. In the example given this amounts to less than $\frac{1}{3}$ mm. This makes no difference to the perfect accuracy of the balance; it only makes a slight difference in the perfect equality of the distances between some marks on the scale.

All need of levelling the balance when it is stood upon any nearly level surface can be avoided by suspending the scale so that it can itself assume the correct position by the action of gravity.

A very simple and effective anti-parallax sight is fixed to the pointer. This consists of a needle having an enlarged eye, through which the observer must look at the pointer, and thus note the point it indicates on the scale.

The cam lever, the swivelled scale, and the anti-parallax sight combine to produce a balance of surpassing excellence for accuracy and speed of measurement. This invention the author presents to the society in the hope that some one will be sufficiently enterprising to put it upon the market, to the great advantage of himself and the public at large.

ART. XVIII.—*Description of a New Native Grass (Poa).*

By D. PETRIE, M.A.

[Read before the Auckland Institute, 22nd November, 1909.]

Poa oraria, sp. nov.

Gramen cæspitosum, parce foliosum, 40–50 cm. altum, leve, politum, perenne.

Culmi multi, erecti, glaberrimi, graciles, a basi ramosi, teretes, 2-nodosi, internodiis elongatis, folia longitudine æquantem, foliorum vaginæ pæne ad imam paniculæ partem vestiti.

Folia longe vaginantia, vaginæ inferiores latæ, membranacæ, stramineæ, leviter striatæ; ligula vaginam latitudine æquans, oblonga, obtusa; lamina teres, erecta, involuta, subrigida, gracillima, leviter striata, apice subacicularis.

Panicula strictissima, linearis, \pm 10 cm. longa; ramis 3 v. paucioribus, brevibus, teretibus, glaberrimis, paucas spiculas sublonge pedicellatas gerentibus.

Spiculæ anguste oblongæ v. plus minus cuneatæ, 8 mm. longæ, 3 mm. latæ, 4 v. 5 flosculos gerentes.

Glumæ vacuæ subæquales, spiculis tertia parte breviores, anguste lineari-lanceolatæ, acuminatæ, 3-nervatæ.

Glumæ floriferæ anguste lanceolatæ, acuminatæ, membranacæ, plerumque 5-nervatæ, nervo medio solo ad apicem attinente, basi parvo pilorum brevium flocco prædita, in nervis subsericæ, alibi plus minus scabridæ.

Palea gluma florifera paulo brevior, 2-nervata, nervis delicatule ciliatis.

Hab.—Moist and wet stations at the head of several of the sounds of western Otago (Deep Cove, &c.). Collected by Mr. B. C. Aston in mid-January, 1909; it appears to flower towards the end of December.