This curious apparatus first reminds us of the frontal clasper in males of different kinds of Chimaera. But this is movable and provided in front with dermal teeth and supported by a piece of cartilage that can be retracted into a dermal pouch. Though its function is not known, it certainly has nothing to do with the carrying of eggs. So functionally the two apparatuses are not to be compared either.

It appears to me one might sooner draw a comparison with the crestlike elevation of the occipital in *Selene* which gains in height with the growth of the individual; also with *Naseus* (*Acanthurus*) *nasicornis,* whose skull sends out a bony horn above the eye, which grows longer as the fish grows older.

A question not easy to find an answer to is how the hook in *Kurtus Gulliveri* is set to work, how in fact the short string with on either side its cluster of eggs, comes to lie under the hook in such a way that the two clusters hang symmetrically on the head of the male. The only line of action I can imagine the couple concerned in the laying of the eggs to take, is that the male should take up a vertical position under the female's genital porus. As soon as this ejaculates the string with its two clusters of eggs — the string now being still soft — it is caught by the male's head and pushed under the hook, possibly by a forward movement on the part of the male.

This is a purely hypothetical explanation — but I know of no better one for the intricate manoevres necessary to bring the eggs in the desired place. The advantage for the eggs, when once in that position, is apparent especially in a stream as the Lorentz River, which is a quick flowing stream and even more so as it floods its banks whenever there is a heavy fall of rain. When carried by the strong parent, there is small danger for the eggs of being swept against the banks or buried under mud and stones or of being harmed in some other way.

But this is not an answer to the question what the origin was of this strange line of action and many other questions in connection with this. It is not known if *Kurtus indicus* uses his hook in the same way.

Physics. — "*The electromotive force of the* WESTON *Normal Cell*".
By Prof. H. HAGA and J. BOEREMA.

At the international Conference on electrical Units and Standards held in London in Oct. 1908, some directions were given for the construction of the WESTON cell, as a standard of electromotive force. For its E. M. F. at 20° 1.0184 international volts, was taken provisionally, till further measurements shall give a more accurate value.

The usual way of determining the E. M. F. of a cell consists in measuring the strength of the current, which gives rise to a difference of potential between the terminals of a known resistance equal to the E. M. F. of the cell.

The various determinations differ in the method of measuring the current. Restricting ourselves to the determinations of the five last years, in 1906 at the *Bureau of Standards* at Washington [1]) the current was measured by means of an electrodynamometer, consisting of two coils, whose axes were placed horizontally and at right angles to each other. The smaller of the two coils was suspended by a phosphor-bronze wire inside the other. From the dimensions of the coils, the modulus of torsion of the wire and the torsion required to keep the inner coil in the original position during the passage of the current, the strength of the current was calculated.

In 1907 at the *National Physical Laboratory* at Teddington [2]) a current weigher was used, which had a coil with vertical axis suspended from each end of the beam inside of a fixed coil; the movable and the fixed coil hanging coaxially. The torque arising from the passage of the current was compensated by weights. From the amounts of these weights and the dimensions of the coils the strength of the current could be found.

In a similar way the E. M. F. was determined at the *Laboratoire central d'électricité* at Paris [3]) in 1908; the coils of the English current weigher, however, were long and wound with a single layer of bare wire round marble cylinders, those of the French instrument were much shorter and wound with several (12—18) layers, which, no doubt, rendered the accurate measurement of the effective area of the coils more difficult.

The following values of the E. M. F. of the WESTON Normal Cell were found at 17°:

Bureau of Standards	1.01864	Volts
National Physical Laboratory	1.01830	„
Laboratoire Central d'électricité	1.01869	„

the current being expressed in C. G. S. ampères, the resistance in international Ohms.

It is in principle much simpler to measure the current by means of the tangent-galvanometer than by these methods, which require

1) Bulletin, Bureau of Standards vol. 2. Nr. 1. p. 33.

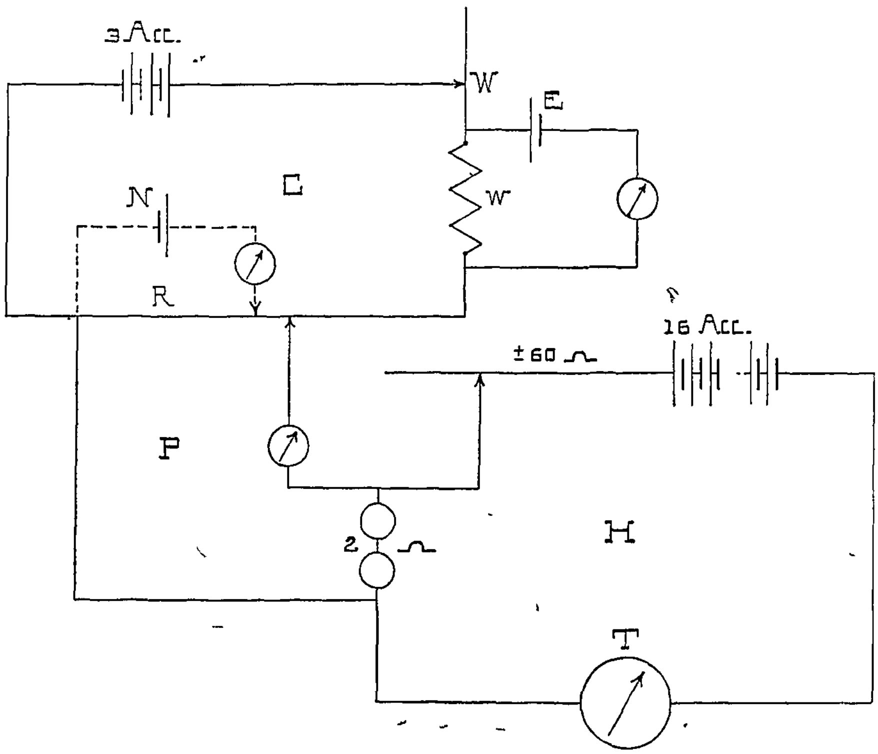
2) Phil. Trans. Roy. Soc. A. Vol. 207. p. 463.

3) Bulletin de la Soc. internationale des Electriciens, 1908, 1910.

rather complicated expressions for the forces acting on the coils. The *Physical Laboratory* of the *University* of Groningen being very suitable for these researches, and the importance of determining a quantity so essential for electrical measurements by different ways being great, a new measurement was undertaken by means of the tangent-galvanometer, though this method has the drawback that an error in the value of the horizontal component of the earth's magnetic field occurs in the value of the E. M. F. $5^1/_2$ times increased.

2. The adjoined figure represents the arrangement of the circuits diagrammatically.

In the main circuit a current of about $^1/_2$ ampère was produced by a battery of 16 accumulators; this current passed through a regulating resistance of manganine wire of about 60 ohms, and two resi-



stances of 1 ohm; its strength was measured by two tangent-galvanometers. These two resistances of 1 ohm had been constructed for this purpose by Otto Wolff, Berlin, from manganine wire of such a section that a current of 1 ampère would cause only a slight rise of temperature; so the current of $^1/_2$ ampère used in the expe-

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riment will only very slightly modify the temperature of the two resistances, which were immersed in a large tank with paraffin oil provided with a stirring-apparatus. Their resistance *in international ohms* was found by comparison with two standard resistances of 1 ohm, which had been tested with special care before and after the investigation at the *Physikalisch Technische Reichsanstalt*

The comparison was made by means of the WHEATSTONE bridge; the four branches being formed by a ratio coil (100, 0,05, 0,05, 100 ohms), the two resistances of 1 ohm, and the two standard resistances of 1 ohm. The galvanometer used was the JAEGER galvanometer, made by SIEMENS & HALSKE, with a movable coil with a resistance of 9,5 ohms; a deflection of 1 mm. with a distance of the scale of 1 meter was obtained by a current of 1.4×10^{-8} ampères; the resistances could be determined to one millionth of an ohm.

The two tangent-galvanometers were the same as had been used by Messrs. G. v. DIJK and J. KUNST in their determination of the electro-chemical equivalent of silver [1]); they were placed one to the north, the other to the south of a bifilarly-suspended magnet, so that the horizontal component of the earth's magnetic field could be determined immediately before and after the measurements of the current, the variometers for the declination and the horizontal intensity being read during the latter. The horizontal component of the earth's magnetic field was determined in the same way as has been at length explained in the above-mentioned paper. An improvement was only made in the method of the determination of the distance of the magnetometers from the bifilarly-suspended magnet, which consisted in this that in the frontside and in the backside of the glass tubes, containing the suspension threads of the magnetometers, holes are bored, 3 mm. wide and 1 cm. high, so that the place of the suspension threads could be accurately determined on a horizontal graduated glass scale placed behind it. Except in this determination the holes were closed by a paper tube. Moreover the wooden 3-meter scale, serving for the measurement of the scale-distances, was replaced by a brass one. The thick copper strips: the leads of the southern tangent-galvanometer, had been replaced by two thin copper wires, which were placed close to each other in a plane normal to the magnetic meridian.

By means of RAPS' potentiometer the difference of potential between the terminals of the resistance of 2 ohms was compared with that of the WESTON Normal Cell N, for which the element

[1]) Arch. Néerland. Série II, Tome IX, p. 442.

marked C_{20} was taken. By means of an auxiliary battery of 3 accumulators, a regulating resistance W, the fixed resistance W of 10190 ohms, the WESTON cell E — a current was obtained of about 0,0001 ampères in the well-known way, and the potentiometer resistance R was determined, required to make the current in the circuit of N zero.

Then the resistance in the main circuit H was adjusted so that with the same resistance R no current passed through the circuit P. When this was obtained the simultaneous reading of the two tangent-galvanometers gave the intensity of the current.

As, however, perfect equality of the potentiometer resistance in the two cases could not be obtained, part of the measurements were made with a somewhat smaller, part of the measurements with a somewhat greater potentiometer resistance in the circuit P than in the circuit of the normal cell, so that the accurate value of the current could be found by interpolation.

The galvanometer used with the potentiometer was an EDELMANN galvanometer with movable coil of 240 ohms; a deflection of 1 mm. for a distance of the scale of 1 meter was caused by a current of $3{,}6 \times 10^{-10}$ ampères; by means of this galvanometer it was possible to determine the potentiometer resistances occurring here with an accuracy of one tenthousandth percent.

On account of the field-magnets of the two galvanometers the circuits P and C were placed at a great distance from the tangent-galvanometers.

3. The WESTON Normal Cells were constructed by one of us (J. B.) according to the procedure at the *National Physical Laboratory* [1]: the mercury was distilled in a space of rarefied air, small air-bubbles being led through it, and then a few times in vacuo; the cadmium amalgam was prepared electrolytically, pure cadmium of KAHLBAUM being used as anode. A hundred parts by weight of the amalgam contained $12^1/_2$ parts by weight of cadmium. The cadmium sulphate furnished by KAHLBAUM, denoted in his catalogue "zur Arsenbestimmung", was recrystallised a few times. We obtained the mercurous sulphate by preparing an acid solution of mercurous nitrate from strong nitric acid and mercury, and by pouring this as a finely divided stream into hot dilute sulphuric acid, while shaking it vigorously. The precipitate was filtered, washed twice with diluted sulphuric acid and then several times with a neutral solution of cadmium sulphate.

1) Phil. Trans Roy. Soc. A. 207, p. 393.

The cells were prepared at different times; they were sealed by the blow-pipe, and placed in a paraffin oil-bath. It appears from the subjoined table 3 that the E. M. F. of the cells differed little from each other; their E. M. F. was 38×10^{-6} volts higher than the E. M. F. of three cells which were kindly-put at our disposal by the *National Physical Laboratory* in October 1908: S_5, S_6, and S_8, [1]) so that the experience obtained in other laboratories that the WESTON Normal Cell, if prepared with care, can be reproduced, is fully confirmed.

4. The dimensions of the instruments required for the determination of the current, the radii of the tangent-galvanometers, the length and the distance of the suspension-threads of the bifilarly-suspended magnet, etc. were determined by one of us (J. B.) by comparison with a standard invar-meter, whose errors of graduation were found by comparison with a double decimeter of invar, which had been examined at the *Bureau international des poids et mesures* at Breteuil.

5. The course of the measurements, which were made with the assistance of Messrs. E. OOSTERHUIS and R. PALSMA, was as follows:

a. Determination of the horizontal component of the earth's magnetic field by simultaneous reading of the positions of the bifilar magnetometer, the two magnetometers of the tangent-galvanometers, and the variometers for the horizontal intensity and the declination.

b. Determination of the deflections of the two tangent-galvanometers at the moment that the circuit P was without current, the potentiometer resistance R also being read. This measurement was made an odd number of times (generally 11), always after reversal of the current in the tangent-galvanometers. At the same time with the tangent-galvanometers the variometers were also read.

c. Determination as under *a*.

For the final determinations ten such series of measurements have been made; so the number of measurements of the current amounts to fifty for every tangent-galvanometer.

On account of the disturbing influence of the electric tram on the positions of the magnetometers and variometers, the measurements had to be made in the night; between half past eleven and two o'clock two series could be finished.

The results of these measurements are given in the tables 1 and 2.

In table 1 the 2nd and 3rd columns give the values of the three determinations of the horizontal component of the earth's magnetic field

[1]) These cells contained cadmium amalgam with 10% cadmium.

TABLE 1.

Date	H_s	H_n	$H(i_1)$	$H(i_2)$	i_s	i_n
26 Sept.	0.18154	0.18148	0.18150	0.18156	0.50915	0 50910
	0.18157	0 18154	0 18153	0.18159	0.50924	0.50915
	0.18161	0.18162	0.18156	0.18162		
27 Sept.	0.18172	0 18172	0.18175	0.18147	0.50918	0.50923
	0.18166	0.18168	0 18176	0.18148	0.50917	0.50916
	0.18147	0.18149	0.18170	0.18143		
28 Sept.	0.18181	0.18178	0.18164	0.18158	0.50925	0.50908
	0.18158	0.18161	0.18164	0.18157	0.50927	0.50922
	0 18164	0.18163	0.18162	0.18155		
29 Sept.	0.18124	0.18128	0.18136	0.18134	0.50919	0.50904
	0.18133	0.18133	0.18131	0.18132	0.50923	0.50907
	0.18131	0.18133	0.18140	0.18138		
30 Sept.	0.18153	0.18146	0.18149	0 18149	0.50919	0.50915
	0 18149	0.18144	0.18145	0.18145	0.50920	0.50924
	0.18152	0.18144	0.18149	0.18149		

TABLE 2.

Date	t	R_P	R_N	t_N	R	E. K. C_{20} at 17°
26 Sept.	0.50913	10190.2	10191 0	15°.6	2.00002_5	**1.01829**
	0 50920	10191.1	10191.0	15 .6	$2\ 00002_0$	**1.01834**
27 Sept.	0 50920	10191.7	10191.1	15 .7	2.00000_9	**1.01830**
	0 50916	10190.6	10191.0_5	15 .8	2.00001_5	**1.01833**
28 Sept.	0 50917	10190.7	10190.9	16 .0	$2\ 00002_0$	**1 01832**
	0.50924	10191.3	10190.9_5	16 .0	$2\ 00002_5$	**1.01841**
29 Sept.	0.50912	10190.6	10190.8	18 .2	2.00014_1	**1.01836**
	0 50915	$10191\ 2_5$	10190 8	18 .2	2.00014_1	**1.01838**
30 Sept.	0 50917	10190.7	10191.0	16 .5	2.00006_8	**1.01838**
	0.50922	10191.2_5	10191.0	16 .5	2.00006_2	**1.01842**
					Mean	**1.01835**

for every day, derived respectively from the deflections of the southern magnetometer H_z, and from those of the northern magnetometer: H_n; the 4th and 5th columns give the value of H, corresponding with the mean position of the intensity-variometer, resp. during the 1st and 2nd measurement of the current, as they are derived from the three H-determinations. By application of the necessary corrections, the strength of the current in ampères was determined from the mean of the values of H obtained in this way, the known radii of the tangent-galvanometers and the angles of deflection; the 6th column gives the strength of the current of the 1st and the 2nd measurement of the current derived from the southern tangent-galvanometer for every day, the 7th column the same from the northern tangent-galvanometer.

TABLE 3.

Differences in the E. M. F. with those of C_{20} in microvolts (10^{-6} V),					
C_{13}	0	C_{24}	+ 1	C_{35}	− 2
C_{14}	0	C_{25}	+ 7	C_{36}	− 2
C_{15}	− 7	C_{26}	+ 3	C_{37}	− 6
C_{16}	+ 2	C_{27}	− 2	C_{38}	0
C_{17}	− 1	C_{28}	− 2	C_{39}	− 1
C_{18}	− 2	C_{29}	+ 4	C_{40}	+ 1
C_{19}	+ 8	C_{30}	+ 7	C_{41}	+ 8
C_{20}	—	C_{31}	+ 3	C_{42}	+ 6
C_{21}	+ 1	C_{32}	− 1	C_{43}	0
C_{22}	+ 5	C_{33}	+ 3		
C_{23}	+ 5	C_{34}	0		

In table 2 the second column gives for every day the value of the two intensities of the current as the mean value from the two last columns of table 1; the 3rd column the potentiometer resistance in the circuit P; the 4th column that of the circuit N; as is seen one value R_P is every day greater, the other smaller than R_N.

The 6the column contains the value of the 2 Ohm resistance for the temperature, which this resistance had during the passage of the current.

The E. M. F. of the cell C_{20} at the temperature mentioned in the 5[th] column was now found as the product $i \cdot R \cdot \frac{R_N}{R_P}$. From the value found in this way the E. M. F. for 17° is calculated by the aid of the temperature formula. It is found in the last column.

As according to table 3 the mean E. M. F. of all the 31 cells is only 1 microvolt higher than the E. M. F. of C_{20} the result of this investigation is that the E. M. F. of the **Weston Normal Cell at 17° is 1.0183$_5$ Volts** (intern. ohm; C.G.S.-ampère), which value may be considered as accurate down to the fourth decimal.

This value is in close agreement which that found in the *National Physical Laboratory*

On account of the remaining doubt as to the accurate value of the electro-chemical equivalent of silver the ratio between the C. G. S.-ampère and the international ampère is not yet accurately known, so that it is not yet possible to express the above result in international volts.

(December 22, 1910).