# Extracts from the papers of Sir Charles Wheatstone

## WHEATSTONE 2: Material relating to experiments designed to measure electromotile forces and electric potential, [1834-1875]

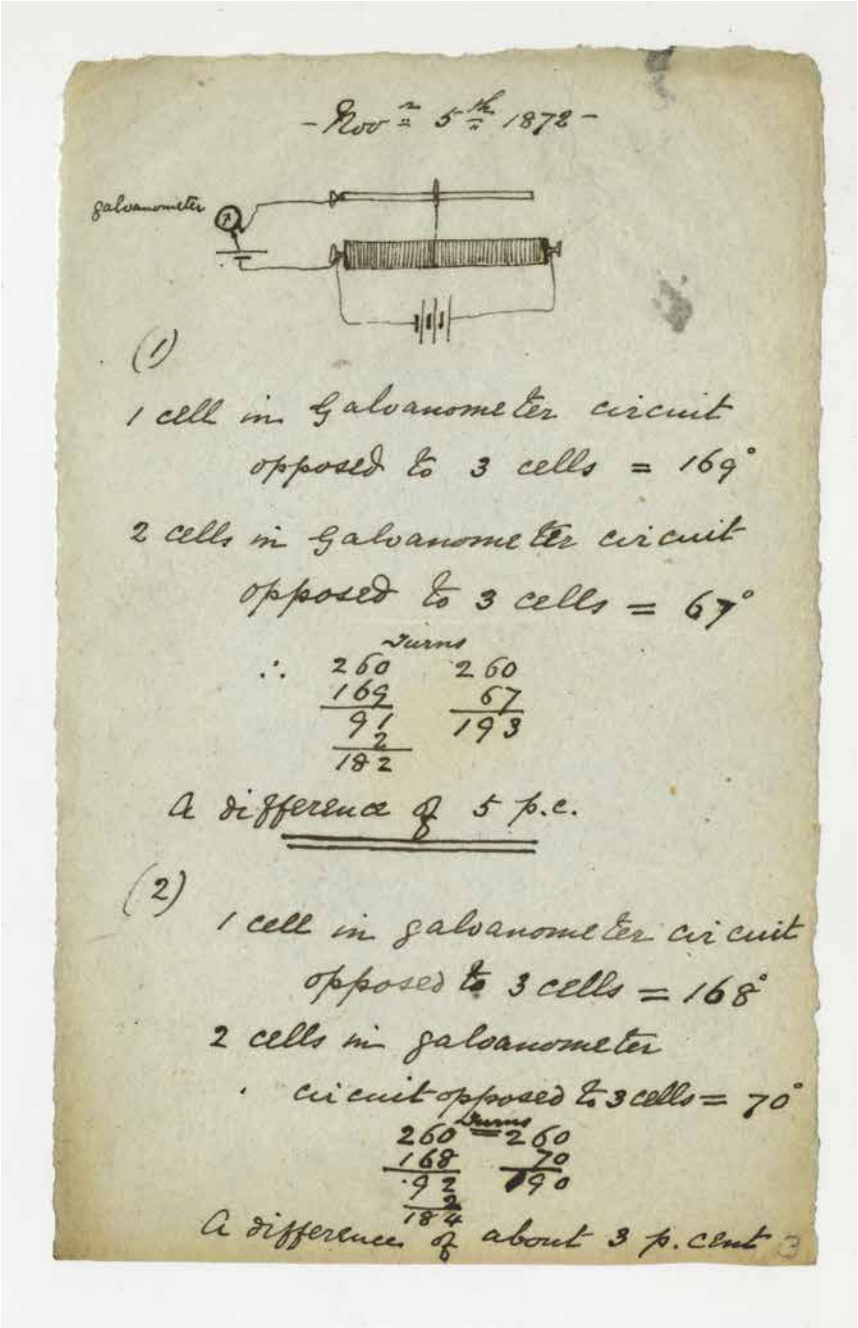
## K/PP107/2/2/1-118

[1871-1872]

Notes compiled by Charles Wheatstone on the measurement of electric potential in an experimental apparatus consisting of rotating electrodes, and in circuits comprising Standard cells and gas batteries; experimental notes on Standard cells applying an apparently innovatory methodology described by the German physicist, Johann Christian Poggendorf (1796-1877), 1871-1872.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



Nov 2nd 5th 1872

galvanometer

(1)

1 cell in Galvanometer circuit
opposed to 3 cells = 169°

2 cells in Galvanometer circuit
opposed to 3 cells = 67°

∴ Turns

| | |
|---|---|
| 260 | 260 |
| 169 | 67 |
| 91 | 193 |
| 2 | |
| 182 | |

a difference of 5 p.c.

(2)

1 cell in galvanometer circuit
opposed to 3 cells = 168°

2 cells in galvanometer
circuit opposed to 3 cells = 70°

| | |
|---|---|
| 260 | 260 |
| 168 | 70 |
| 92 | 190 |
| 2 | |
| 184 | |

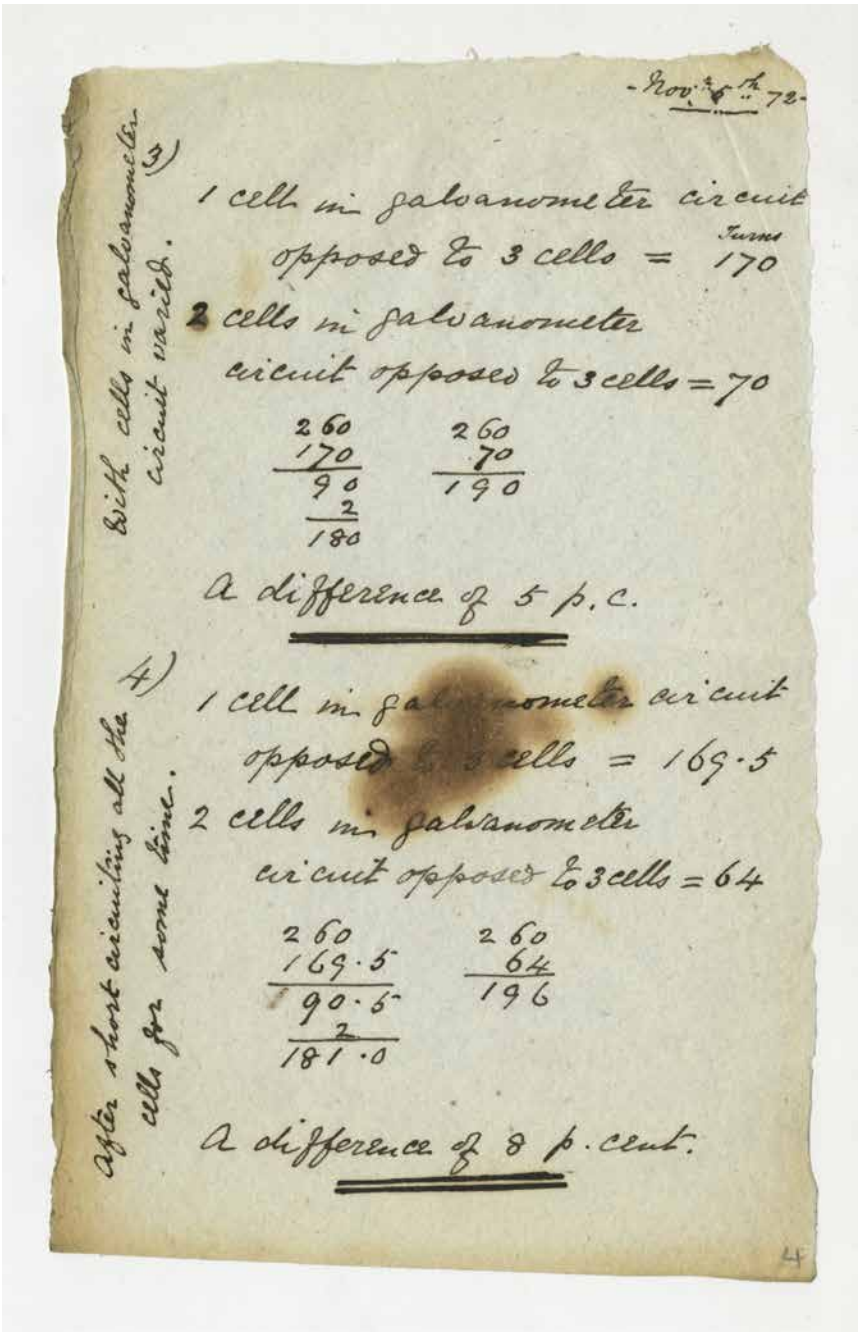
A difference of about 3 p. cent

K/PP107/2/2/3

Experimental notes by John Rymer Jones (1851-[1919]), chemist and electrical engineer, on Standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1871 Nov 5, page 1.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



Nov. 5th 72

3) With cells in galvanometer circuit varied.

1 cell in galvanometer circuit opposed to 3 cells = 170 Turns

2 cells in galvanometer circuit opposed to 3 cells = 70

260 − 170 = 90 ; 90 × 2 = 180

260 − 70 = 190

a difference of 5 p.c.

4) After a short circuiting all the cells for some time.

1 cell in galvanometer circuit opposed to 3 cells = 169·5

2 cells in galvanometer circuit opposed to 3 cells = 64

260 − 169·5 = 90·5 ; 90·5 × 2 = 181·0

260 − 64 = 196

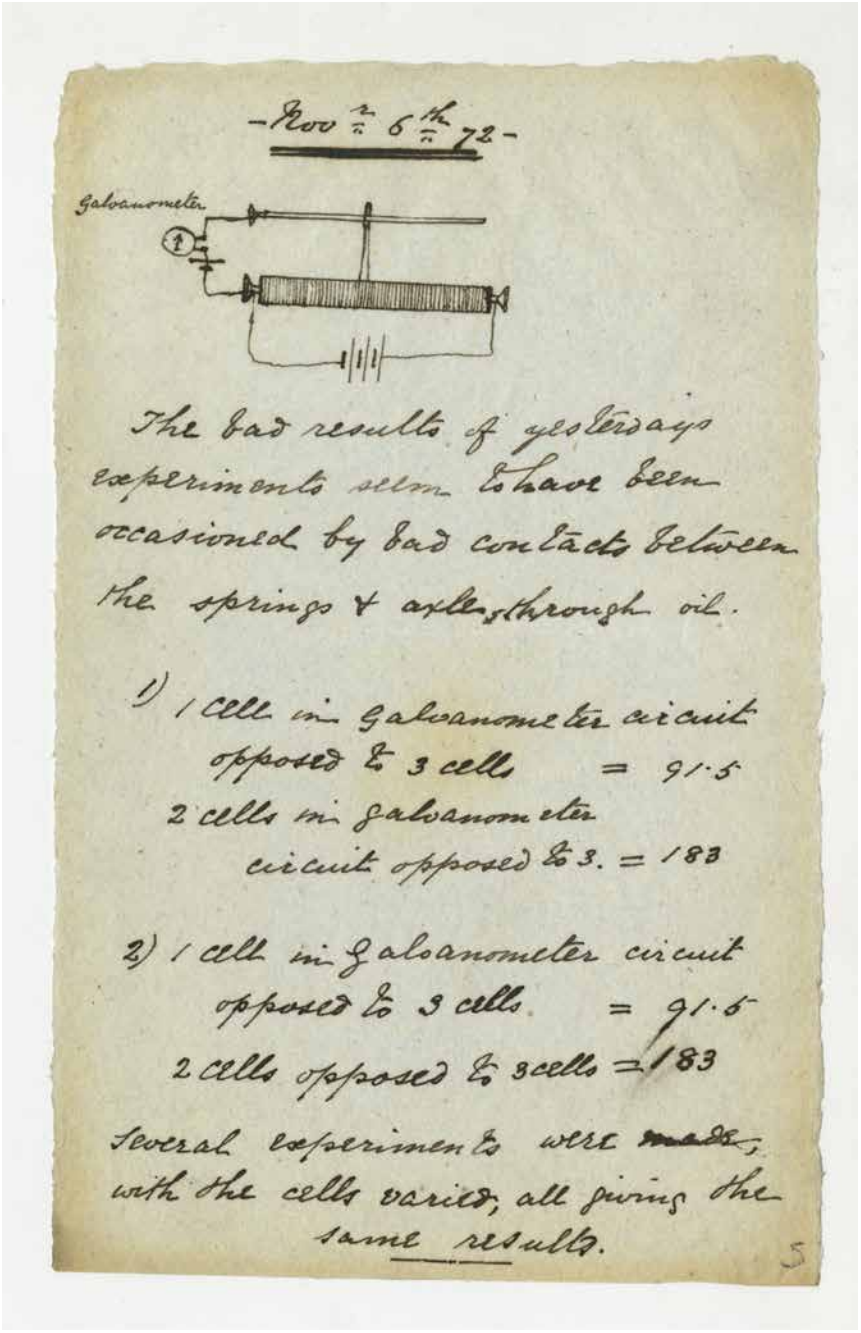
a difference of 8 p. cent.

K/PP107/2/2/4

Experimental notes by John Rymer Jones (1851-[1919]), chemist and electrical engineer, on Standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1871 Nov 5, page 2.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



-Nov 2 to 6th 72-




The bad results of yesterdays experiments seem to have been occasioned by bad contacts between the springs & axles through oil.

1) 1 cell in Galvanometer circuit opposed to 3 cells = 91·5
2 cells in galvanometer circuit opposed to 3. = 183

2) 1 cell in Galvanometer circuit opposed to 3 cells = 91·5
2 cells opposed to 3 cells = 183

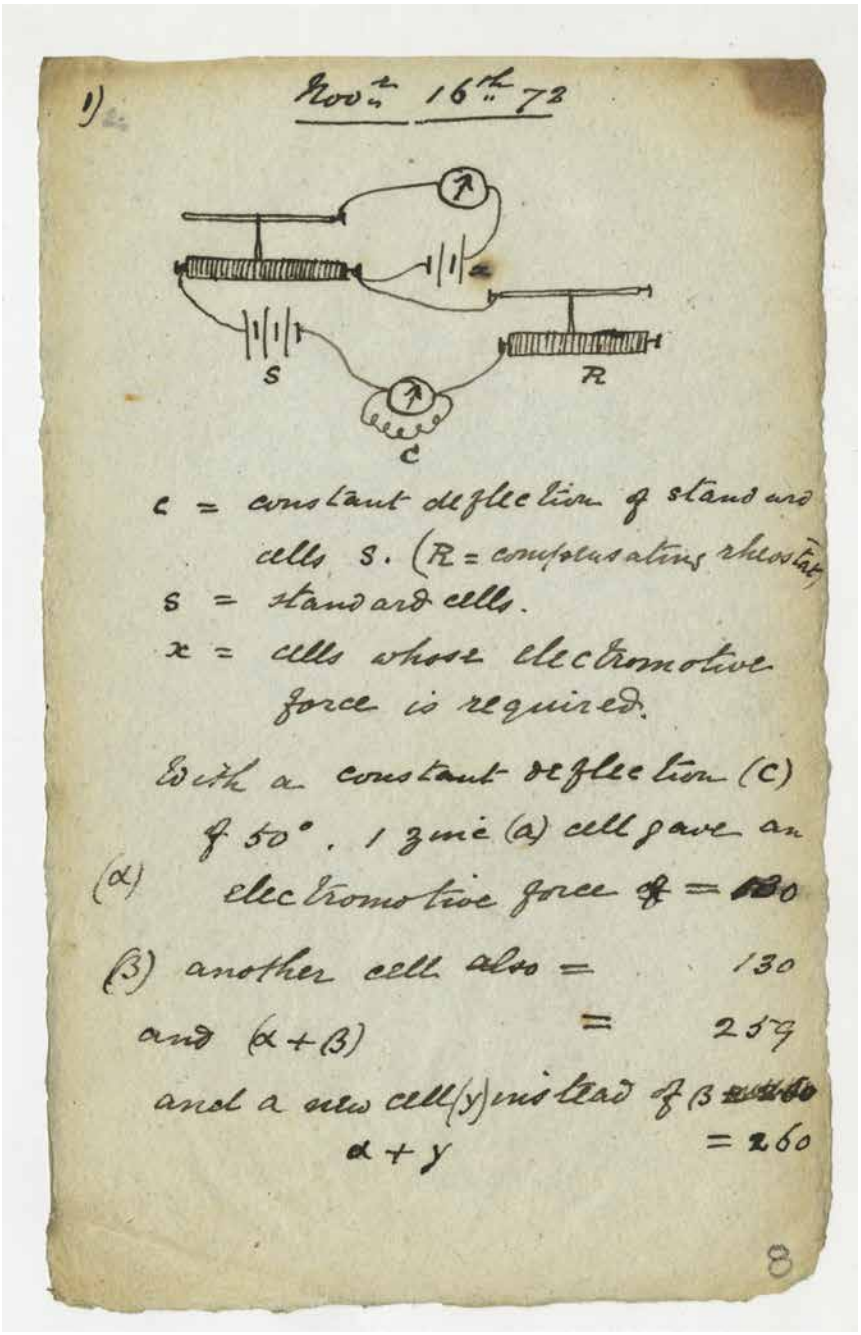
Several experiments were made, with the cells varied, all giving the same results.

5

K/PP107/2/2/5
Experimental notes by John Rymer Jones (1851-[1919]), on Standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1872 Nov 6.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



1) Nov.r 16th 72




c = constant deflection of standard cells S. (R = compensating rheostat)

s = standard cells.

x = cells whose electromotive force is required.

With a constant deflection (C) of 50°. 1 zinc (α) cell gave an

(α) electromotive force of = 130

(β) another cell also = 130

and (α + β) = 259

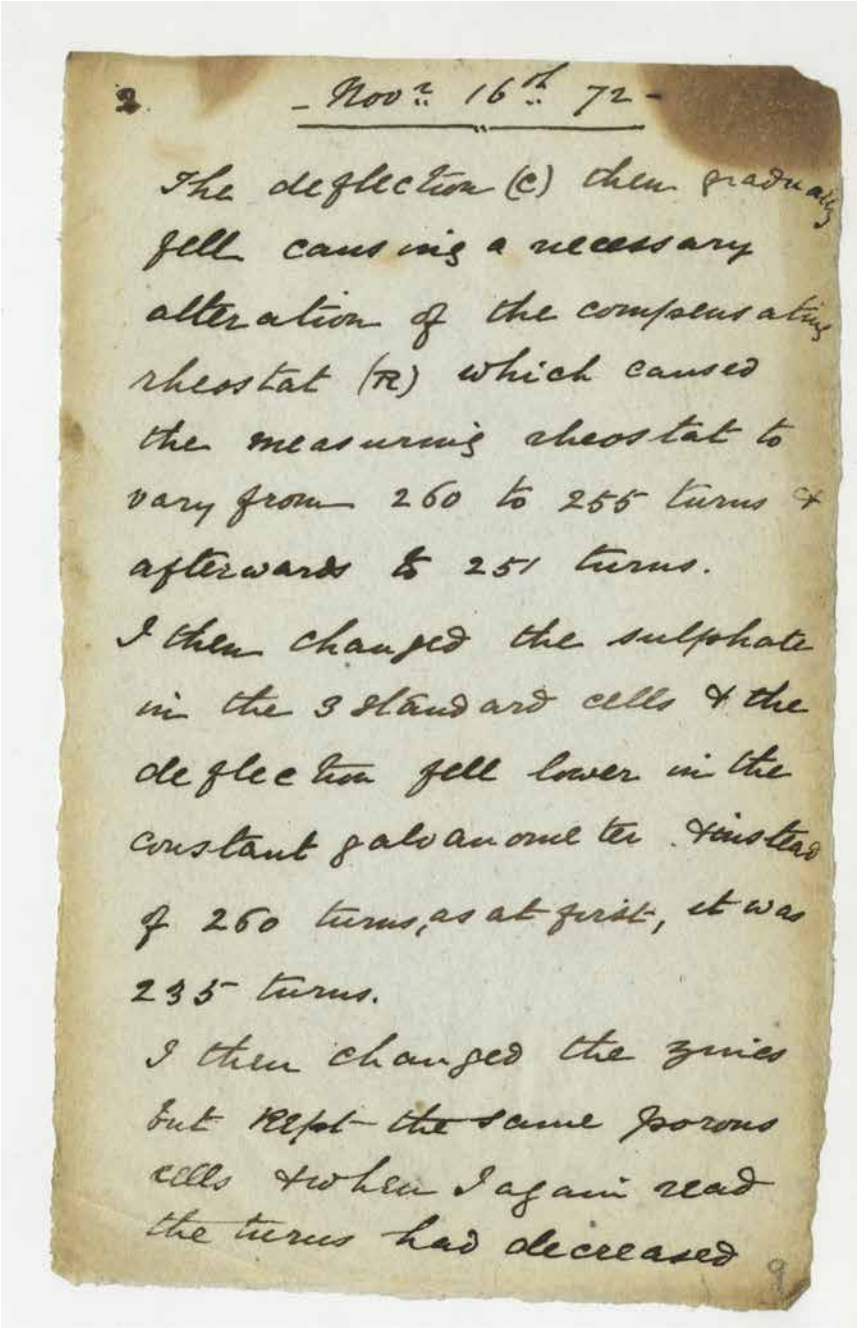
and a new cell (γ) instead of β = 260

α + γ

8

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph

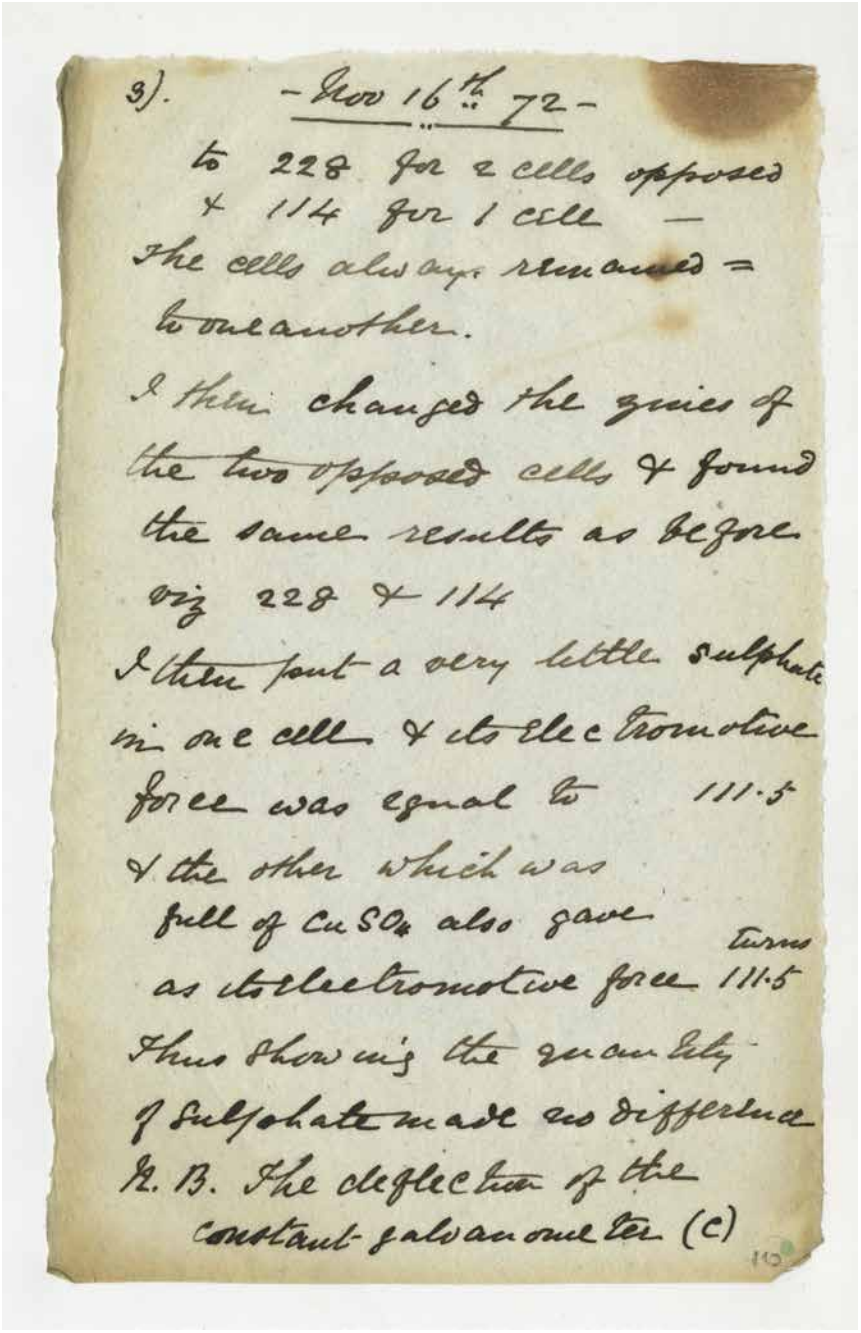


2. Nov.r 16.th 72.

The deflection (c) then gradually fell causing a necessary alteration of the compensating rheostat (R) which caused the measuring rheostat to vary from 260 to 255 turns & afterwards to 251 turns.

I then changed the sulphate in the 3 Standard cells & the deflection fell lower in the constant galvanometer. Instead of 260 turns, as at first, it was 235 turns.

I then changed the zincs but kept the same porous cells & when I again read the turns had decreased



3). — Nov 16th 72 —

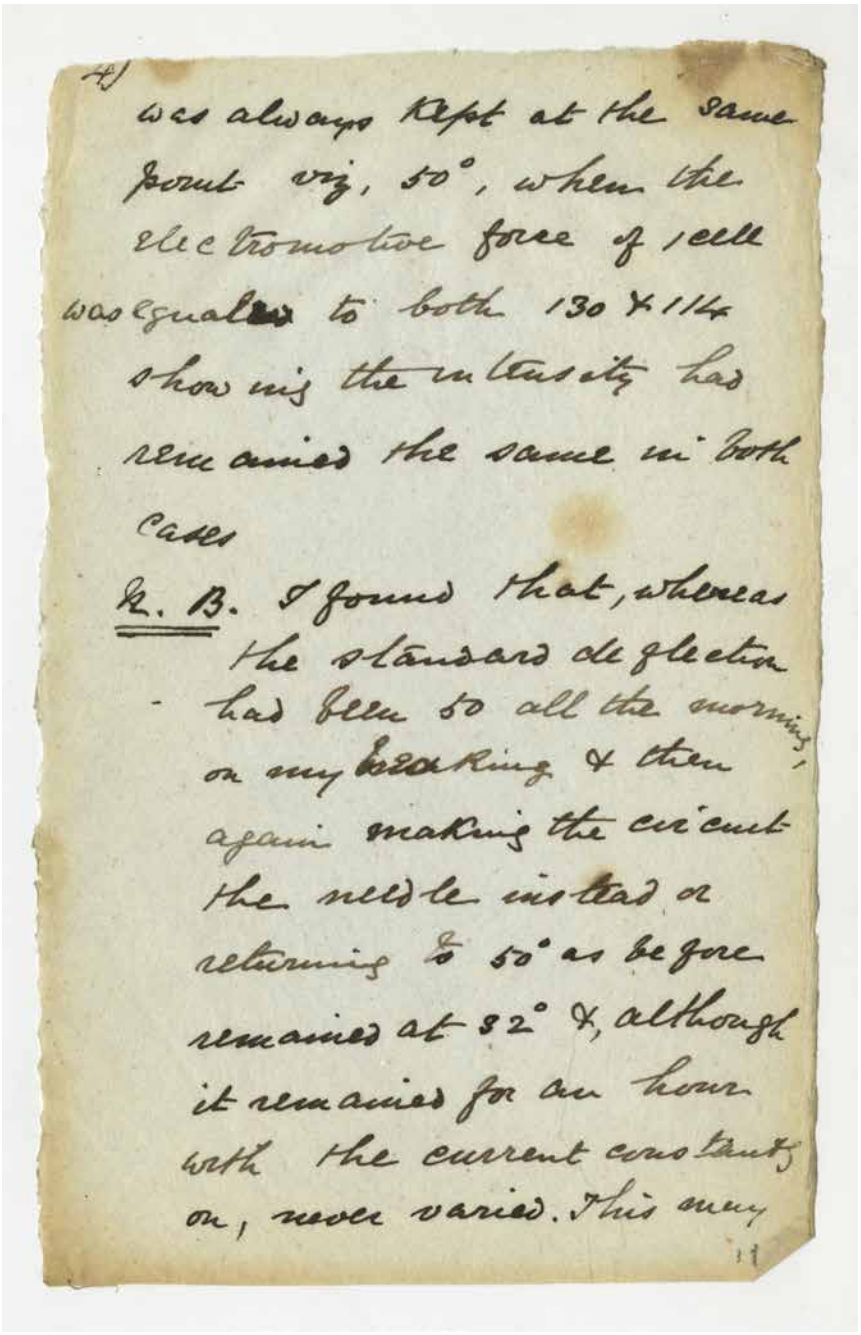
to 228 for 2 cells opposed
+ 114 for 1 cell —
The cells always remained =
to one another.

I then changed the zincs of
the two opposed cells & found
the same results as before
viz 228 + 114

I then put a very little sulphate
in one cell & its Electromotive
force was equal to 111.5
& the other which was
full of $CuSO_4$ also gave
as its electromotive force 111.5 turns

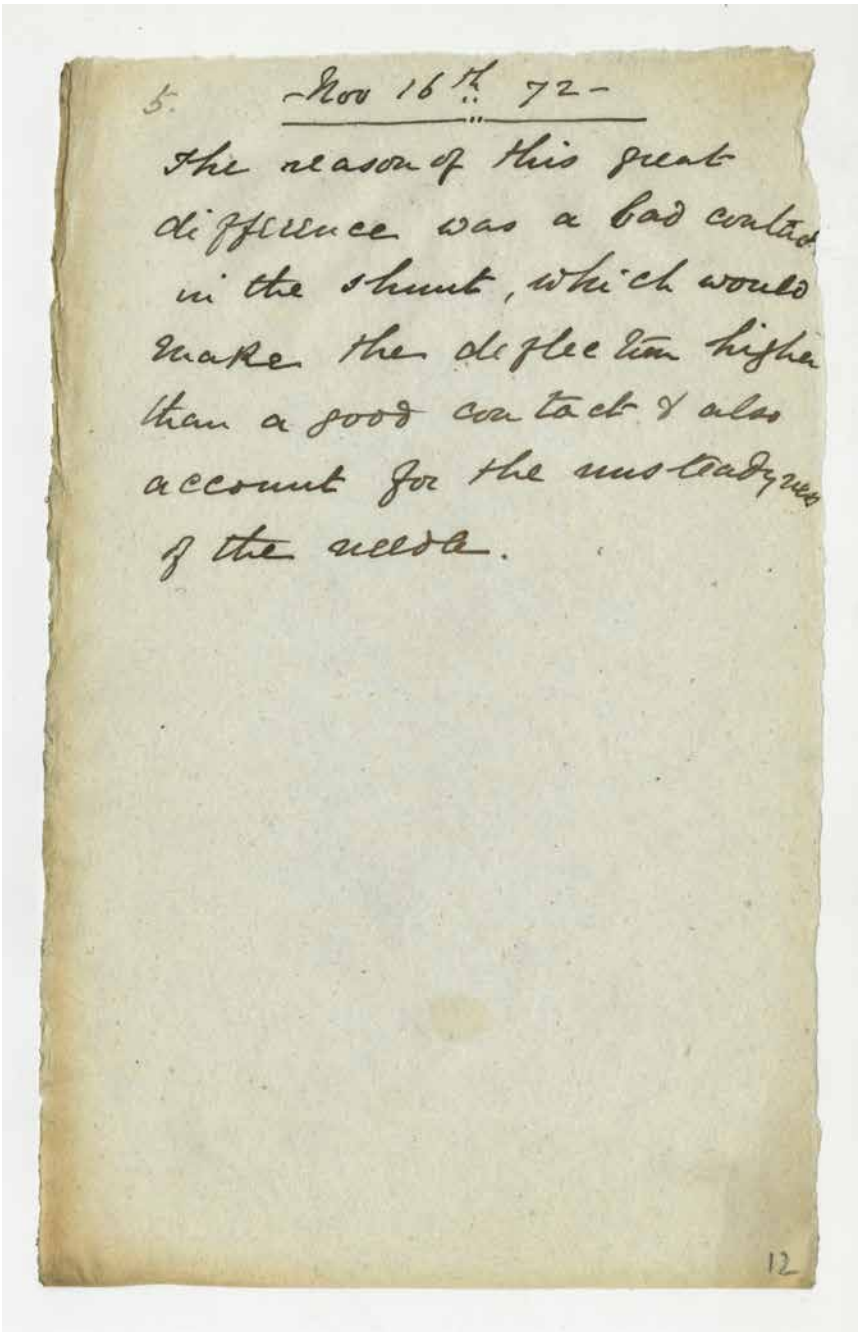
Thus showing the quantity
of sulphate made no difference

N. B. The deflection of the
constant galvanometer (C)



was always kept at the same point viz, 50°, when the electromotive force of 1 cell was equal to both 130 & 114 showing the intensity has remained the same in both cases

R. B. I found that, whereas the standard deflection had been so all the morning, on my breaking & then again making the circuit the needle instead of returning to 50° as before remained at 82° & although it remained for an hour with the current constant or, never varied. This many



5. Nov 16th 72-

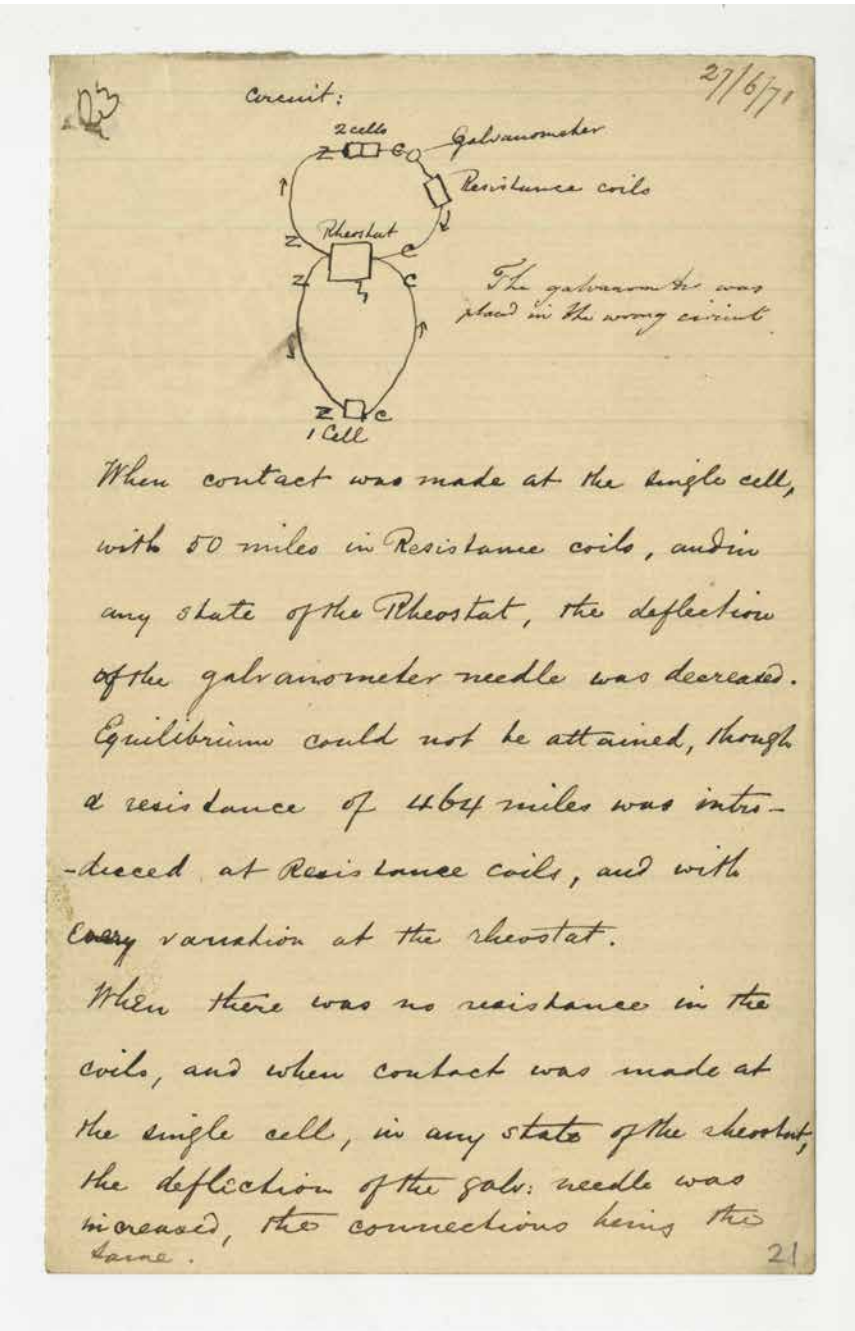
The reason of this great difference was a bad contact in the shunt, which would make the deflection higher than a good contact & also account for the unsteadiness of the needle.

12

K/PP107/2/2/12
Experimental notes by John Rymer Jones (1851-[1919]), on Standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1872 Nov 16, page 5.

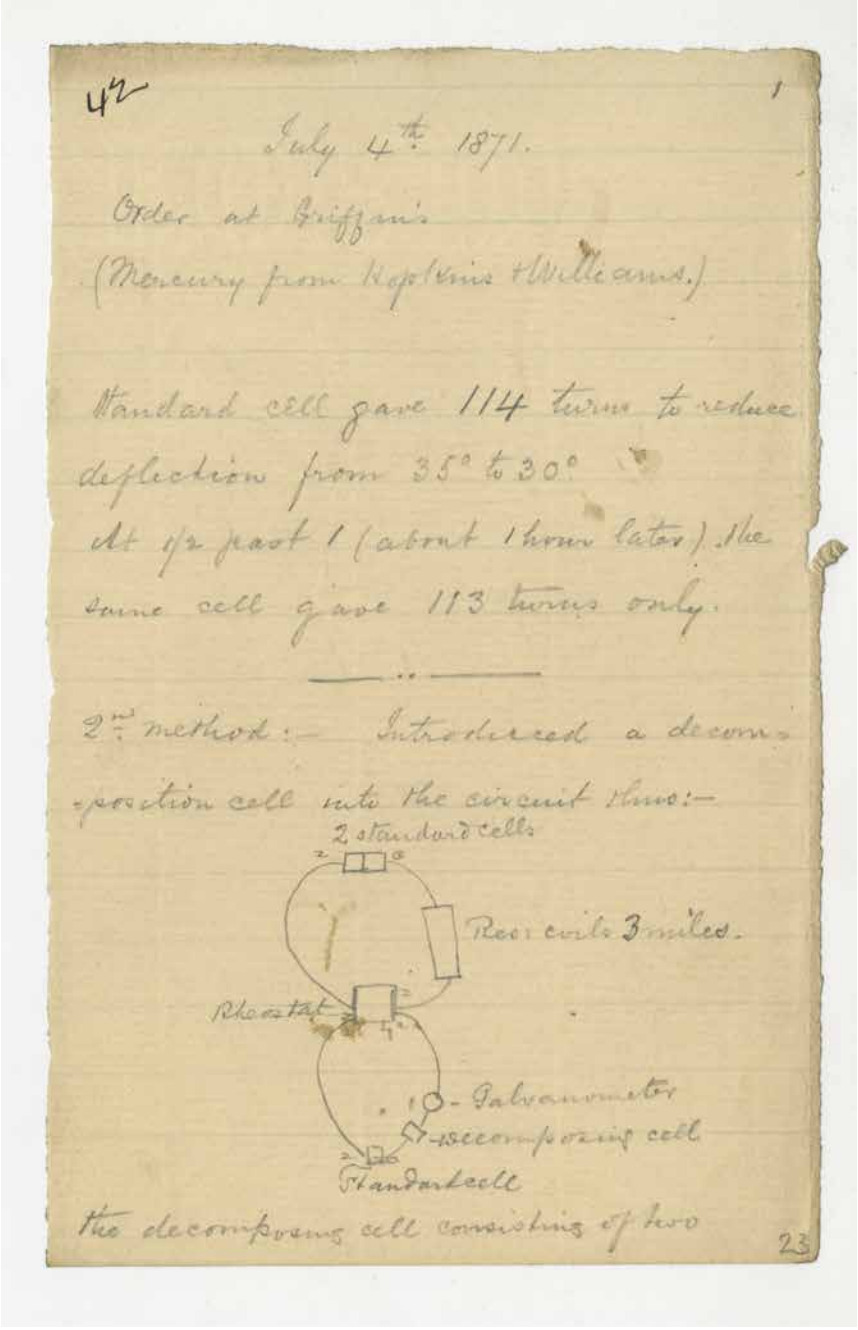
# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph




K/PP107/2/2/21

Experimental notes by Richard William Mellingford Higgs, chemist, with annotations by Wheatstone, on Standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1871 Jun 27.



42 1

July 4th 1871.

Order at Griffin's

(Mercury from Hopkins & Williams.)

Standard cell gave 114 turns to reduce deflection from 35° to 30°

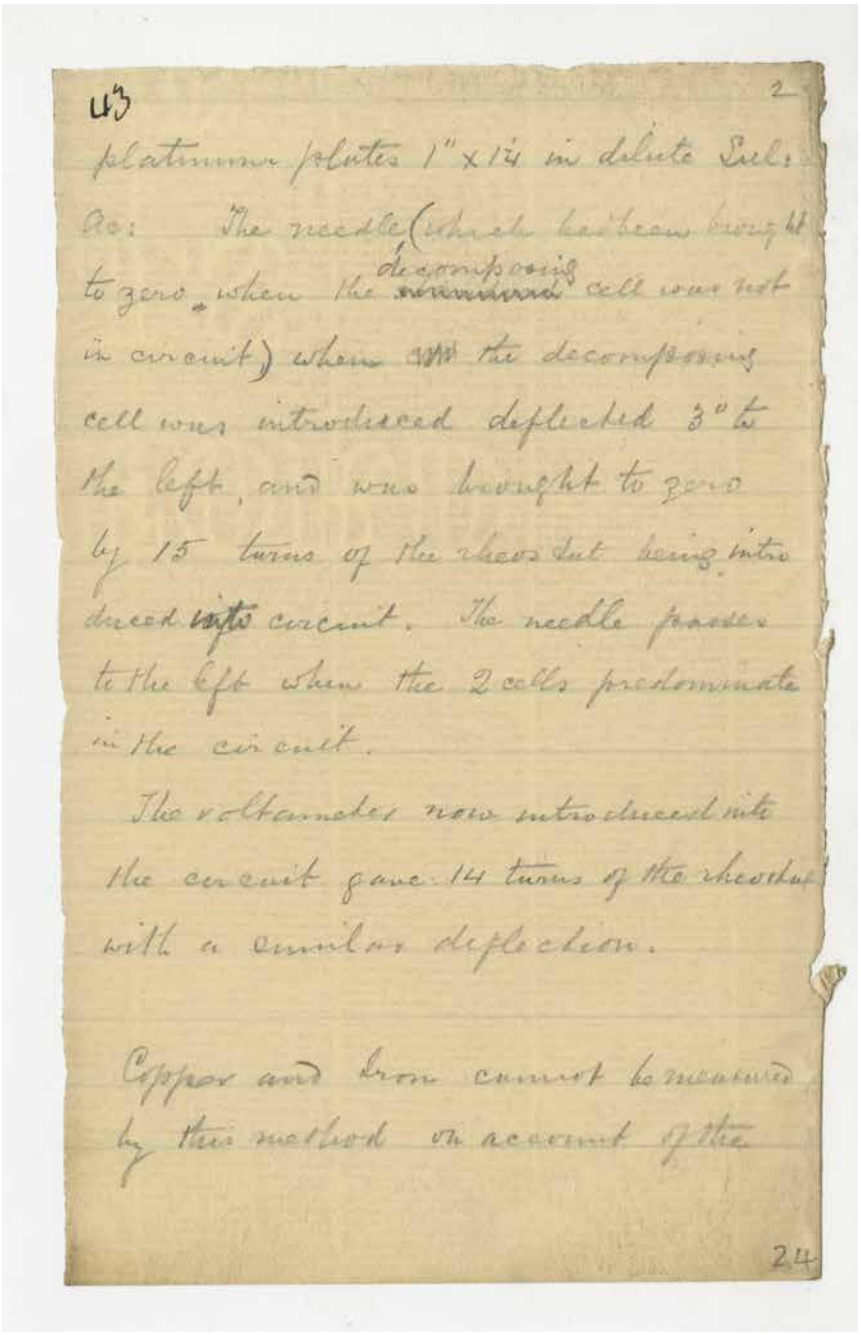
At ½ past 1 (about 1 hour later) the same cell gave 113 turns only.

2nd method:— Introduced a decomposition cell into the circuit thus:—




the decomposing cell consisting of two

23



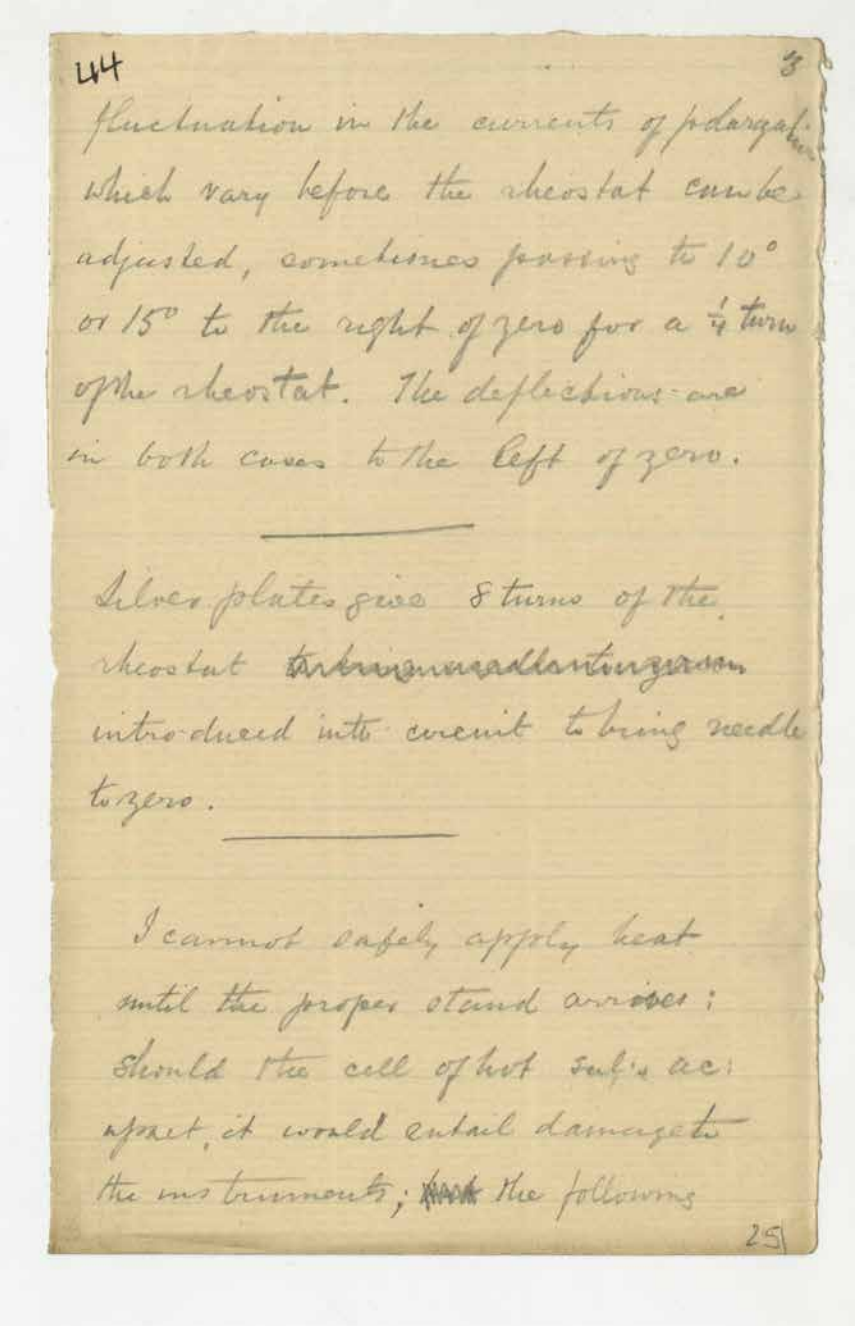
43 2

platinum plates 1" x 1¼ in dilute Sul: Ac: The needle (which has been brought to zero, when the ~~decomposing~~ decomposing cell was not in circuit) when the decomposing cell was introduced deflected 3° to the left, and was brought to zero by 15 turns of the rheostat being introduced into circuit. The needle passes to the left when the 2 cells predominate in the circuit.

The voltameter now introduced into the circuit gave 14 turns of the rheostat with a similar deflection.

Copper and Iron cannot be measured by this method on account of the

24



44 3

fluctuation in the currents of polarization which vary before the rheostat can be adjusted, sometimes passing to 10° or 15° to the right of zero for a ¼ turn of the rheostat. The deflections are in both cases to the left of zero.

---

Silver plates give 8 turns of the rheostat ~~to bring~~ introduced into circuit to bring needle to zero.

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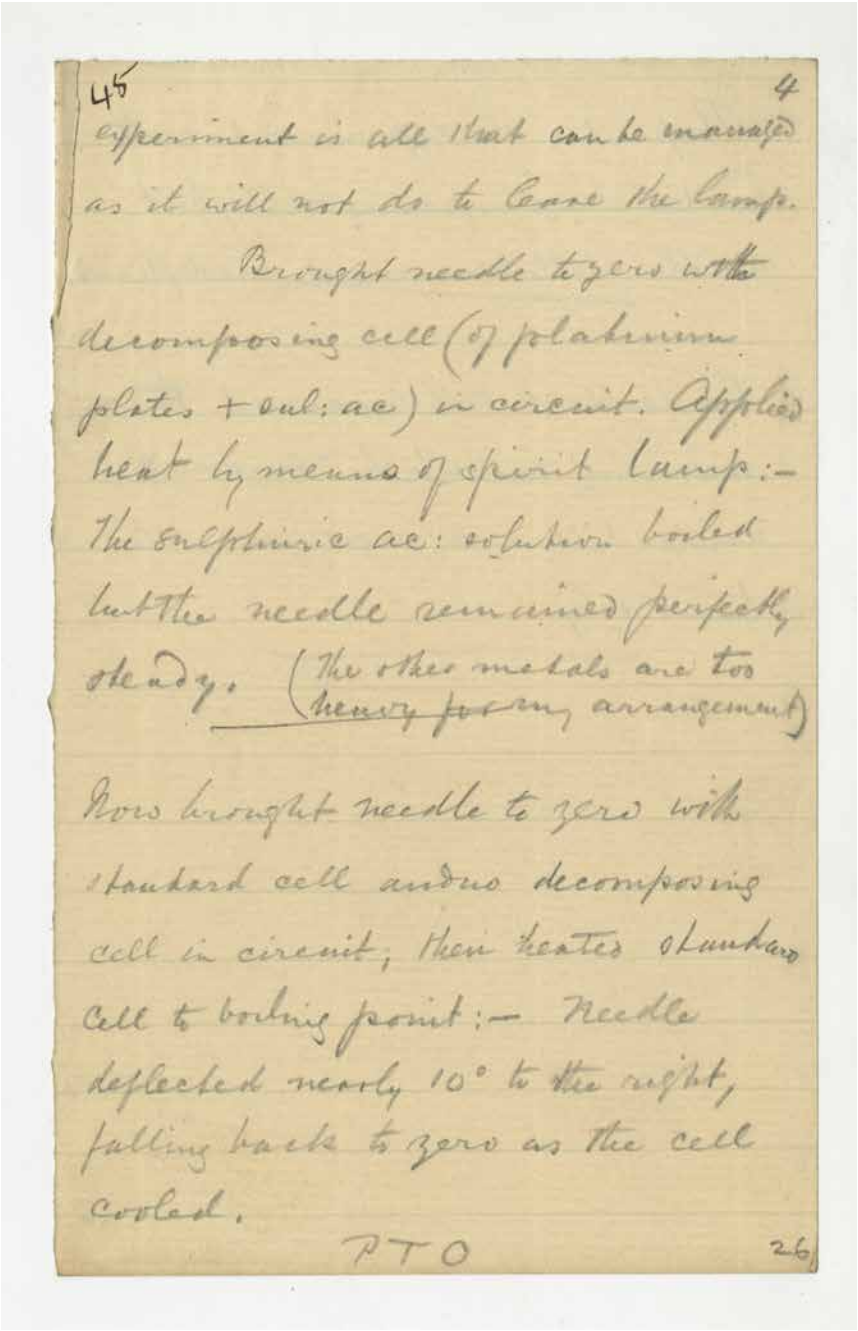
I cannot safely apply heat until the proper stand arrives; Should the cell of hot sulf's acid upset, it would entail damage to the instruments; ~~the~~ the following

25



45 4

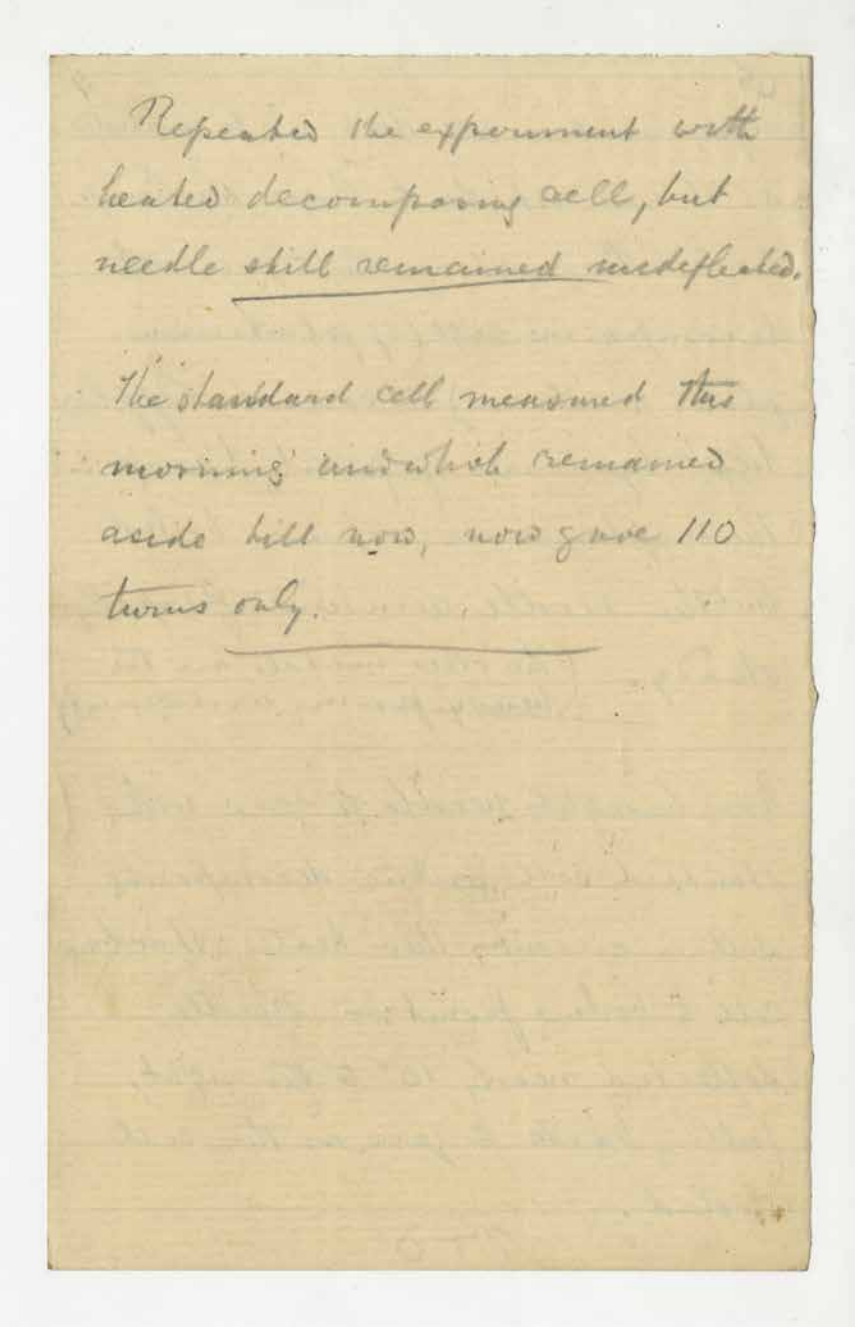
experiment is all that can be managed as it will not do to leave the lamp.

Brought needle to zero with decomposing cell (of platinum plates + sul: ac) in circuit. Applied heat by means of spirit lamp:- The sulphuric ac: solution boiled but the needle remained perfectly steady. (The other metals are too heavy for my arrangement)

Now brought needle to zero with standard cell and no decomposing cell in circuit; then heated standard cell to boiling point:- Needle deflected nearly 10° to the right, falling back to zero as the cell cooled.

PTO

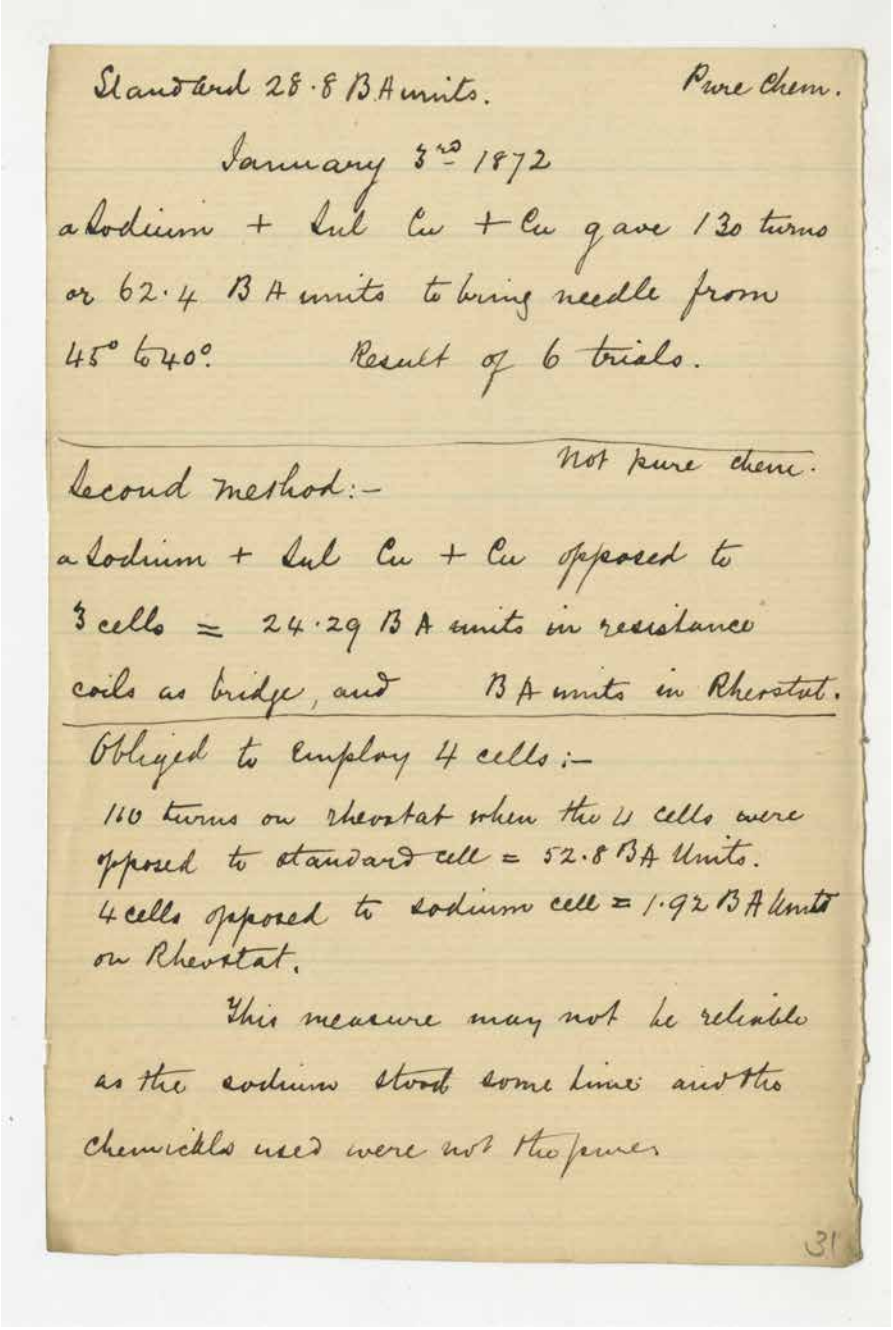
26



Repeated the experiment with heated decomposing cell, but needle still remained undeflected.

The standard cell measured this morning and which remained aside till now, now gave 110 turns only.

K/PP107/2/2/26
Experimental notes by Richard William Mellingford Higgs, chemist, with annotations by Wheatstone, on Standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1871 Jul 4, page 5.



Standard 28·8 BA units. Pure Chem.

January 3rd 1872

a Sodium + Sul Cu + Cu gave 130 turns or 62·4 BA units to bring needle from 45° to 40°. Result of 6 trials.

Second method:- Not pure chem.

a Sodium + Sul Cu + Cu opposed to 3 cells = 24·29 BA units in resistance coils as bridge, and BA units in Rheostat.

Obliged to employ 4 cells:-

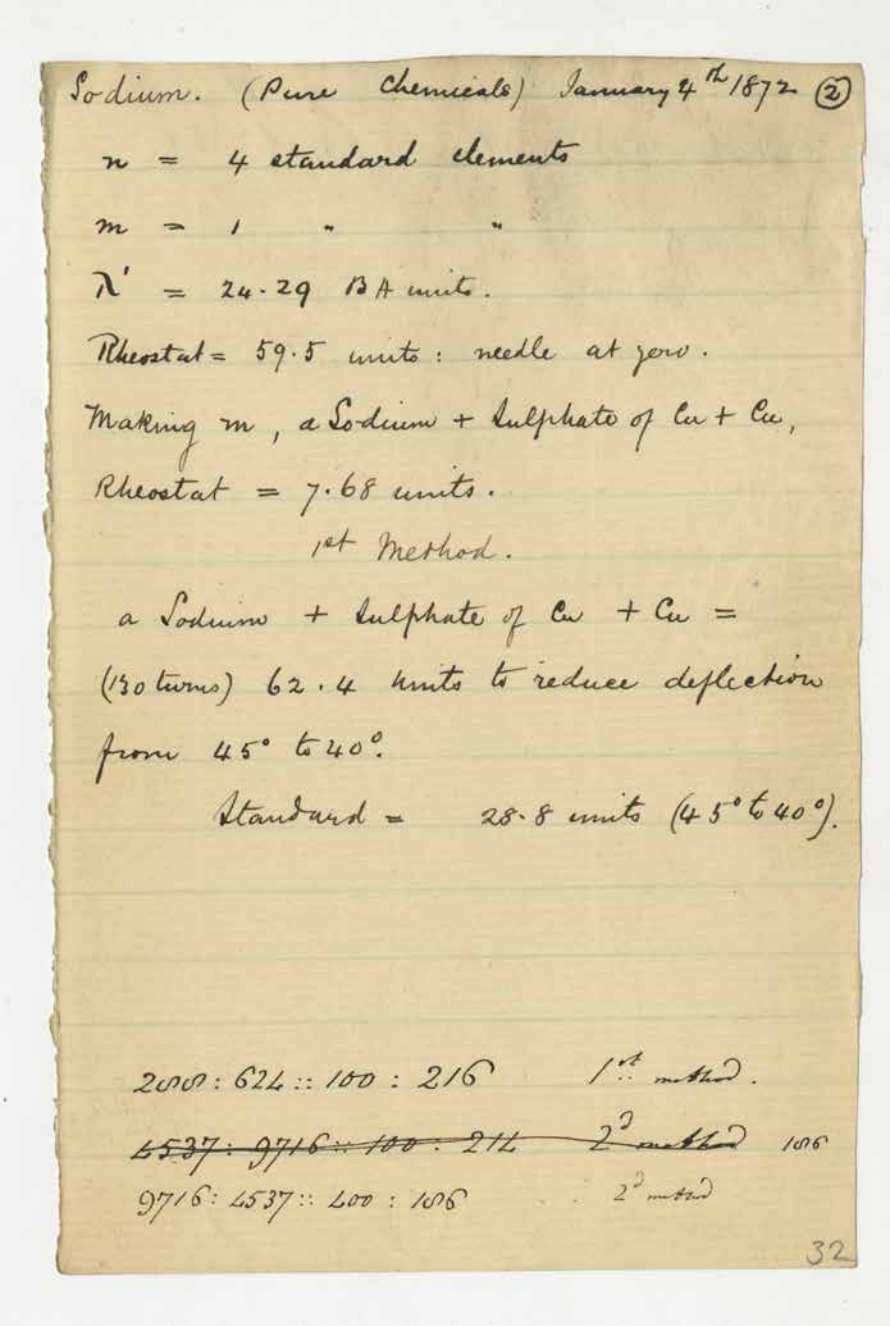
110 turns on rheostat when the 4 cells were opposed to standard cell = 52·8 BA Units.

4 cells opposed to sodium cell = 1·92 BA Units on Rheostat.

This measure may not be reliable as the sodium stood some time and the chemicals used were not the purest

31

K/PP107/2/2/31
Experimental notes by Richard William Mellingford Higgs, chemist, with annotations by Wheatstone, on standard cells applying an apparently innovatory methodology described by Johann Christian Poggendorf (1796-1877), German physicist, 1872 Jan 3, page 1.



Sodium. (Pure Chemicals) January 4th 1872 (2)

n = 4 standard elements

m = 1 " "

λ' = 24.29 BA units.

Rheostat = 59.5 units: needle at zero.

Making m, a Sodium + Sulphate of Cu + Cu,

Rheostat = 7.68 units.

1st Method.

a Sodium + Sulphate of Cu + Cu =

(130 turns) 62.4 units to reduce deflection

from 45° to 40°.

Standard = 28.8 units (45° to 40°).

2000 : 624 :: 100 : 216 1st method.

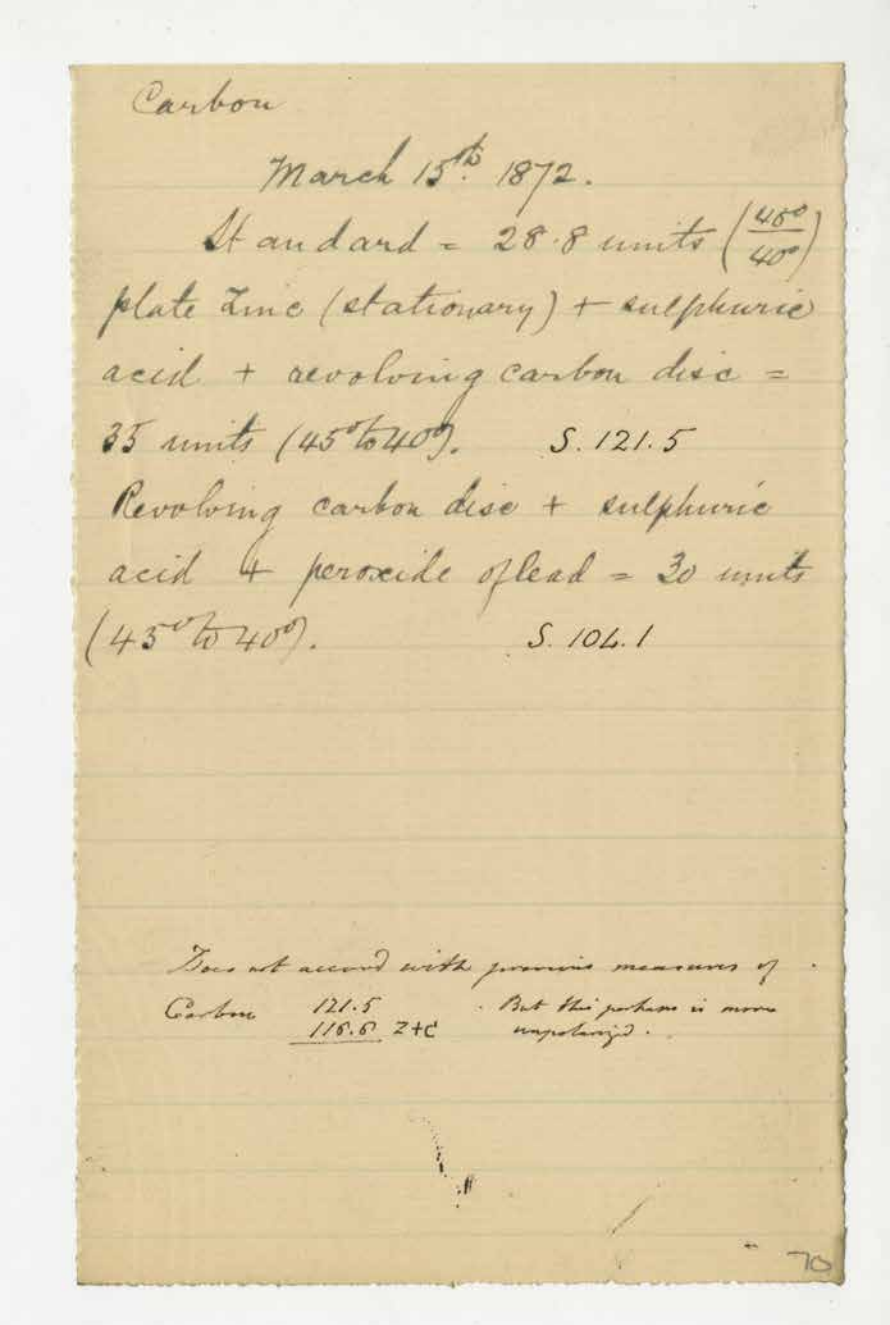
~~4537 : 9716 :: 100 : 214 2d method~~ 106

9716 : 4537 :: 100 : 106 2d method

32

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



Carbon

March 15th 1872.

Standard = 28·8 units $\left(\frac{40°}{40°}\right)$ plate Zinc (stationary) + sulphuric acid + revolving carbon disc = 35 units (45° to 40°). S. 121.5

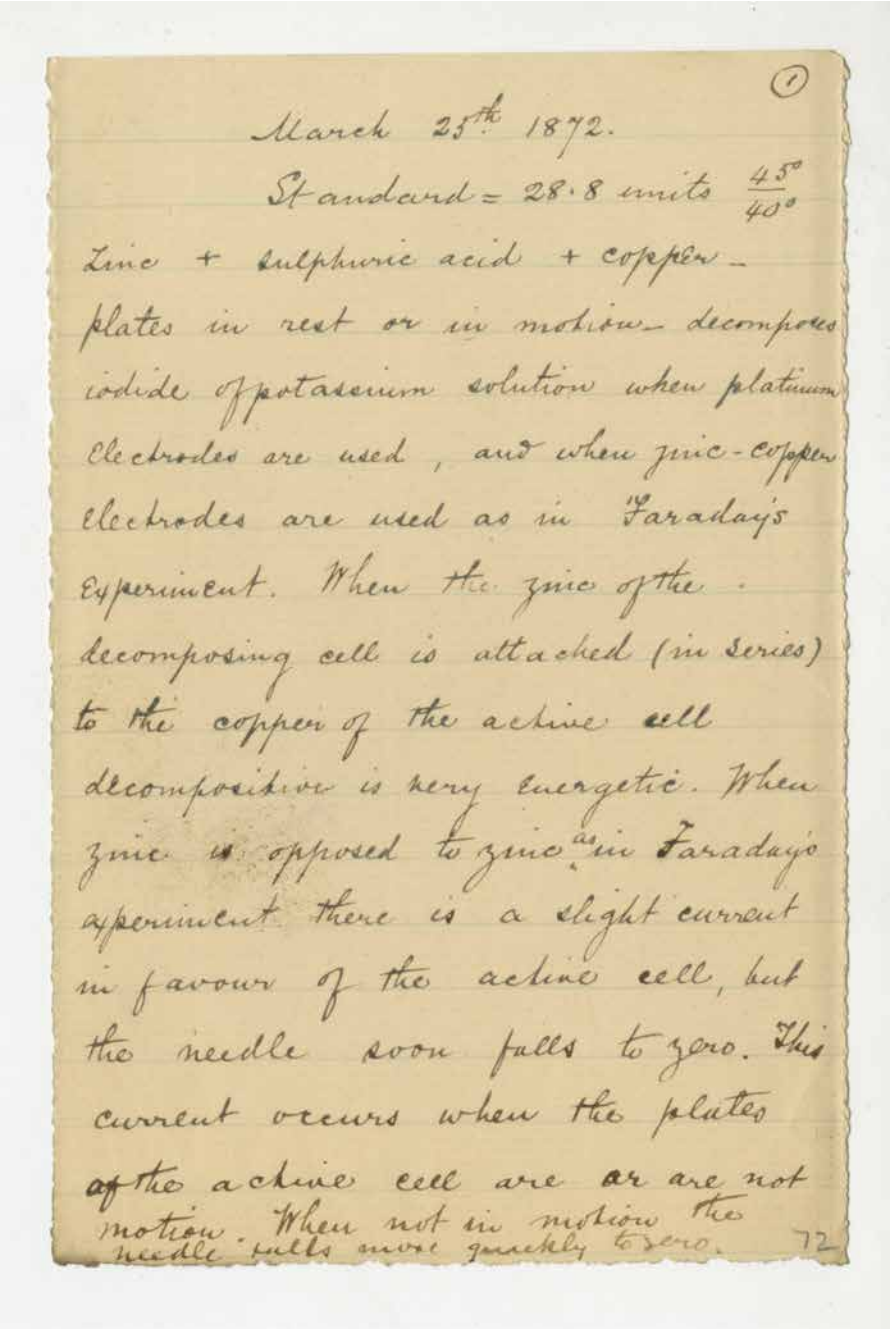
Revolving carbon disc + sulphuric acid + peroxide of lead = 30 units (45° to 40°). S. 104.1

Does not accord with previous measures of Carbon 121.5 / 118.6 Z+C · But this portion is more unpolarized.

70

K/PP107/2/2/70

Notes from a bundle on the use of an experimental apparatus consisting of rotating electrodes by Richard William Mellingford Higgs, chemist, with annotations by Wheatstone, 1872 Mar 15.



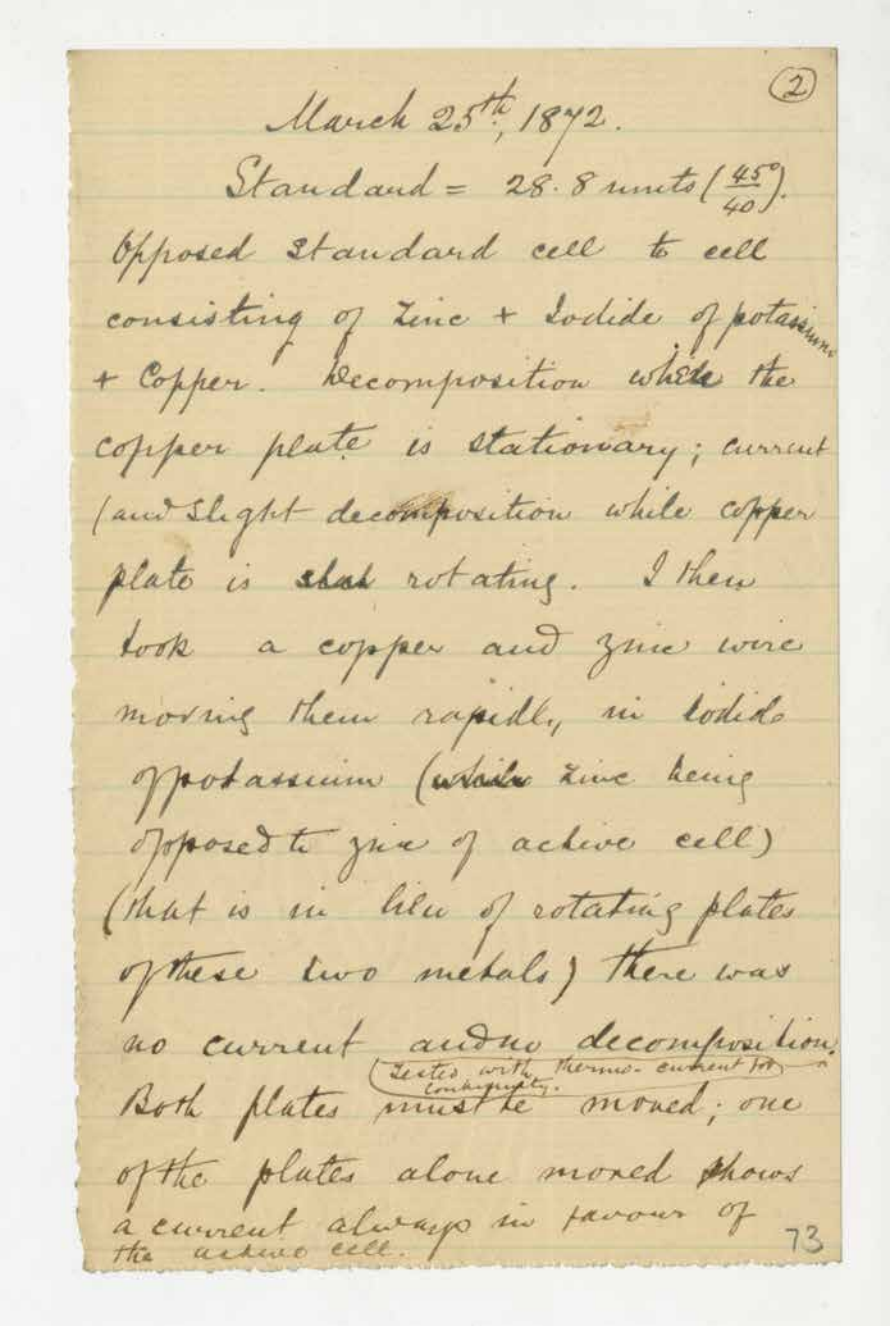
(1)

March 25th 1872.

Standard = 28·8 units $\frac{45°}{40°}$

Zinc + sulphuric acid + copper plates in rest or in motion decomposes iodide of potassium solution when platinum electrodes are used, and when zinc-copper electrodes are used as in Faraday's experiment. When the zinc of the decomposing cell is attached (in series) to the copper of the active cell decomposition is very energetic. When zinc is opposed to zinc as in Faraday's experiment there is a slight current in favour of the active cell, but the needle soon falls to zero. This current occurs when the plates of the active cell are or are not motion. When not in motion the needle falls more quickly to zero. 72

K/PP107/2/2/72
Note by Richard William Mellingford Higgs, chemist, from a bundle on the use of an experimental apparatus consisting of rotating electrodes used by Michael Faraday (1791-1867), natural philosopher, 1872 Mar 25, page 1.



(2)

March 25th, 1872.

Standard = 28·8 units $(\frac{45°}{40})$.

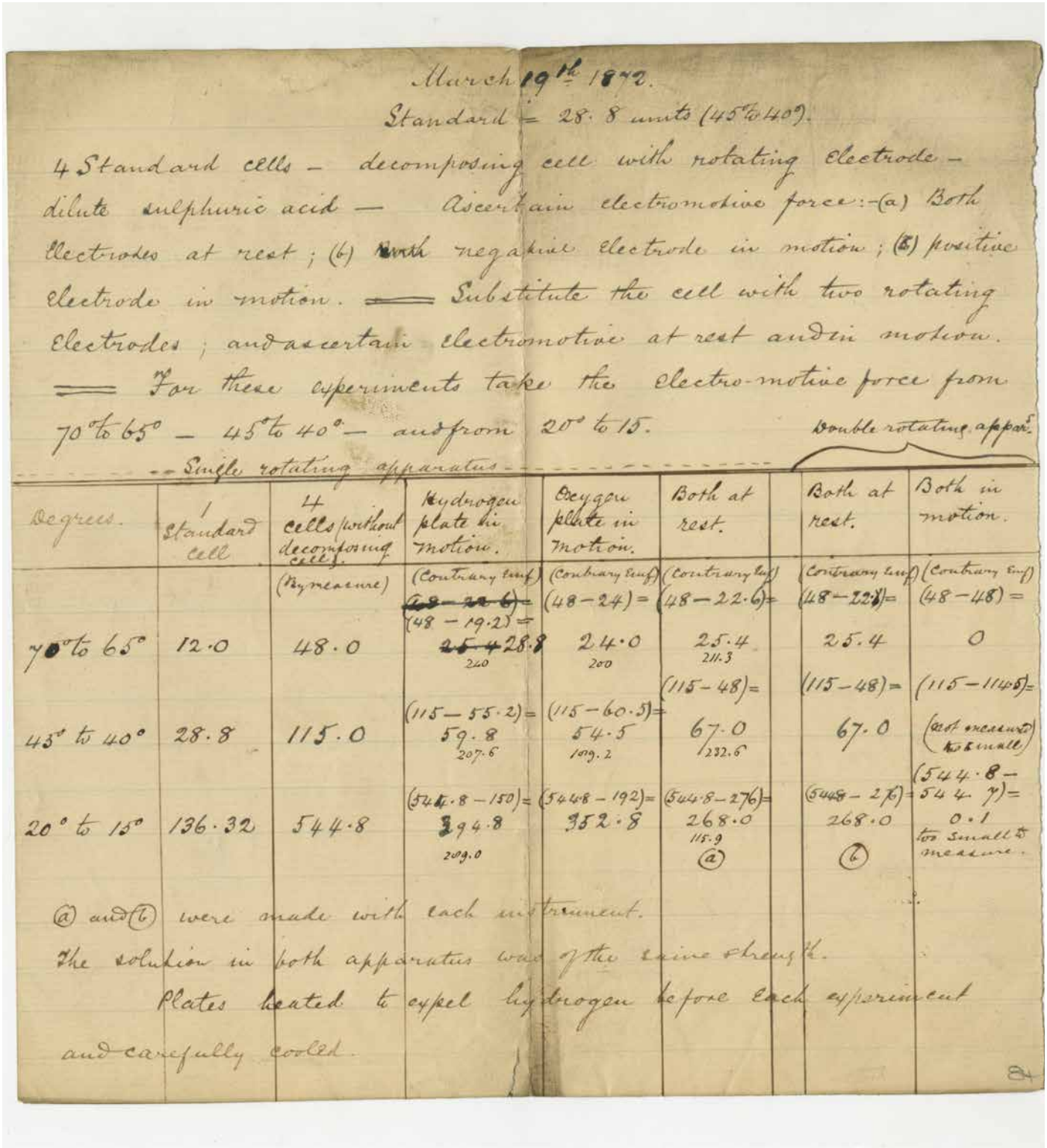
Opposed standard cell to cell consisting of Zinc + Iodide of potassium + Copper. Decomposition while the copper plate is stationary; current (and slight decomposition while copper plate is ~~shak~~ rotating. I then took a copper and zinc wire moving them rapidly, in Iodide of potassium (~~while~~ Zinc being opposed to zinc of active cell) (that is in lieu of rotating plates of these two metals) there was no current and no decomposition. (Tested with thermo-current 10 consequents.) Both plates must be moved; one of the plates alone moved shows a current always in favour of the active cell.

73

K/PP107/2/2/73
Note by Richard William Mellingford Higgs, chemist, from a bundle on the use of an experimental apparatus consisting of rotating electrodes used by Michael Faraday (1791-1867), natural philosopher, 1872 Mar 25, page 2.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



March 19th 1872.

Standard = 28·8 units (45° to 40°).

4 Standard cells – decomposing cell with rotating electrode – dilute sulphuric acid — Ascertain electromotive force:-(a) Both electrodes at rest; (b) with negative electrode in motion; (c) positive electrode in motion. ═══ Substitute the cell with two rotating electrodes; and ascertain electromotive at rest and in motion. ═══ For these experiments take the electro-motive force from 70° to 65° – 45° to 40° – and from 20° to 15°.

Double rotating apparatus

Single rotating apparatus

| Degrees. | 1 Standard cell | 4 cells (without decomposing cell). | Hydrogen plate in motion. | Oxygen plate in motion. | Both at rest. | Both at rest. | Both in motion. |
|---|---|---|---|---|---|---|---|
| | | (By measure) | (Contrary Emf) ~~(48 – 22·6) =~~ (48 – 19·2) = | (Contrary Emf) (48 – 24) = | (Contrary Emf) (48 – 22·6) = | (Contrary Emf) (48 – 22·8) = | (Contrary Emf) (48 – 48) = |
| 70° to 65° | 12·0 | 48·0 | ~~25·4~~ 28·8 220 | 24·0 200 | 25·4 211·3 | 25·4 | 0 |
| 45° to 40° | 28·8 | 115·0 | (115 – 55·2) = 59·8 207·6 | (115 – 60·5) = 54·5 189·2 | (115 – 48) = 67·0 232·6 | (115 – 48) = 67·0 | (115 – 114·5) = (not measured) too small |
| 20° to 15° | 136·32 | 544·8 | (544·8 – 150) = 394·8 209·0 | (544·8 – 192) = 352·8 | (544·8 – 276) = 268·0 115·9 (a) | (544·8 – 276) = 268·0 (b) | (544·8 – 544·7) = 0·1 too small to measure. |

(a) and (b) were made with each instrument.

The solution in both apparatus was of the same strength.

Plates heated to expel hydrogen before each experiment and carefully cooled.

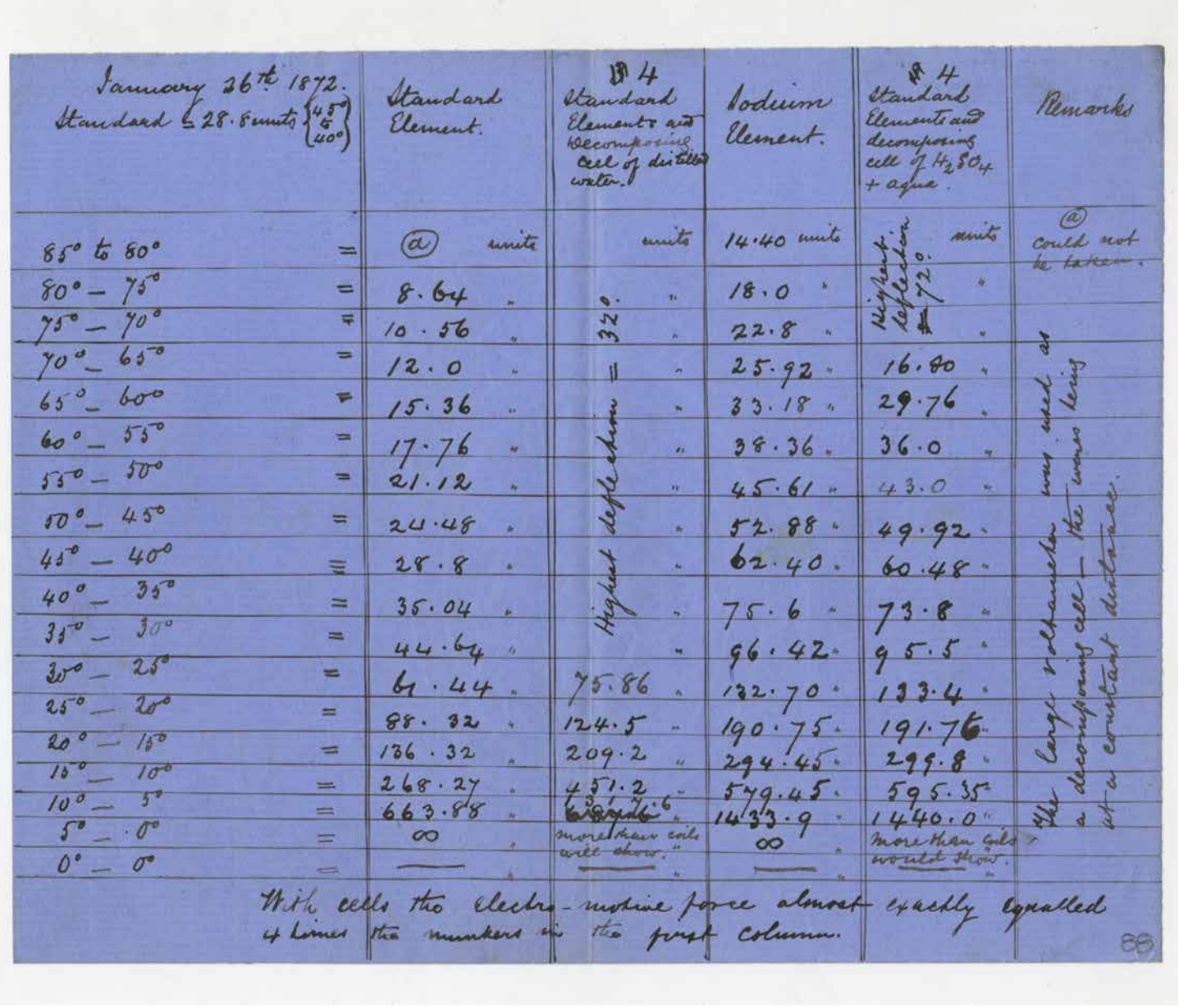
84

K/PP107/2/2/81

Note by Richard William Mellingford Higgs, chemist, from a bundle on the use of an experimental apparatus consisting of rotating electrodes used by Michael Faraday (1791-1867), natural philosopher, 1872 Mar 19.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



January 26th 1872.
Standard = 28.8 units (45° to 40°)

| | | Standard Element. | № 4 Standard Element & decomposing cell of distilled water. | Sodium Element. | № 4 Standard Element and decomposing cell of $H_2SO_4$ + aqua. | Remarks |
|---|---|---|---|---|---|---|
| 85° to 80° | = | (a) units | units | 14.40 units | units | (a) could not be taken. |
| 80° – 75° | = | 8.64 " | 32° " | 18.0 " | Negligent deflection = 72° " | |
| 75° – 70° | = | 10.56 " | = " | 22.8 " | " | |
| 70° – 65° | = | 12.0 " | Highest deflection " | 25.92 " | 16.80 " | |
| 65° – 60° | = | 15.36 " | " | 33.18 " | 29.76 " | |
| 60° – 55° | = | 17.76 " | " | 38.36 " | 36.0 " | |
| 55° – 50° | = | 21.12 " | " | 45.61 " | 43.0 " | |
| 50° – 45° | = | 24.48 " | " | 52.88 " | 49.92 " | |
| 45° – 40° | = | 28.8 " | " | 62.40 " | 60.48 " | |
| 40° – 35° | = | 35.04 " | " | 75.6 " | 73.8 " | |
| 35° – 30° | = | 44.64 " | " | 96.42 " | 95.5 " | |
| 30° – 25° | = | 64.44 " | 75.86 " | 132.70 " | 133.4 " | |
| 25° – 20° | = | 88.32 " | 124.5 " | 190.75 " | 191.76 " | |
| 20° – 15° | = | 136.32 " | 209.2 " | 294.45 " | 299.8 " | |
| 15° – 10° | = | 268.27 " | 451.2 " | 579.45 " | 595.35 " | |
| 10° – 5° | = | 663.88 " | ~~451.6~~ " | 1433.9 " | 1440.0 " | |
| 5° – 0° | = | ∞ " | more than coils will show. " | ∞ " | more than coils would show. " | |
| 0° – 0° | = | —— " | —— " | —— " | | |

With cells the electro-motive force almost exactly equalled 4 times the numbers in the first column.

The large voltameter was used as a decomposing cell — the cross being at a constant distance.

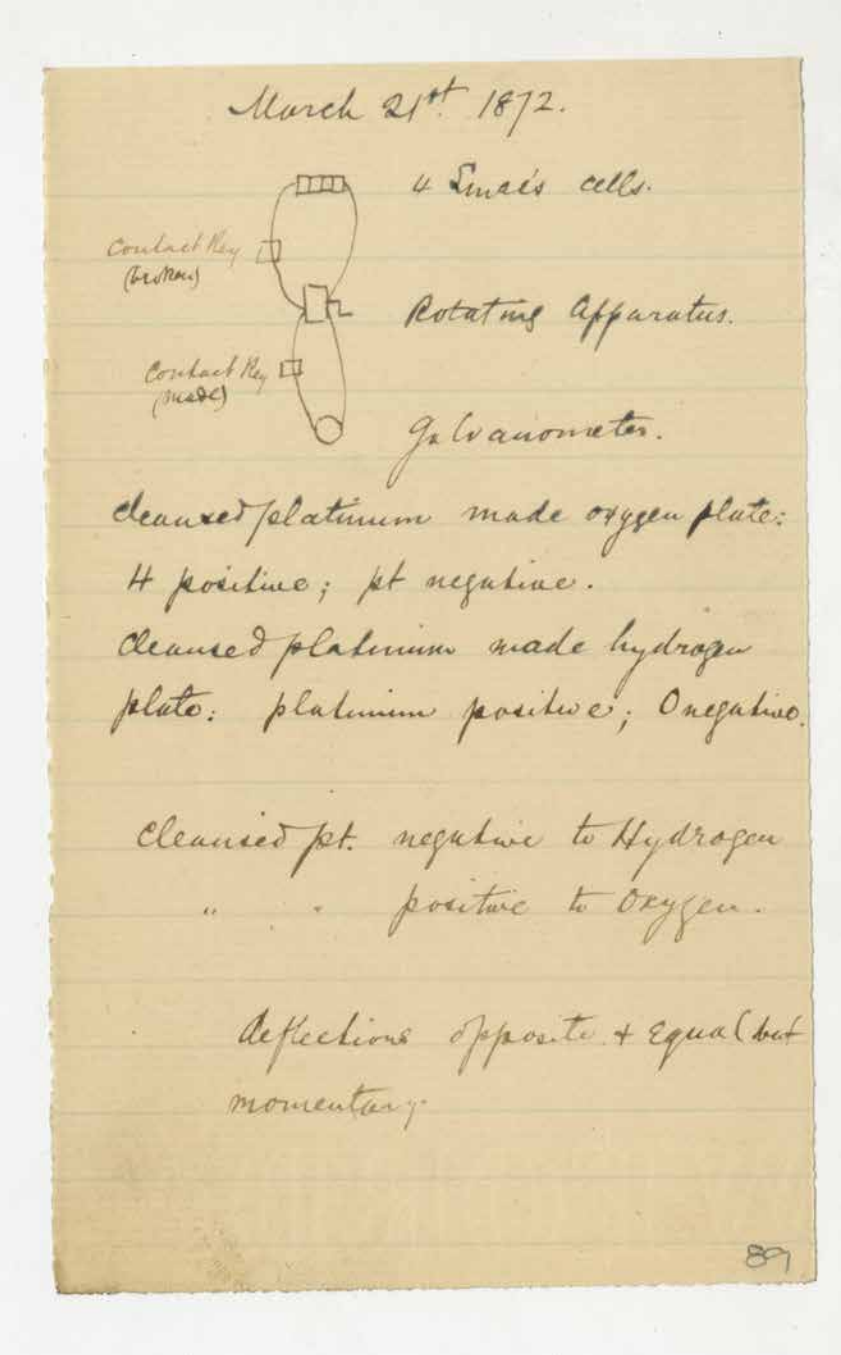
88

K/PP107/2/2/88

Experimental notes from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery - table of results by Richard William Mellingford Higgs, chemist, 1872 Jan 26.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph


March 21st 1872.




4 Smee's cells.

Rotating Apparatus.

Galvanometer.

cleansed platinum made oxygen plate:
H positive; pt negative.
cleansed platinum made hydrogen
plate. platinum positive; O negative.

Cleansed pt. negative to Hydrogen
" " positive to Oxygen.

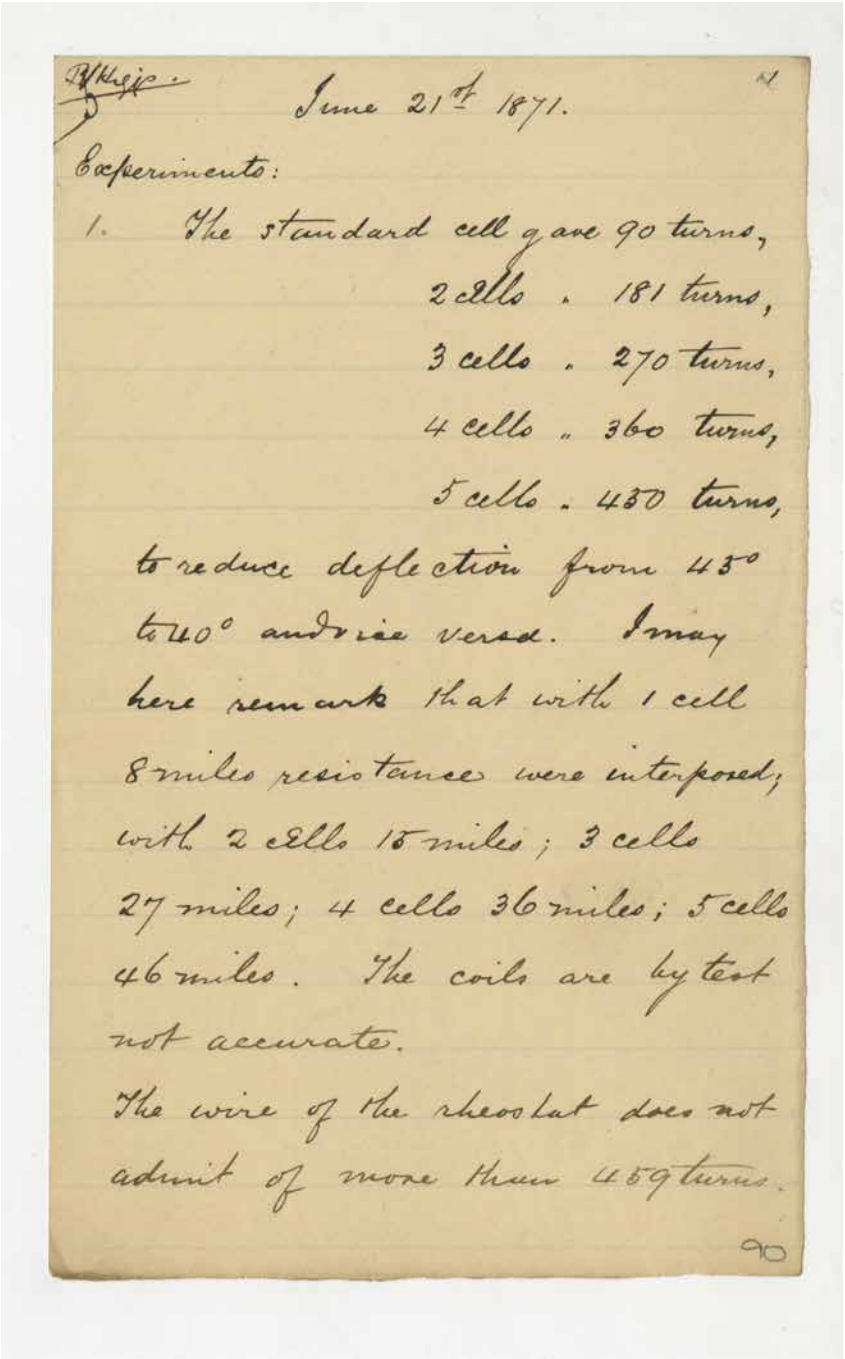
deflections opposite + Equal (but
momentary.

89

K/PP107/2/2/89
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1872 Mar 21.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



June 21st 1871.

Experiments:

1. The standard cell gave 90 turns,
   2 cells . 181 turns,
   3 cells . 270 turns,
   4 cells . 360 turns,
   5 cells . 450 turns,

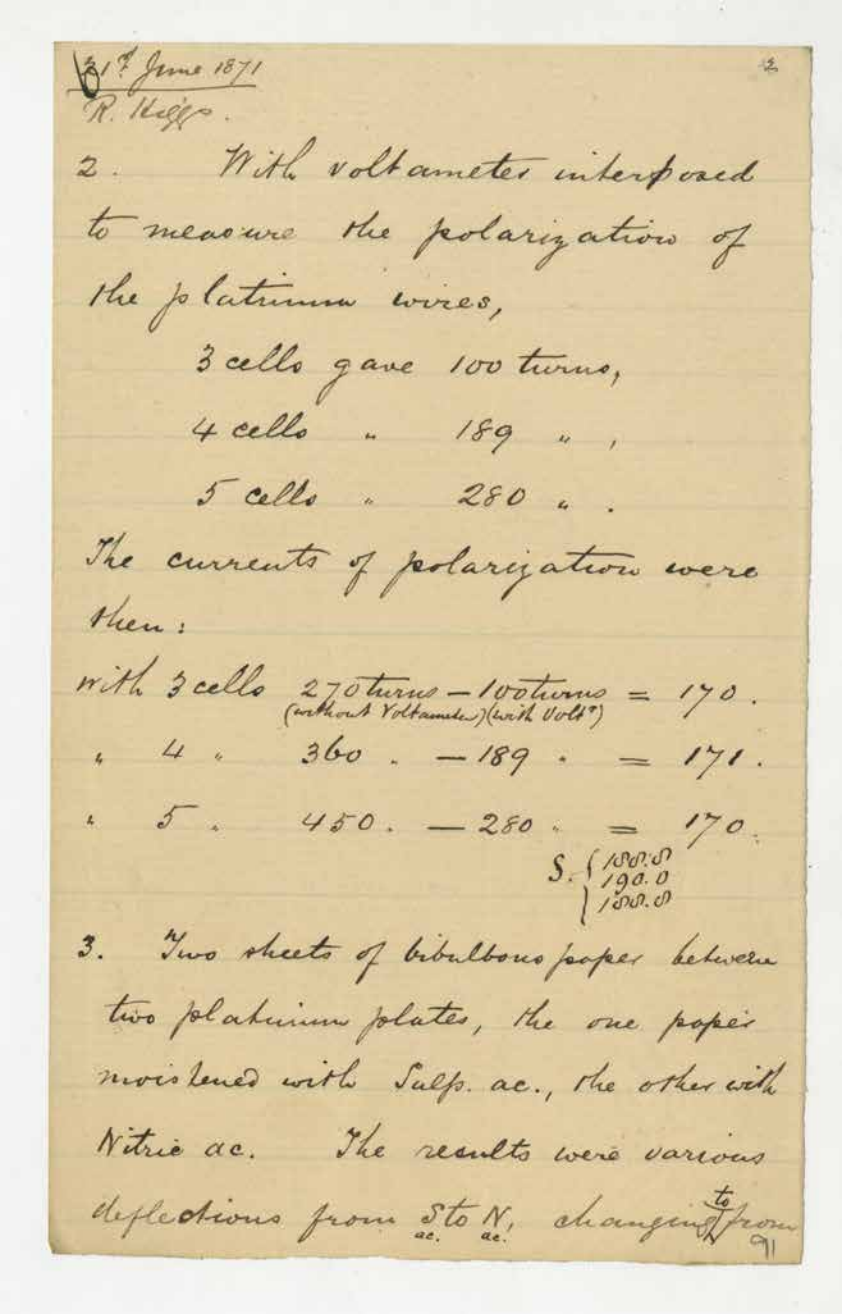
to reduce deflection from 45° to 40° and vice versa. I may here remark that with 1 cell 8 miles resistance were interposed, with 2 cells 18 miles; 3 cells 27 miles; 4 cells 36 miles; 5 cells 46 miles. The coils are by test not accurate.

The wire of the rheostat does not admit of more than 459 turns.

90

K/PP107/2/2/90

Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1871 Jun 21, page 1.



21st June 1871 2.
R. Higgs.

2. With voltameter interposed to measure the polarization of the platinum wires,

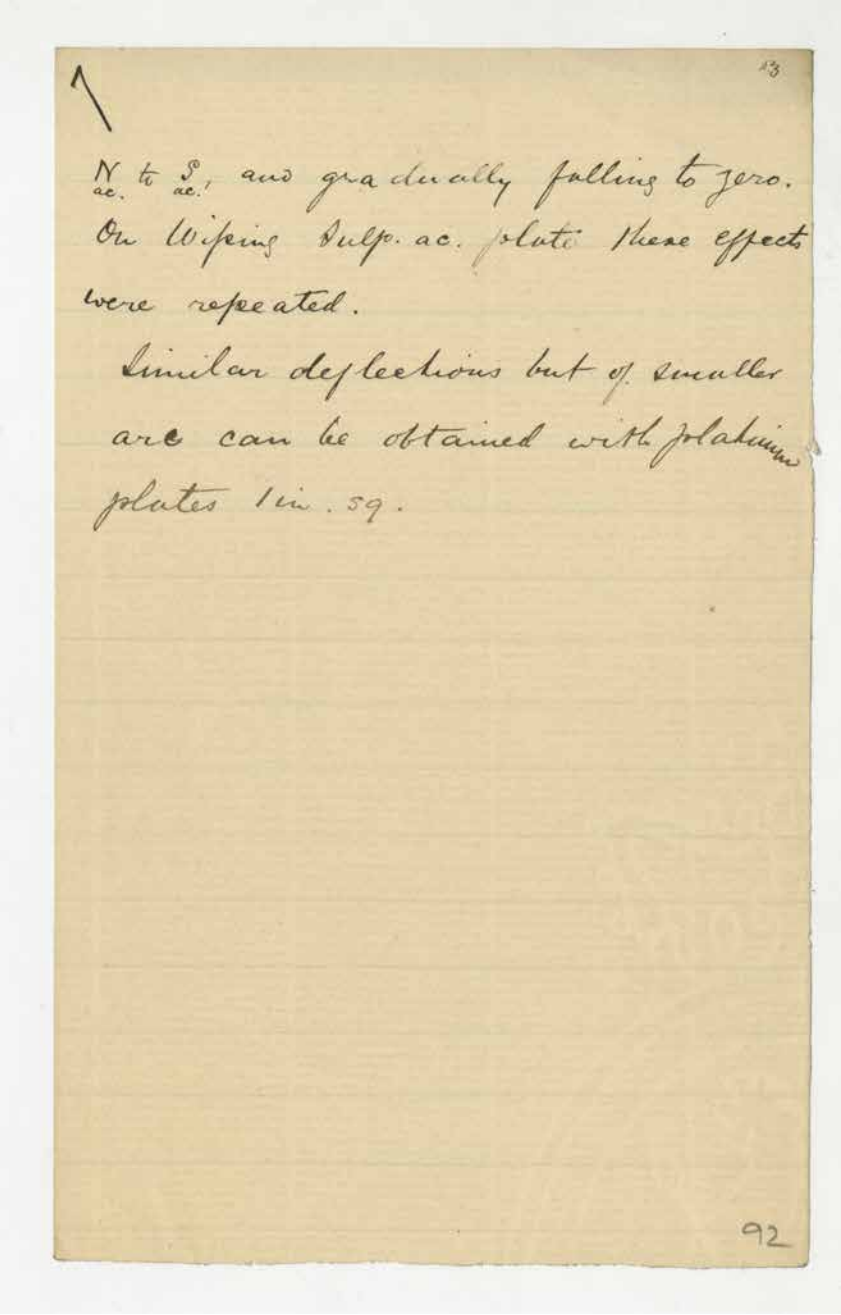
3 cells gave 100 turns,
4 cells " 189 " ,
5 cells " 280 " .

The currents of polarization were then:

with 3 cells 270 turns (without Voltameter) − 100 turns (with Volt$^{r}$) = 170.
" 4 " 360. − 189. = 171.
" 5 " 450. − 280. = 170.

S. { 180.0 / 190.0 / 180.0

3. Two sheets of bibulous paper between two platinum plates, the one paper moistened with Sulp. ac., the other with Nitric ac. The results were various deflections from S to N, ac. ac. changing to from 91



13

N ac. to S ac., and gradually falling to zero.
On Wiping Sulp. ac. plate these effects were repeated.

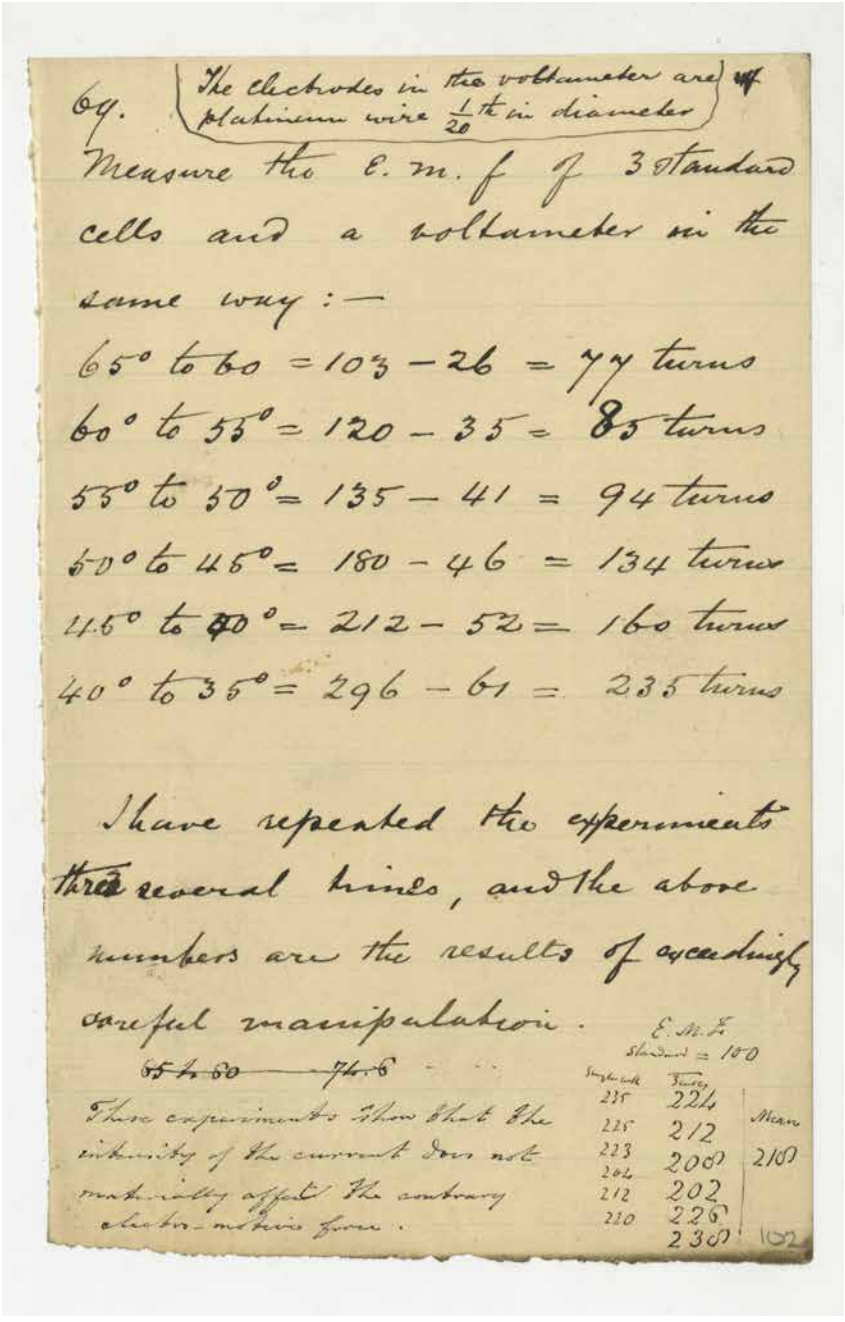
Similar deflections but of smaller arc can be obtained with platinum plates 1 in. sq.

92

K/PP107/2/2/92
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1871 Jun 21, page 3.

# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph



64. The electrodes in the voltameter are platinum wire $\frac{1}{20}$th in diameter

Measure the E. m. f of 3 Standard cells and a voltameter in the same way:—

65° to 60° = 103 − 26 = 77 turns

60° to 55° = 120 − 35 = 85 turns

55° to 50° = 135 − 41 = 94 turns

50° to 45° = 180 − 46 = 134 turns

45° to ~~40~~° = 212 − 52 = 160 turns

40° to 35° = 296 − 61 = 235 turns

I have repeated the experiments three several times, and the above numbers are the results of exceedingly careful manipulation.

~~65 to 60 — 74.6~~

These experiments show that the intensity of the current does not materially affect the contrary electro-motive force.

E. M. F.
Standard = 100

| Single cell | Battery | |
|---|---|---|
| 235 | 224 | |
| 225 | 212 | Mean |
| 223 | 200 | 210 |
| 204 | 202 | |
| 212 | 226 | |
| 220 | 230 | |

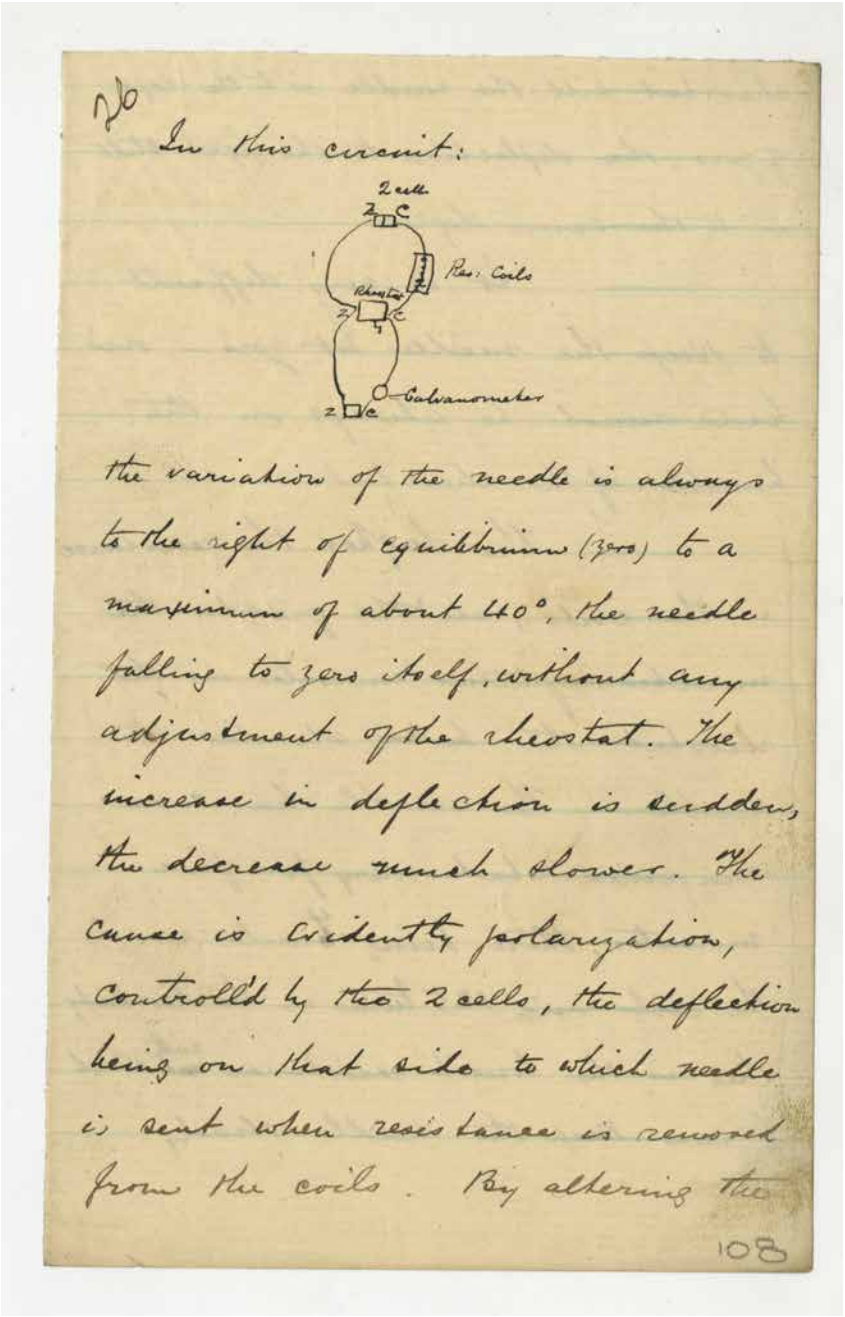
102

K/PP107/2/2/102

Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, [1871-1872].

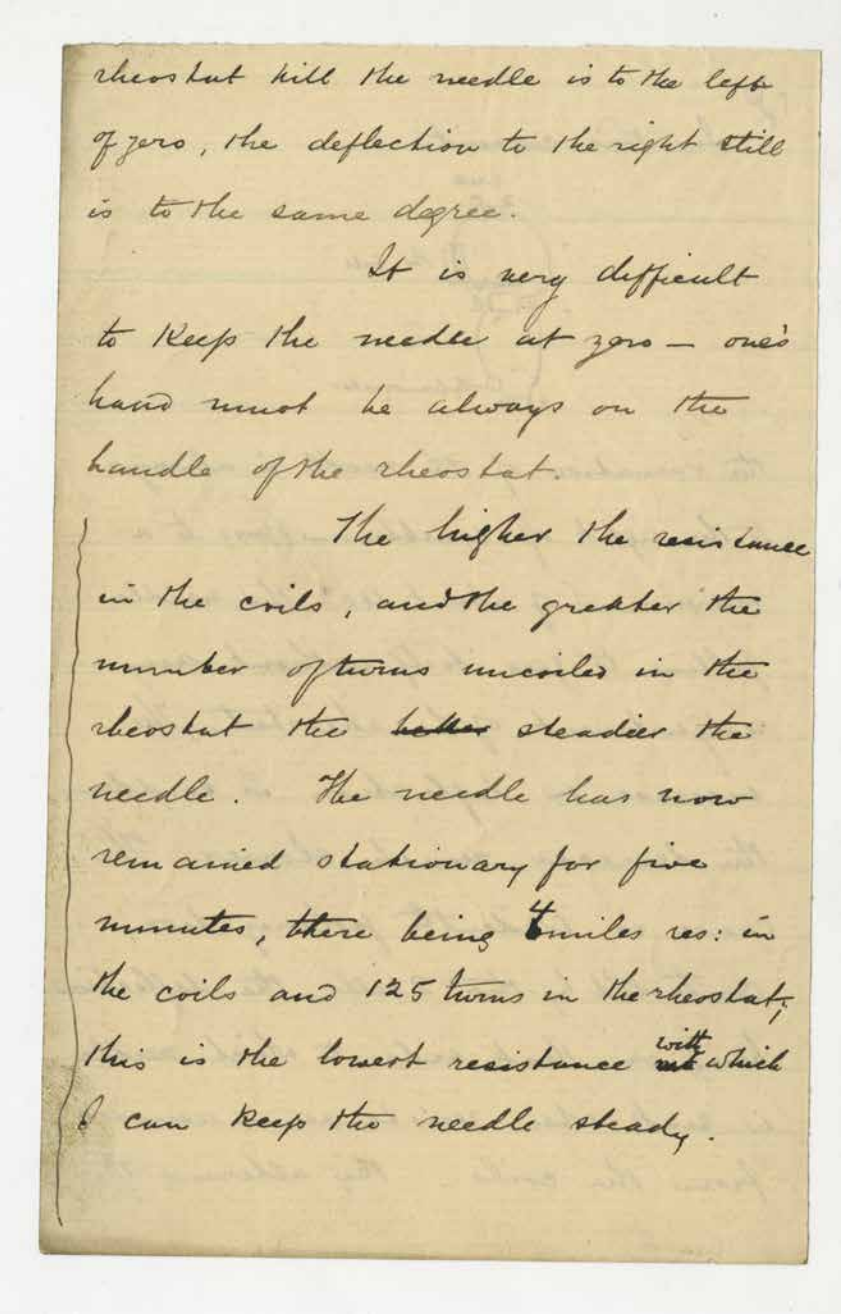
# The Papers of Charles Wheatstone

## K/PP107/2/2 - Papers relating to the development of the electric telegraph




K/PP107/2/2/108

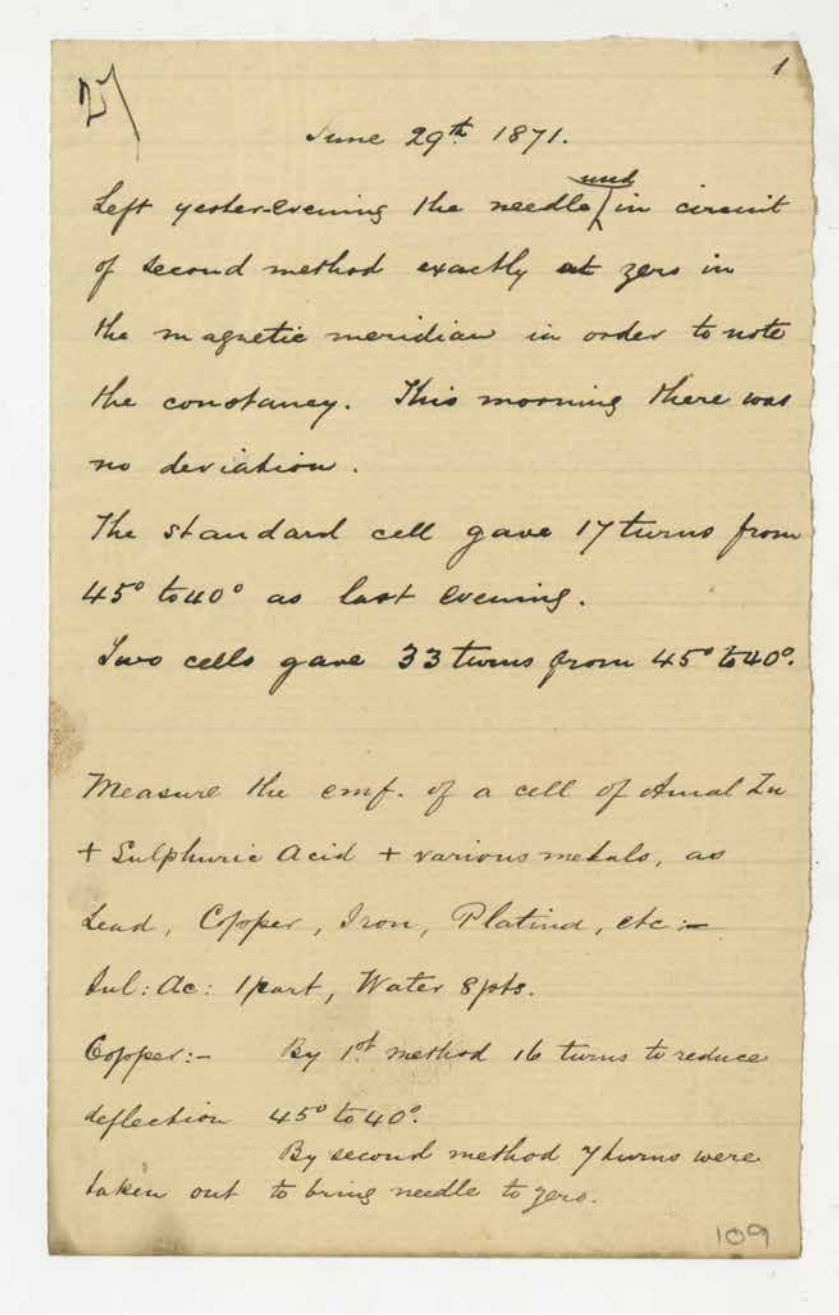
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, [1871-1872], page 1.



rheostat till the needle is to the left 7 zero, the deflection to the right still is to the same degree.

It is very difficult to keep the needle at zero — one's hand must be always on the handle of the rheostat.

The higher the resistance in the coils, and the greater the number of turns in the rheostat the better steadier the needle. The needle has now remained stationary for five minutes, there being 4 miles res: in the coils and 125 turns in the rheostat, this is the lowest resistance with which I can keep the needle steady.



1

June 29th 1871.

Left yesterevening the needle ~~used~~ in circuit of second method exactly at zero in the magnetic meridian in order to note the constancy. This morning there was no deviation.

The standard cell gave 17 turns from 45° to 40° as last evening.

Two cells gave 33 turns from 45° to 40°.

Measure the emf. of a cell of Amal Zn + Sulphuric Acid + various metals, as Lead, Copper, Iron, Platina, etc:—

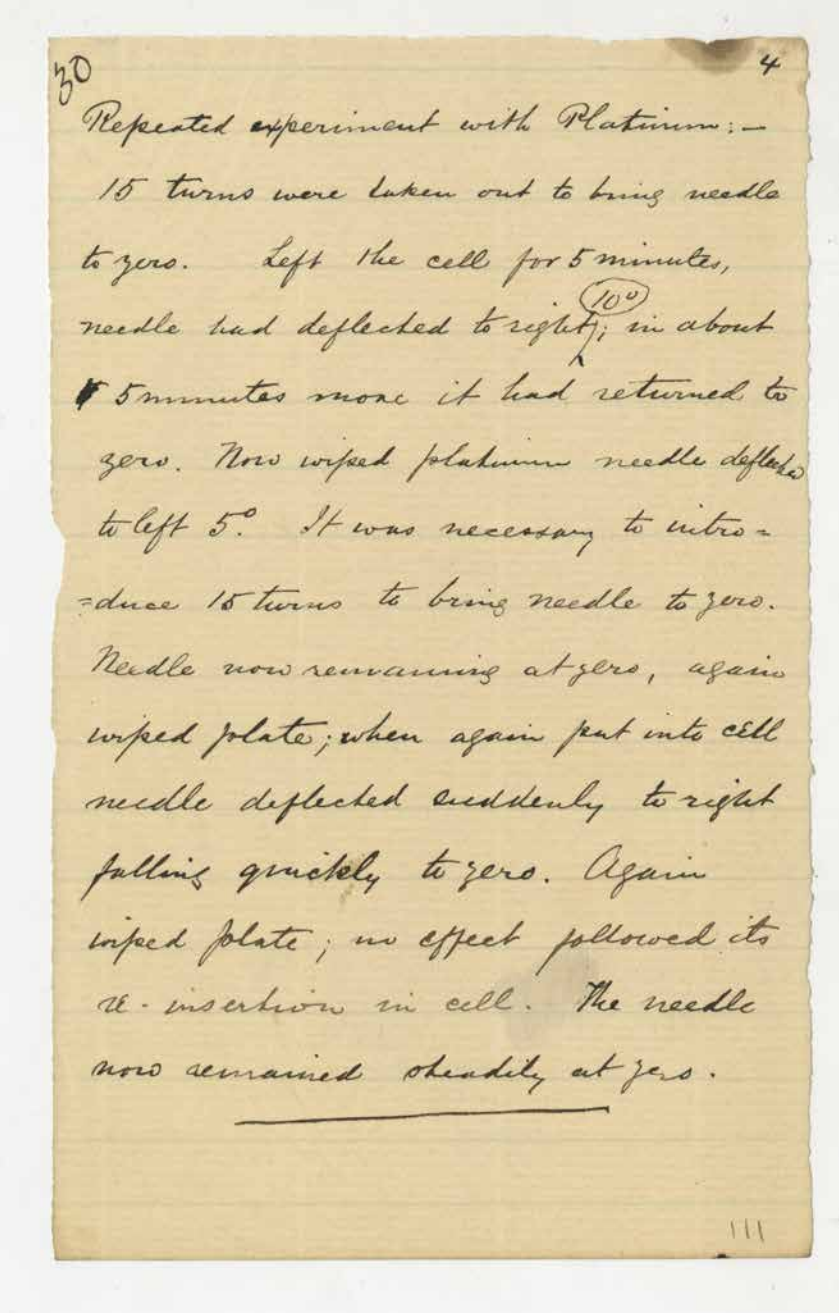
Sul: Ac: 1 part, Water 8 pts.

Copper:— By 1st method 16 turns to reduce deflection 45° to 40°.

By second method 7 turns were taken out to bring needle to zero.

109

K/PP107/2/2/109
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1871 Jun 29.

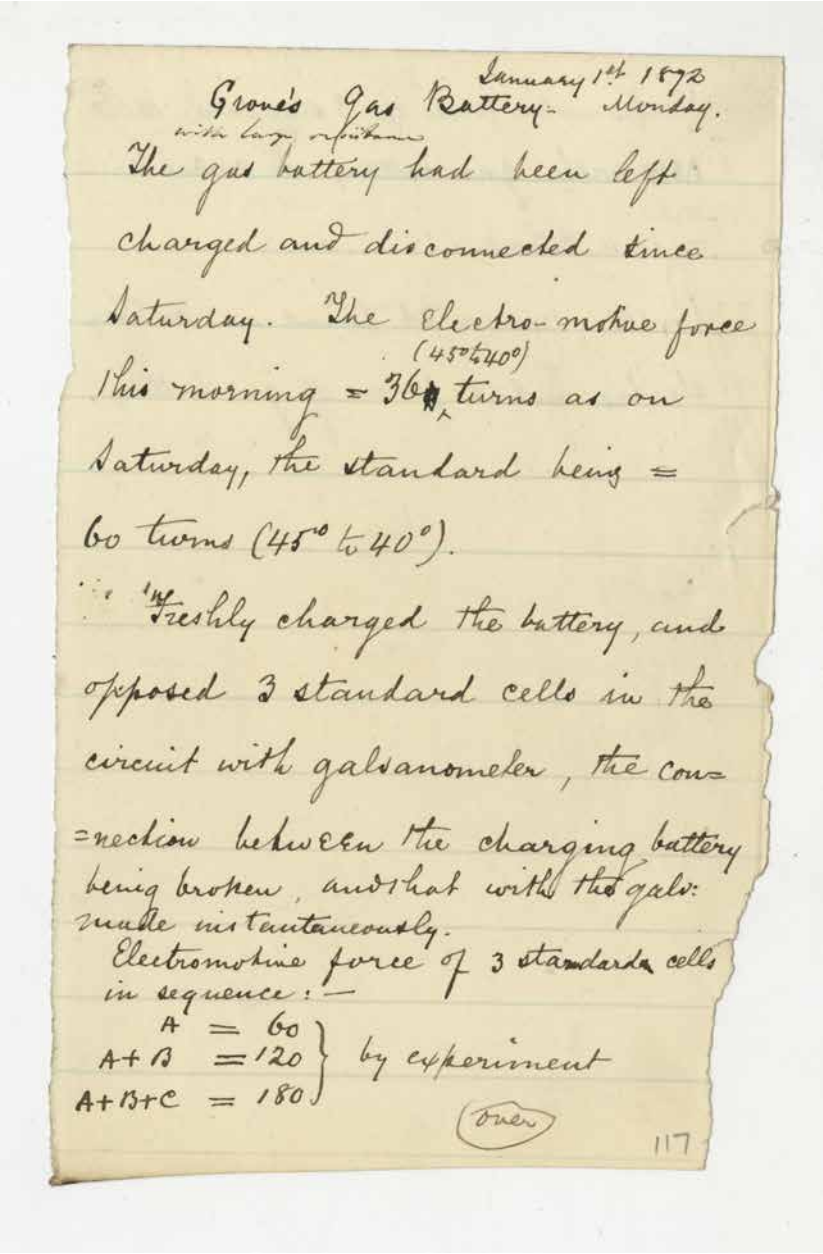


30 4

Repeated experiment with Platinum:—
15 turns were taken out to bring needle
to zero. Left the cell for 5 minutes,
needle had deflected to right (10°); in about
5 minutes more it had returned to
zero. Now wiped platinum needle deflected
to left 5°. It was necessary to intro-
-duce 15 turns to bring needle to zero.
Needle now remaining at zero, again
wiped plate; when again put into cell
needle deflected suddenly to right
falling quickly to zero. Again
wiped plate; no effect followed its
re-insertion in cell. The needle
now remained steadily at zero.

111

K/PP107/2/2/111
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, [1871-1872].



Grove's Gas Battery – January 1st 1872 Monday.
with large platinum

The gas battery had been left charged and disconnected since Saturday. The electro-motive force this morning = 36 (45° to 40°) turns as on Saturday, the standard being = 60 turns (45° to 40°).

Freshly charged the battery, and opposed 3 standard cells in the circuit with galsanometer, the connection between the charging battery being broken, and that with the galv: made instantaneously.

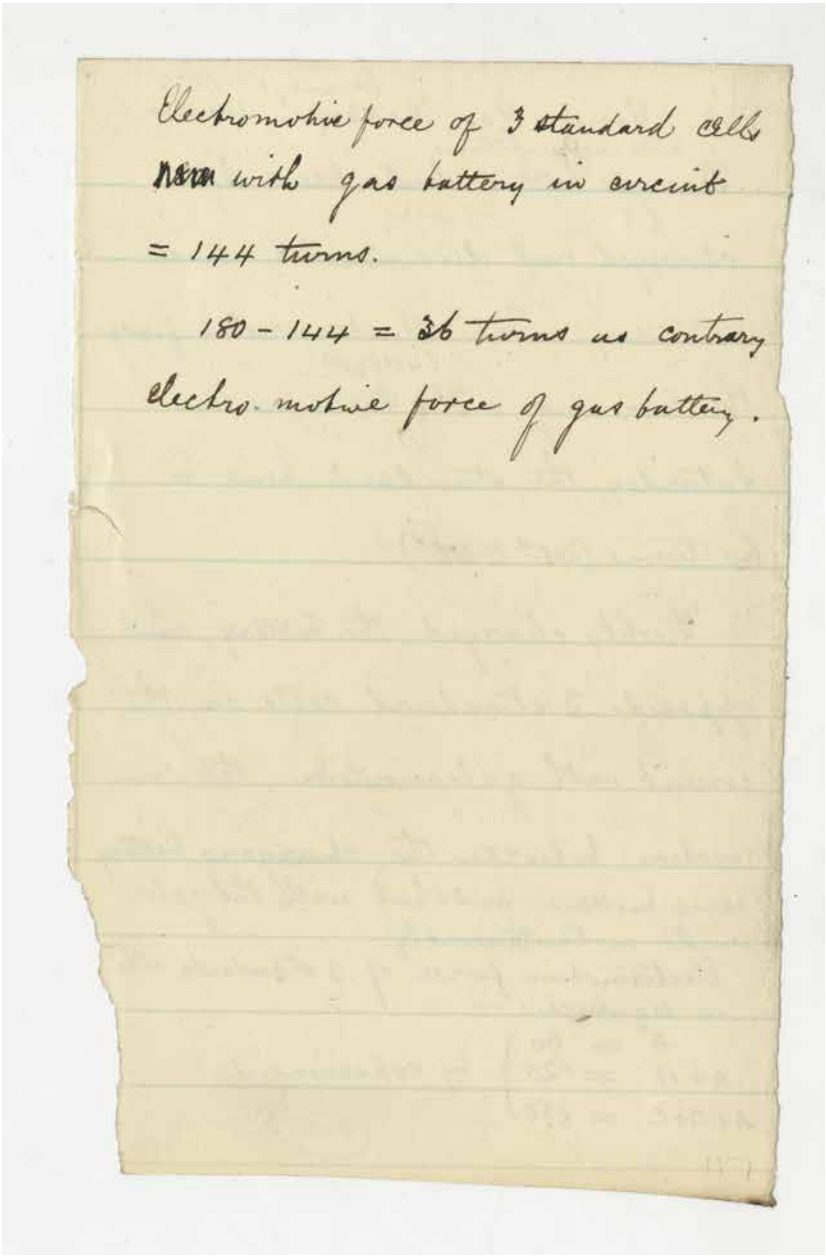
Electromotive force of 3 standards cells in sequence: –

A = 60
A+B = 120 } by experiment
A+B+C = 180

over

117

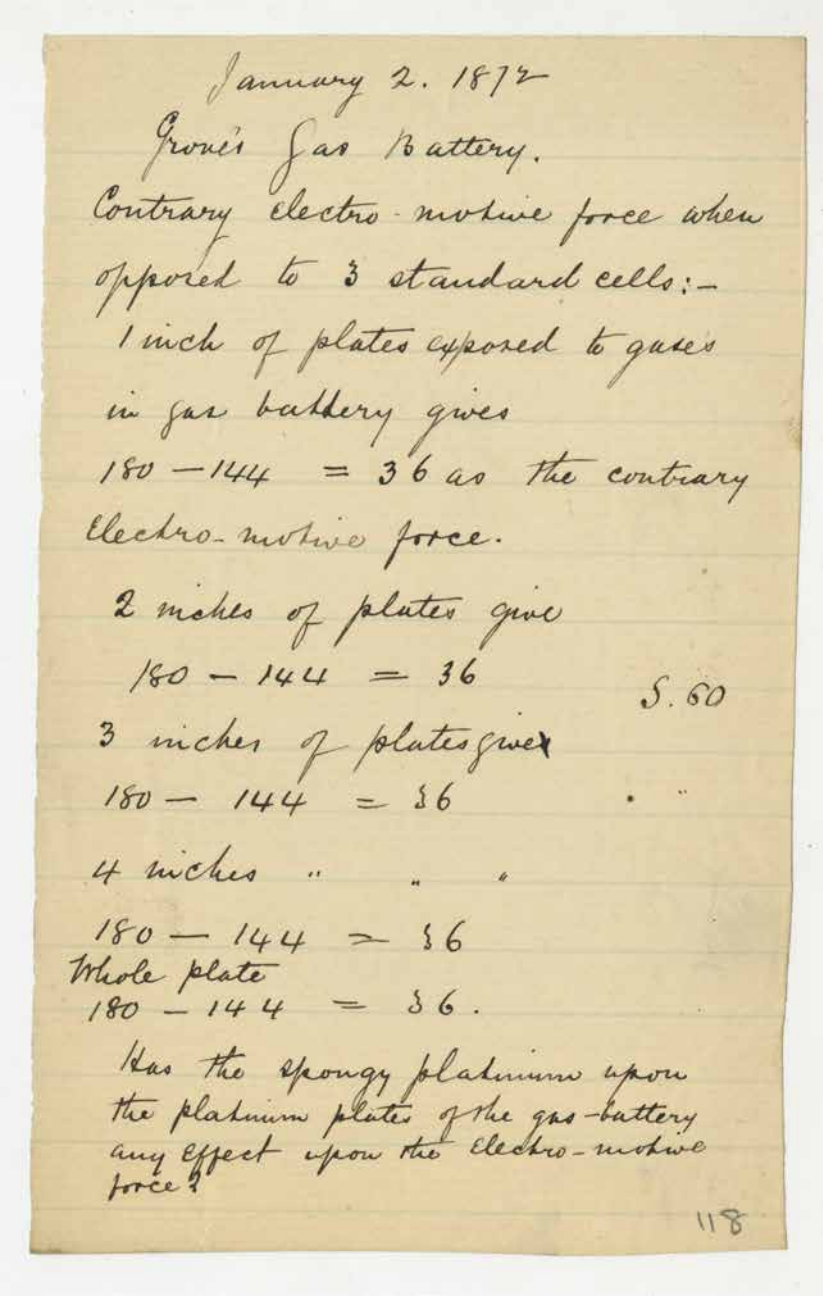
K/PP107/2/2/117
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1872 Jan 1, page 1.



Electromotive force of 3 standard cells
~~was~~ with gas battery in circuit
= 144 turns.

180 - 144 = 36 turns as contrary
electro. motive force of gas battery.

K/PP107/2/2/117
Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1872 Jan 1, page 2.



January 2. 1872

Grove's Gas Battery.

Contrary electro-motive force when opposed to 3 standard cells:-

1 inch of plates exposed to gases in gas battery gives

180 — 144 = 36 as the contrary electro-motive force.

2 inches of plates give

180 — 144 = 36

3 inches of plates gives

180 — 144 = 36

4 inches " " "

180 — 144 = 36

Whole plate

180 — 144 = 36.

S. 60

Has the spongy platinum upon the platinum plates of the gas-battery any effect upon the electro-motive force?

118

K/PP107/2/2/118

Experimental notes by Richard William Mellingford Higgs, chemist, from a bundle on contrary electromotive forces using William Robert Grove's (1811-1896), natural philosopher and judge, gas battery, 1872 Jan 2.