

# THE MANCHESTER PHYSICS LETTER BOOK, 1871–1882

by

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## 1 Introduction

Between 1871 and 1882, Professor Balfour Stewart, the Director of the Physical Laboratories at Owens College, Manchester, kept a letter book in which copies of much of the correspondence sent out by him and other members of the staff were kept. The book has pages of tissue paper and the technique was to place a freshly hand-written letter underneath a clean page and then place the book in a flower press which transferred some of the ink to the page, allowing the text to be read from the other side of the book page. Much of the correspondence was sent to the contemporary instrument makers whose names live on.

Owens College had been founded in 1851 and initially, physics had been taught by a mathematician Archibald Sandeman. The College could not award degrees of its own and any student who reached the required standard, received a degree from University College London (UCL). When UCL began to teach physics as a subject in its own right in 1860, Manchester quickly followed and appointed its first professor of physics, Robert Bellamy Clifton, who stayed in post for five years before moving to Oxford in 1865. A mathematician from Glasgow, William Jack was next in post, but did not achieve much before moving on to become the editor of the Glasgow Herald, where his tenure was also not illustrious. He finally returned to Glasgow University as professor of mathematics. Balfour Stewart, director of the Kew Observatory, was appointed to succeed Jack in 1870 and the steady rise in the reputation of physics in Manchester can be traced to that date. Stewart brought a combination of methodical observation, measurement and managerial skills to the post. As well as the letter book, Stewart also kept meticulous and detailed records of all the experiments carried out by students in the teaching laboratory, including those by J J Thomson. The letter book and the laboratory notes, having been found by the current author in the Manchester physics department basement, forgotten and disintegrating, have all been conserved at the John Rylands University Library in Manchester and placed in their historic archives.

The complete contents of the letter book and in some cases, matching records from the teaching laboratory notes are reproduced here and some comments on the instruments or instrument maker have been added for interest. In rare instances, the letter copying procedure failed and a word or two became smudged or failed to transfer. Essentially no information has been lost by these few failures.

In many cases, the firms of instrument makers, operating out of small premises in London, have gone on to become worldwide consortia.

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## 2 The Letters

pp 6-7

Owens College  
Manchester  
3rd October 1871

Dear Sir,

Be good enough to make for me a Cathetometer similar to the one you made for Dr Hughes of Westminster Hospital but with such alterations or modifications as he has kindly promised to point out. I should also mention that eventually it may be desired to fix it permanently to masonry while for the present it must be used standing on the floor or a table. I should be glad if you could make it so that it could withstand such alterations . . . . . Perhaps as mentioned to Mr Kingdon, you would kindly go down to the Kew Observatory and see Mr Beckley who will show you the instrument they have. I should like to have it as soon as possible.

Yours truly  
B Stewart

Mr L Oertling  
Moorgate Road  
London.

Similar to a theodolite and still in use today, in foundries, workshops and for aligning aircraft parts, the 19th century version of a cathetometer is described in Hicks' Catalogue [1] as "an instrument for measuring, with unerring accuracy, the difference in level between two points." It was priced at £20. If Stewart had ordered his cathetometer from Hicks, that might have been the end of it, with "unerring accuracy" achieved in the students' laboratory. But he chose L Oertling and the subsequent correspondence, which unfolds below, demonstrates how Victorians maintained a fine balance between stiffness of resolve and good manners. He could also have obtained a Kew type cathetometer from L Casella [2] Scientific Instrument Maker to "H.R.H. the Prince of Wales, The Admiralty and Ordnance, the Board of Trade, The Army Medical and War departments, The Governments of India, Russia, Germany, France, Italy, Spain, Portugal, the United States and Brazils, China and Japan; the Universities of Oxford, Cambridge and London; The Meteorological and The Royal Geographical Societies; The Leading Hospitals and Infirmaries; and the Observatories of Greenwich, Kew, Armagh, Cape of Good Hope, Washington, Victoria, Toronto, Calcutta, The Mauritius, etc. etc." A Casella cathetometer cost from £12 15s upwards, with the one as used at Kew listed at £28.

p 8  
Messrs Kemp & Co

October 5th 71

Gentlemen,

Please send me one of your Winters' Machines to the above address, - a No 4, price £11-11 - provided you guarantee that it will give a 12 inch spark. Let me know when you can send it.

Yours truly  
Thos H Core

Such machines, invented by Carl Winter in the mid 19th century generated high voltage static electricity by means of friction between two circular rotating glass plates.

p 9

5th October 71

Gentlemen,

Will you inform me if you will permit me to erect a small wooden house, for magnetic observations - in the back garden attached to my home at Fallowfield on the understanding that if I leave, I may remove the house making the ground on which it stood, the same as before.

Messrs Pennington  
& Bridgen

I am  
Gentlemen  
Yours truly  
B Stewart

Stewart had it in mind to build the observatory away from the noise and pollution of the city centre. He needed

the landlord's permission to erect the hut and the College's approval to pay for it. He must have been confident of both because the next day, he ordered the materials.

p 10

6th October 71

Gentlemen,

Would you be good enough to forward to the above address 20 curve sheets the pattern of which is enclosed. Would you also put them in a wooden box in which they can be sent flat. The cost will be defrayed by Owens College.

Yours truly

B Stewart

Messrs Stanford

p 11

October 9th 71

Messrs Weale & Co

Sirs,

Do you sell Willis' apparatus for illustrating lectures in Experimental Mechanics? If so, please let me know the price of it, and if it can be sent at once.

Yours truly

Thos H Core

The Reverend Robert Willis FRS, Professor of Mechanical Philosophy (i.e. Engineering) at Cambridge University, was renowned for his teaching of mechanics, and the quality of the working models that he had designed and constructed [3].

p 12

October 9th 71

Messrs Griffin & Sons

Sirs,

Please send to the above address, a working model of Bramahs Hydrostatic press. Catalogue No 95, price £14 - And advise me of its being sent off.

pro Dr Stewart

Thomas H Core.

The brothers Richard Thomas and John Joseph Griffin set up as dealers and manufacturers of chemical apparatus in Glasgow some time between 1826 and 1837. They started a London Branch around 1848, eventually becoming Griffin & Tatlock in 1930. Joseph Bramah is credited with the invention of the hydraulic press, securing a patent on the device in 1778. Bramah is also renowned for his development of the flush toilet, which like his press, was based on a sound knowledge and application of Pascal's Law: Pressure on a confined fluid is transmitted undiminished and acts in all directions with equal force on equal areas, including at 90° to the container wall. Queen Victoria had his water closets installed in Osbourne House, on the Isle of Wight, where they are still in working order.

By the 10th of October, Stewart had not heard back from his landlords and sent a reminder:

p 13

10<sup>th</sup> October 71

Dear Sirs

Would you kindly write me a note in answer to mine of 5<sup>th</sup> inst so that your answer may be brought before the College Council before they take any steps.

Yours truly

B Stewart

Messrs Pennington & Bridgen

Bank Chambers

Essen St

Manchester

Two days later, presumably on the basis of a reply from the landlord, Stewart turned his attention on the College Principal:

pp 14–15

12th October 71

Dear Principal Greenwood

With reference to the conversation I had with you and with Professor Roscoe – I have now received permission from my landlord to erect a wooden observatory in the garden attached to my house with liberty to remove it should I leave. – I think the situation will be very free from the influence of view certainly from that of moveable view. If it seems good to the council to pursue any branch of observational science in connexion with the Physical Laboratory I do not think that there would be any better branch than Terrestrial magnetism whether for practising the students in accurate observation or for obtaining results valuable in themselves. A set of instruments for absolute determination of the magnetic elements would cost about £100.

Probably a wooden house would cost £100 more and I should be happy to superintend the taking of monthly observations of the absolute magnetic elements in this house.

I have also received a letter from Dr Joule who is anxious that a Dip circle invented by him should be compared with an ordinary dip circle by means of such observations.

Altogether the research is a promising one and I should feel obliged by your bringing the subject before the council at their next meeting.

Yours very sincerely  
B Stewart

Barely a week later, Stewart sought to consolidate his position with the Principal:

pp 16–17

18th October 71

Dear Principal Greenwood

It has occurred to me that it might be a legitimate application of our Physical Laboratory funds if about £20 were devoted to the purchase of certain books \*\*\*\*\* of such a special interest that they could not properly be purchased through the general College fund.

If you agree with me would you kindly undertake to bring the subject before the Council which meets tomorrow.

Yours very sincerely  
B Stewart

PTO

I fancy that this application along with that for magnetic appliances will exhaust the remainder of the £500 that are available for the Physical Laboratory.

p 18

30th October 71

My Dear Sir

I should like to have for Owens College one of the Unifilers you make for determining absolute magnetic declination and also for determining absolute horizontal force. I mean the equipment costing £60 if I rightly remember. I should wish to have this instrument verified at Kew and the authorities here would order payment upon receipt of the Kew verification.

Yours very sincerely  
B Stewart

C Becker Esq  
of Messrs Elliott Bros.  
St Martin's Lane  
Strand London  
WC

William Elliott started trading as an instrument maker, probably in 1804, before taking his two sons into the business in 1850, which then became known as William Elliott and Sons. Soon after the death of William in 1853, the two sons began trading as Elliott Brothers, makers of quality scientific instruments, continuing the commercial

success of their founder. The firm expanded into aviation in 1909 and then into computing (the Elliot 4501 digital computer) in 1950. The company, by now employing 35,000 staff was taken over by English Electric in 1967, before merging with Marconi and GEC in 1968. After changing its name to GEC–Marconi Avionics in 1993, the company was eventually absorbed into British Aerospace in 1999.

p 19

30th October 71

Dear Sir

I should like to have one of your dip circles for Owens College. I should wish to have this instrument verified at Kew and the authorities here would order payment upon receipt of the Kew verification. The dip circles are those that I have seen at Kew.

Yours truly  
B Stewart

Mr Dover  
Optician  
Charlton  
Nr Woolwich

p 20

30th October 71

My Dear Sir

I have ordered a Unifilar from Elliott Brothers and a Dip Circle from Dover of Charlton and asked these opticians to send their instruments to Kew for verification. Would you kindly undertake this task of verifying the instruments.

Yours truly  
B Stewart

PS Would you oblige us at your leisure with the verification for the standard yard.

S Jeffrey Esq  
(missing) Kew  
Observatory

The chief official of the Kew Observatory, also known as the King's Observatory, was initially known as the King's Observer. Balfour Stewart himself held this post from 1859 to 1871 and was succeeded by Samuel Jeffrey, 1871-6. The relevant King was George III. The tutor to the Royal Family, Dr Stephen Charles Demainbray, had interested George III in the observations planned for the transit of Venus and the King decided to erect his own observatory so that he and the Royal Family could join in the international programme. The site of a monastery was chosen in 1768 as the place for the erection of the King's Observatory, it was designed by William Chambers and completed on time for observations of the transit on 3 June 1769.

By now, Professor Core had received the hydraulic press which he had ordered from Griffin & Son on the 9th of October but was not best pleased:

p 21

30th October 71

Messrs Griffin & Son  
Gentlemen

The hydrostatic press you sent does not work satisfactorily. The collar of the piston is of ordinary stuffing instead of the usual leather ring, and the consequence is that it is not water tight. Other minor defects are that the 2 middle screws which fasten the lid of the cistern are useless, & the nut-key you sent is too slim.

There are some nuts also which the key does not fit.

On the whole, Dr Stewart and I are of opinion (sic) that the press is not a creditable one for you to have sent us. We shall therefore return it, and request you to send us a good one.

Yours truly  
Thos H Core

In the flurry to equip the laboratory to the required standard at the start of the College year, this was not the only case where the equipment or service received did not come up to scratch. When the situation became delicate, Balfour Stewart sometimes let his staff write the necessary letters. So it was barely a week after the order for a Unifilar had gone to Elliott Brothers, that a plaintive note was sent to the instrument makers.

p 22

7 Nov<sup>r</sup> 71

Dear Sir

Dr Stewart is just now in receipt of your favor & directs me to say that he wishes for a Unifilar not a Bifilar. It is an instrument for determining the absolute magnetic intensity that he wants.

Yours faithfully  
Francis Kingdon

C Becker Esq  
Messrs Elliott Bros.  
112 St. Martin's Lane  
Strand  
London W.C.

The now obsolete word "favor" was used at the time for a communication, especially a letter. Next day, Balfour Stewart joined the discussion between Core and Griffin & Son regarding the hydraulic press and other equipment. He specified the hydrostatic press more clearly and began to discuss other equipment.

p 23

8th November 71

Gentlemen,

Referring to our correspondence regarding the construction of your apparatus for teaching Physics in Elementary schools I now enclose a rough sketch of a Bramah such as we would like for such schools. The dimensions are all given in the sketch. I may add that the balance ought to be sufficiently sensitive to enable you to detect easily the difference between the weight of a vessel (not too large) filled with air and filled with carbonic acid gas. Such a balance can be constructed fine for 32/-. Presuming your price will not exceed it, would you kindly begin without delay to construct such an instrument.

Yours truly  
B Stewart

Messrs Griffin & Son  
22 Garrick Street  
Covent Garden

WC

pp 24-25

13th November 1871

Dear Principal Greenwood

Last year I received a grant of £150 for apparatus for the Physical Laboratory which grant is now expended. I have this year received a grant of £200 for magnetic purposes. Thus the two grants already made amount to £350 – I understand however that the whole sum available for the Physical Laboratory is £500. I should therefore like to have a grant of the remainder of this sum of £150 for general apparatus for the Physical Laboratory – I think too that we should require a grant e.g. of £25 to provide for the \*\*\*\* of experiments both in the Natural Philosophy class room & in this laboratory.

Yours very sincerely  
B Stewart

p 26

22<sup>d</sup> November 1871

Gentlemen

The balance which is here will stand 2 lbs in each scale pan and then 7 grains of excess will cause the pointer to deviate about an inch.

Also when a moderate sized vessel full of air is counterbalanced if the air is taken away the pointer will deviate about 7 inches.

The Bramah should have a good strong iron stand but I suppose it ought to pack into small compass. Yours truly

B Stewart

Messrs Griffin & Son

Early in 1872, Professor Stewart became aware that an order he had placed with Elliott Brothers, before his railway accident in 1870, had not been properly carried out. He got Francis Kingdon to sort it out:

p 27

22 Jan<sup>y</sup> 1872

Sir

I have to call your attention to an error in the execution of the order which Dr Stewart gave you for electrical apparatus in the autumn of 1870. In consequence of Dr S's accident the error had not been discovered/or at least clearly made out) till now. It arose apparently from the order having been executed in two parts.

Three lines in your a/c. viz

Double reversing Keys	-	3.	10.	0
2 Short circuit Keys	---	1.	5.	0
1 doz Mercury cups	---	-	14	-

were repeated, that is we have twice the number of articles charged while the two articles viz

Set of Shunts	-----	3.	0.	0
1 doz empty reels	-----	1.	16.	0

have not been sent at all.

We will therefore return you the duplicates of Keys & mercury cups & shall be glad to have the set of Shunts & doz empty reels as soon as possible.

I am Sir

Yours Resp<sup>fy</sup>

for B Stewart

Francis Kingdon

C Becker Esq

Messrs Elliott Bro<sup>s</sup>

112 St. Martin's Lane

Strand, London W.C.

p 28

31 Jan 1872

Sir

The Double reversing Key + the 2 short circuit keys + 1 doz mercury cups will be sent to you tomorrow by Globe Express.

The resistance of our galvanometer is marked on the box as 3348.0 BA unit

We want a set of shunts for it + the empty reels.

Yours faithfully

Francis Kingdon

C Becker Esq

112 St Martin's Lane

Strand

London

Globe Parcel Express (also known as John Hinshelwood and Co) had their head office in Glasgow. The earliest

known mention of either Globe Parcel Express or John Hinshelwood and Co, was in Glasgow and Manchester in 1858. Globe Express Ltd, was registered in 1896, taking over the business of both Globe Parcel Express and John Hinshelwood and Co. It ceased operations in 1918 and the final disposal of its assets took place in 1923.

It was the laying of the first transatlantic cable that revealed the inadequacy of the many conflicting resistance standards in the mid 19th century. In September 1861, Sir Charles Tilston Bright and Josiah Latimer Clark, presented a paper [4] at the meeting of the British Association in Manchester which urged the establishment of universally received standards of electrical quantities, including resistance. Measurements were made by James Clerk Maxwell and Fleeming Jenkin in the attic of Maxwell's house in Palace Gardens Terrace, London W. Steamers passing on the Thames caused a disturbance, hence the use of the attic. This resulted in a resistance standard called the B.A. unit, equal to  $10^9$  c.g.s. units eventually to be named the ohm. The B.A. remained the standard only until 1881 when it was found to differ from Maxwell's theoretical unit by 1.3%.

Meanwhile, Professor Core, finished off the business with the hydraulic press with Griffin & Sons.

p 29

1 Jan 1872

Sir

We have returned the Hydraulic Press as we found that it was totally useless. It is now too late in the session to be of any use to us this year.

Yours truly  
Thos H. Core

J Griffin & Sons

p 30

23 Feb 1872

Sir

I am instructed by Dr Stewart to request you to send to him at the above address a wet & dry bulb thermometer on stand complete. The cost will be defrayed by the Owens College authority.

Yours faithfully  
for Dr Stewart  
Francis Kingdon

Mr L Casella  
23 Hatton Garden  
London E.C.

In 1838, Louis Paschal Casella (1812–1897) became a partner of a London firm of instrument makers which had been established by Cesare Tagliabue in 1799. By 1848, the firm had become known as L Casella & Co, making and marketing a wide range of scientific instruments. The firm became C F Casella & Co Ltd in 1910, continued to prosper and became established in the USA. Casella's various activities were taken over by Ideal Industries Inc and today, the associated firms of Casella Measurement Ltd, Casella CEL Ltd and Casella Monitor Ltd have operations in the UK, USA, China and Spain.

p 31

4 Mar 1872

Dear Sir

Will you please send us 3 small mirrors with mag needle attached suitable for a Thompson's galv'mr.

Yours faithfully  
for Dr Stewart  
Francis Kingdon

C Becker Esq  
112 St Martin's Lane  
Strand  
London W.C.

p 32

14 Mar 1872

Sir

Prof Roscoe and I both want half a dozen thermometer tubes each out of which to make thermometers. Prof Roscoe would like half a dozen tubes about 18 inches long with a top chamber and cylindrical bulb the cylindrical bulb and if possible the tube – thinner than your usual size (so as to be available for small quantities of liquid). To range from somewhat below 0° C and up to 350° C. I should like half a dozen tubes 18 inches long with top chamber and cylindrical bulb of usual size to range from slightly below 0° C and somewhat above 100° C. All the thermometers for both of us to be made of your usual glass and to be invoiced separately.

Yours very truly  
B Stewart

L Casella Esq

p 33

13 May 1872

Dear Sir

Please send to the above address to Dr Stewart a tripod stand suitable for the magnetic instrument you have now underhand for us, or just finished.

Yours faithfully  
for Dr Stewart  
F. Kingdon

C Becker Esq  
Messrs Elliott Bros.  
112 St Martin's Lane  
Strand  
London W.C.

p 34

14 June 1872

Sir

On Monday next there will be sent to you from here a Ruhmkorff coil which is out of order. Please see to it & set it right & let us have it back again as soon as possible.

Yours Respfy  
for Dr Stewart  
Francis Kingdon  
Physical Laboratory

Mr W Ladd  
11 & 12 Beak St.  
Regent St.  
London  
W.

William Ladd was an instrument maker of repute, specialising in microscopes of which a chain driven version was noteworthy. Ladd's catalogue of 1861 [5] lists various microscope ranging in price from £3 10s to £22 11s. A 4½ inch astronomical telescope could be had for £100, and a phantasmagoria lantern for £4 10s. More relevant to the above letter, W Ladd made and sold induction coils and it is likely that the Ruhmkorff being returned for repair was purchased from them at some time before the letter book started in 1871 and after practical laboratory classes were started in 1860. No further correspondence on the coil took place so it can be assumed that it was returned in working order. As well as keeping a letter book, Balfour Stewart wrote up all the experiments carried out by students and staff in the department. Results from the magnetic observatory in Stewart's garden were published in journals.

The coil features in Stewart's written log in an interesting way, where an experiment undertaken by student J. J. Thomson to measure the voltage of a cell failed. As indicated in the text in figure 2, Thomson was trying to measure

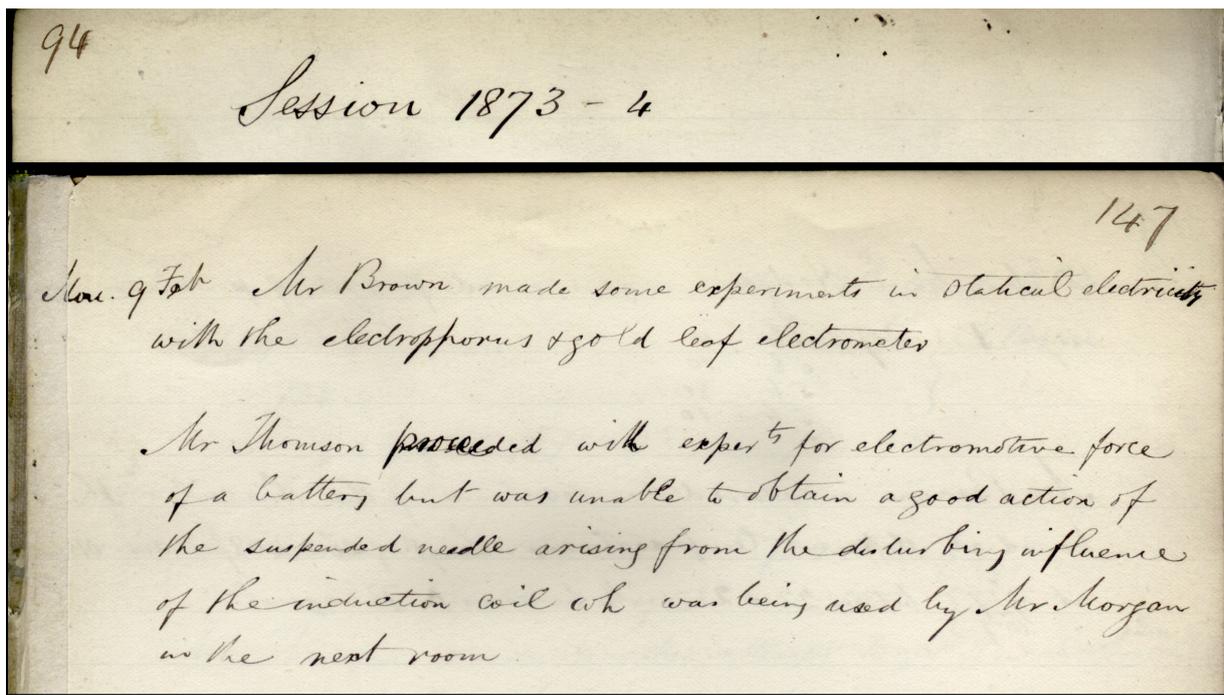


Figure 1: An entry in the Laboratory Log Book maintained by Balfour Stewart during the session 1873–4 relating to a failed experiment by J J Thomson.

the e.m.f. of a battery using a galvanometer with a suspended needle, possibly the one mentioned in the letter on page 31 of the Letter Book, copied above. Subsequent entries show that Thomson finished his experiment and the assumption is that Mr Morgan's sparking coil was silenced for the duration and all concerned failed to appreciate that Mr Morgan could signal wirelessly that it was time for lunch, some twelve years before Heinrich Hertz made his discovery which ensured that he went down in history.

pp 35–36

November 12 1872

Dear Principal Greenwood

Shortly after my appointment to the chair of Nat Phil at this college I was asked to make a statement of the fittings which I thought would be required for the rooms in the new buildings. In accordance with this request I prepared such a statement which I understand received the attention of the extension committee with the exception of one \* \* \* \* \* which was considered to be \* \* \* \* \*. This statement was I believe also communicated to the architect who spoke to me regarding it. One of the chief requirements was a total and independent foundation in the Physical Laboratories and \* \* \* advised that I consulted Coln Strange, director of the observatory of the India office who had shortly before decided on establishing a solid foundation at his observatory in Belvedere Road, Lambeth. The enclosed extract from my letter to Dr Watts giving my list of requirements and containing the advice I received regarding the foundations from Col Strange.

I have recently learned from Mr Harrison that this plan has not been strictly adhered to and that \* \* \*

I cannot think that this plan \* \* \* that which I indicated but \* \* \* I do not now consider myself \* \* \* was made without consulting me.

Would you kindly bring this letter before the extension Committee

I remain

Yours truly

B Stewart

The order for a cathetometer places with L Oertling on the 3rd October 1871 had not gone well. Oertling had written to Stewart on the 6th December 1872 and now Stewart replied:

p 37

Dec. 9 1872

Sir

In reply to your letter of 6<sup>th</sup> inst I must still consider you yourself responsible for the completion of the Cathetometer and must again request you to name a day on which it may be sent to us.

Your ob<sup>l</sup> servant

B Stewart

L Oertling Esq

Stewart received no satisfaction in reply and five days later, presumably in response to a further letter from Oertling, Kingdon wrote again on Stewart's behalf:

p 39

14 Dec<sup>r</sup> 1872

Sir

Dr Stewart requests me to say that you have already received full instructions about the Cathetometer to which he refers you & again requests you will name a day when it will be sent.

Yours Respfy

for Dr Stewart

F. Kingdon

Mr L Oertling  
27 Moorgate St.  
London

Ludwig Oertling (1818–1893) had been an apprentice to his brother, Johann August Daniel Oertling, in Berlin. Their father had made sextants in Berlin in the 18th century. By 1847, Ludwig was working in London and established the company L Oertling in 1849. He was briefly in partnership with Edward Wilds Ladd as Ladd and Oertling 1860-70. The company became renowned for its precision weighing scales and was eventually absorbed into the Avery Group of companies in 1925. Avery made their characteristic mechanical weighing scales, from which the price could be read off, for most grocery stores in the UK during the 20th century. Avery itself was taken over by GEC in 1979 which then acquired the Dutch company Berkel. A US company Weigh-Tronix acquired both the firm Salter and then Avery-Berkel from GEC and today is owned by Illinois Tool Works Inc.

pp 40–41

21 March 1873

My Dear Sir

I have just received your letter regarding instruments. I was not quite sure whether you were aware that I have now no connexion with the Kew observatory the superintendent of which is now Samuel Jeffrey.

The Kew equipment for absolute observation of a \* \* \* \* \* consists of a dip circle and an instrument that serves for determining the horizontal force by means of vibrations and deflections as well as the observations by means

\* \* \* \* \*

Trusting that you will be able to do so too.

I remain

Yours very truly

B Stewart

E J Stone Esq

E. J. Stone FRS held the post of Astronomer Royal at the Cape of Good Hope from 1870 to 1879, during which period this letter was written. He observed the total eclipse of April 16, 1874 in South Africa and is perhaps best known for producing the Catalogue of Southern Hemisphere Stars, a task assigned to his predecessor at the Cape, Thomas Maclear, who had not completed the task, nearly 40 years after being asked to do it.

p 42

21 March 1873

Dear Sir

I am authorised to order for the Royal Observatory Cape of Good Hope a dip circle with two needles and in other

respects pricing similar to the one you made for this college.

Yours truly  
B Stewart

Mr John Dover

Meanwhile, the cathetometer saga with Ludwig Oertling rumbled on.

p 43

2 June 1873

Dear Sir

You must still allow me to send the Cathetometer back to you with the request that you will put it right.

We do not object to pay a proper price for a good instrument but we cannot accept an instrument unless it will do that which it is intended to do. Now your Cathetometer has not worked well and as a matter of fact it is about  $\frac{1}{16}$  of an inch out sideways besides being out in the other direction.

Yours truly  
B Stewart

L Oertling Esq

p 44

2 June 1873

Dear Sir

Mr Stone (Royal Observatory Cape of Good Hope) would like to have the unifilar you mentioned some time since as being ready and would like you to forward it to Kew for verification.

Yours truly  
B Stewart

C Becker Esq  
Messrs Elliott Bros

p 45

9 June 1873

Dear Sir

Would you kindly send the dip circle intended for the Cape of Good Hope to Kew observatory for verification.

Yours truly  
B Stewart

Mr Dover  
Optician

p 46

9 June 1873

My Dear Sir

Mr Stone (Royal Observatory Cape of Good Hope) is anxious to have a Unifilar and dip circle which he has ordered verified at Kew.

I have therefore written to Messrs Elliott Bros and to Mr Dover to send the instruments to Kew for verification.

It would oblige Mr Stone if you would undertake to have the instruments dispatched to him after verification. I suppose he wrote to me imagining that I was still connected with the observatory.

Yours sincerely  
B Stewart

S Jeffrey Esq  
Kew Observatory

p 47

1<sup>st</sup> June 1874

My Dear Sir

I should like to have <sup>x</sup> a dozen thermometer tubes about 18 inches long with a top chamber and cylindrical bulb of usual size to range from slightly below 0° C to somewhat above 100° C. The glass of the usual kind. The last thermometers we had from you seemed apt to flaw.

<sup>x</sup> for Owens College

Yours very truly

B Stewart

L Casella Esq

pp 48–49

7<sup>th</sup> May 1875

Dear Principal Greenwood

As I understand that at present it would be a convenience to let Prof Williamson have a portion of the new Physical Laboratory on Monday afternoons and as we can at present arrange to do so without interfering with our work I shall offer no objection to this temporary arrangement. There is however one small table containing an adjusted instrument which I should not wish to be disturbed and I would therefore suggest that by means of rope a small portion at one end of the room should be separated off so as to prevent the students from interfering with the instrument in question.

Yours very truly

B Stewart

The second batch of thermometers ordered from Casella on the 1<sup>st</sup> June 1874 must have been no better than the first which were “apt to flaw” and now Stewart tried another instrument maker, James Joseph Hicks, whose premises were a few doors away from Ludwig Casella’s. It was as common then as it is today for firms to relabel and market goods made by another manufacturer. For example among other items, Hicks made Sikes hydrometers for the Inland Revenue, but almost certainly also supplied them to other firms for marketing under a private label. Thus it remained possible that Stewart, even by switching supplier, still got thermometers made by the same instrument maker.

There was a possible reason, not divulged to the supplier, why the thermometers were “apt to flaw” and this was down to delicacy or robustness with which the thermometers, and other equipment, were handled by the students. Things are probably no different today; except that in those days, any breakages were ruthlessly recorded by Balfour Stewart, so that the perpetrator can be identified today. Figure 2 shows a few extracts from Stewart’s laboratory log book. Mr Brown was susceptible to breakages and his reputation probably went before him when he joined J J Thomson to compare the calibration of one of the thermometers. Thomson wisely slipped into the background when the tube needed shaking.

p 50

16 June 1875

My Dear Sir

I should like to have for Owens College a dozen thermometer tubes about 18 inches long with a top chamber and cylindrical bulb of the usual size to range from slightly below 0° C. to somewhat above 100° C. The glass of the usual kind.

Yours truly

for Dr B Stewart

F. Kingdon

J. J. Hicks, Esq  
8 Hatton Garden  
London

p 51

4 October 1875

Gentlemen

Please send us 6 small mirrors with magnets & threads attached ready for suspension in a Thompsons (sic) galvanometer.

Yours Respfy

120

Calibration of Thermometer marked No 4 Nov. 14 1873  
 by Mr Brown. Finished calibration 19 Nov & fixed freezing & boiling points  
 Freezing at highest part of mark wh. is nearly this shape ~~3~~  
 Boiling point at highest edge of mark Bar<sup>o</sup> being 30.108 alt. Therm<sup>o</sup> 54

Temp<sup>o</sup> of steam at 30.040 =  $212.24^{\circ}F = 100.13^{\circ}C$ .  
 correction to freeze  $\frac{.068}{30.040}$

This thermometer was broken in verifying.

130

Mon. 1 Dec. Mr Brown proceeded with his estimate of Sp. Wt  
 of mercury but unfortunately broke the bottle in the process  
 of drying it. He has procured another.

Fri 9 Jan Mr Brown & Mr Thomson again tested the thermometer  
 in melting ice when it stood again at the same point as  
 yesterday. On examining the thermometer out of the ice  
 it was found there was a break in the column of mercury  
 a little way above the bulb. Mr Brown in trying to  
 jerk the mercury into its proper place broke the tube

Figure 2: Some extracts from the Laboratory Log Book maintained by Balfour Stewart during the session 1873-4. Breakages are regularly mentioned.

for Dr B Stewart  
F. Kingdon

Messrs Elliott Bros.  
112 St. Martin's Lane  
Strand  
London

p 52

6 October 1875

Sir

Please send to above address a thermo-electric pair, one large pair of Antimony and Bismuth, such as you have supplied on a former occasion to Dr Stewart at Kew.

Yours Respfy  
for Dr B Stewart  
F. Kingdon

Mr W White  
Glasgow

Almost exactly a year after switching suppliers of thermometers to Hicks, Stewart was back with Casella:

p 53

28 June 1876

Sir

I should like to have for Owens College half a dozen thermometer tubes about 18 inches long with a top chamber and cylindrical bulb of the usual size to range from slightly below 0° C. to somewhat above 100° C. The glass of the usual kind.

Yours faithfully  
for Dr B Stewart  
F. Kingdon

L Casella Esq

The episode with the cathetometer did not prevent further business between the College and Ludwig Oertling:

p 54

28 June 1876

Dear Sir

I should like to have from you for our Physical Laboratory another balance similar to the one you sent us some five years since and which we lately sent to you for repairs. It has a ticket with a number (2717) on it and is a balance of large size. We should like to have it as soon as possible.

Yours truly  
B Stewart

L Oertling Esq

This balance was for Stewart's new protogé, J. H. Poynting, who would use it to weigh the Earth.

p 55

October 27<sup>th</sup> 1876

To Casella

Dear Sir

I should like to have from you for our Physical Laboratory a standard barometer to fasten against the wall. It must have an adjustable cistern, both a French and English scale and the tube must have a diameter of about  $\frac{7}{10}$  of an inch. The other details I will leave to yourself.

Yours truly

B Stewart

[Not an exact copy]

Unlike all other copies, this particular letter had been rewritten on College notepaper and stuck into the book. By March 1877, more thermometers were needed.

p 56

March 21 1877

Dear Sir

I should like to have for Owens College two dozen thermometer tubes about 18 inches long with a top chamber and cylindrical bulb of the usual size to range from slightly below 0° C. to somewhat above 100° C. The glass of the usual kind.

Yours faithfully  
for Dr B Stewart  
J H Poynting

L Casella Esq

This is the first of several letters by J. H. Poynting and it was written out in pencil on a page of the book. His next letter, in October of that year, announced a line of research that would occupy Poynting for several years, continuing after he had left Manchester to become Professor of Physics at Mason College, Birmingham, eventually Birmingham University.

p 58

October 11 1877

Gentlemen

Will you please send us 6 small mirrors with magnets attached suitable for Thomson's Galvanometer. Also two small plane silver or silver on glass mirrors each  $\frac{3}{4}$  inch broad and one 1 inch long the other  $1\frac{1}{4}$  inch long. These two mirrors should be as light as possible. I shall be glad if you can send me them soon.

Yours faithfully  
for Dr B Stewart  
J H Poynting

Messrs Elliott Brothers

This time, Poynting did not use pencil, but had mastered the copying technique to produce one of the clearest letters in the book. Page 57 in the letter book is missing and perhaps Poynting did not wish to have his first efforts in the letter book seen by posterity. Unlike Kingdon in October 1875, Poynting spelt Thomson's name (Thomson as in Lord Kelvin) correctly. Poynting had been as student at Owens College from 1867 to 1872, entering at age 15 and graduating with the degree of B.Sc.. After getting a further degree at Cambridge, he returned to Manchester in 1877 as a demonstrator.

The normal "by return of post" service was not enjoyed by Poynting and after seven weeks of mounting impatience to get started on weighing the Earth, he prodded Elliott Brothers:

p 59

October 11 1877

Gentlemen

In my letter of Oct 11<sup>th</sup> there was an order for two small mirrors which you have apparently overlooked as we have not heard anything concerning them. I asked you to send us two small plane silver, or silver on glass mirrors one of them  $\frac{3}{4}$  in by 1 in the other  $\frac{3}{4}$  in by  $1\frac{1}{4}$  in. These mirrors should be as light as possible. I am now waiting for them in order to make some experiments and shall therefore be glad if you can send them soon.

I remain  
Yours sincerely  
J H Poynting

Messrs Elliott Bros

Poynting clearly got his mirrors and set to work. But by January 1878, he was having trouble:

p 60

Jan<sup>y</sup> 21 1878

Gentlemen

In October last I ordered from you two small mirrors which I now find are not suitable for my purpose. I have to reflect a beam of light several times between the two but they are not sufficiently perfect to do this without distortion (whether this arises from a want of planeness or from the fact that the mirrors are only silvered at the back I do not know).

Can you kindly send me two of the same dimensions (each  $\frac{3}{4}$  in broad and one 1 in long the other  $1\frac{1}{4}$  in long) either polished silver or silvered glass silvered on the surface whichever is most likely to be the most accurate plane. This is extremely important I find now that the image of a scale seen through a telescope after these reflections is so distorted that I can hardly read the figures whereas I want at least ten or a dozen reflections before observing with the telescope. You will probably know which sort of mirror is most suitable for this.

I remain

Yours sincerely

J H Poynting

Messrs Elliott Bros

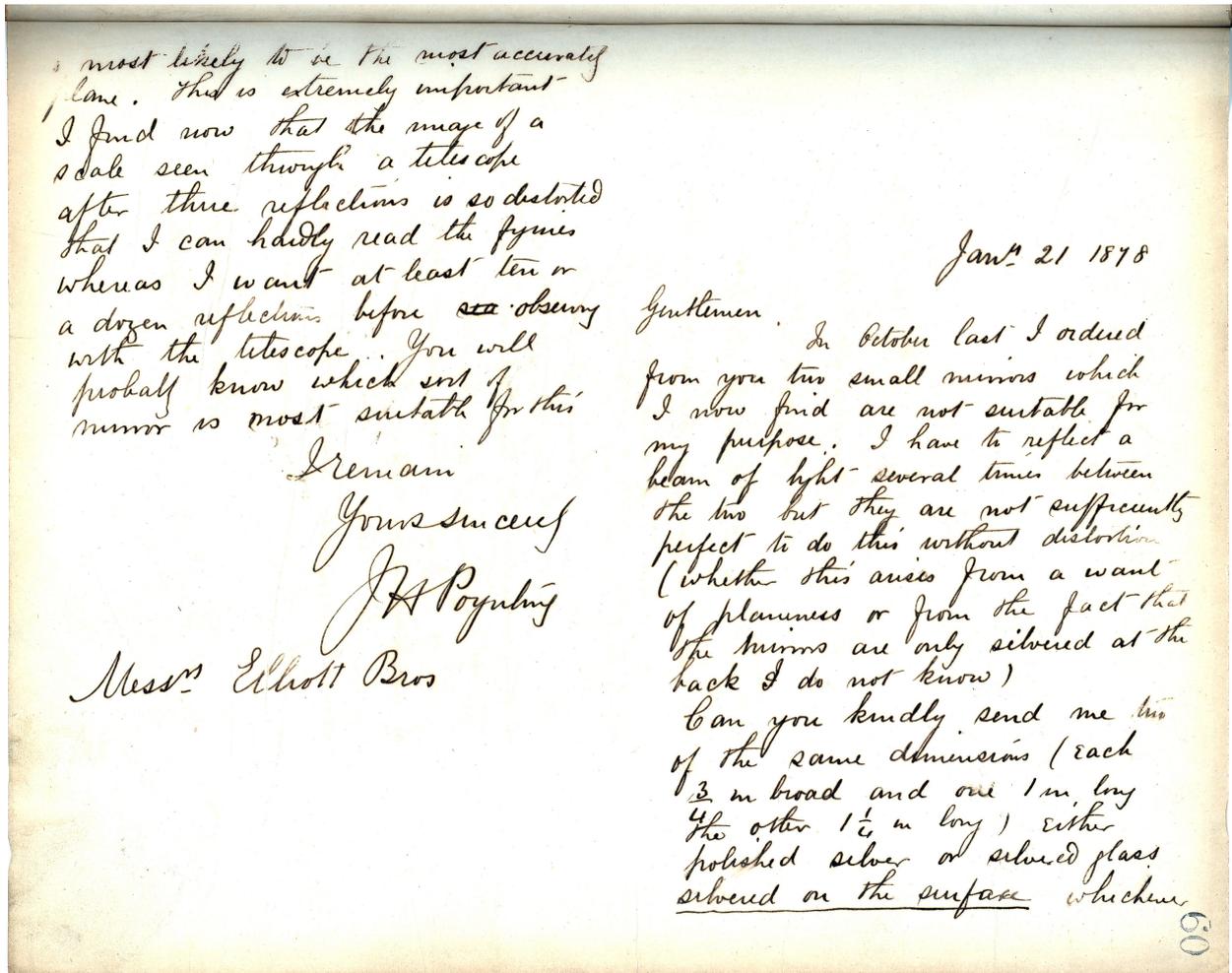


Figure 3: Poynting's hand written letter to Elliott Bros, regarding the mirrors for his experiment to weigh the Earth.

Poynting got new mirrors and they were good enough. Stewart, as a Fellow of the Royal Society presented the results of his protégé's research before the Society on 21 June 1878 [6] where the apparatus and procedure is described in fine detail, including the use of the mirrors. The measurements were carried out in the basement of the Chemistry Department in Manchester and Poynting obtained a value of 5.69 for the mean (relative) density of the earth, with a probable error of 0.15. The detailed error analysis was unusual for that time and gives an overall impression of the meticulous care of Poynting's work, reflected also in the unique quality of his letter pressings. He had already published a paper which was founded on statistics, namely a study of drunkenness in large towns [7].

Poynting was essentially repeating and refining the work of Henry Cavendish, who published a value of 5.48 in 1798. Poynting himself re-evaluated Cavendish's average value and corrected it to 5.448; there was presumably a

transcript error in the original text. The current accepted value is 5.52 which differs from Poynting's determination by one probable error or 3%. The average of Cavendish's and Poynting's first measurements, 5.57, differ from the current accepted value by less than 1%.

The hand written version of the above letter to Elliott Bros is shown in figure 3. No other member of staff achieved such clarity with the copying process.

p 61

17 March 1879

Dear Sir

In reply to your letter of 14<sup>th</sup> inst I should like to have a Hydraulic Press such as you mention for £12.10 – also a Piezometer such as you mention for £12 \_ \_ \_  
To prevent all ambiguity by a Piezometer I mean an instrument such as that described in the 4<sup>th</sup> Edition of Ganot page 70.

I remain

Yours sincerely  
B Stewart

L Casella Esq

Piezometers had become increasingly utilised in oceanography and the laying of submarine cables in the years before Stewart's order to Casella. John Y. Buchanan FRS used many instruments of his own design, including a piezometer, during the H.M.S Challenger expedition of 1872–77. Some of these instruments were later manufactured and marketed by Casella and also used by Prince Albert I of Monaco on his yacht the Princess Alice, a vessel on which Buchanan himself tested the effects of high pressure on his instruments. [9]

Adolphe Ganot (1804-1887) wrote a physics textbook [8] translated by Edmund Atkinson who was professor of experimental science at the Royal Military College, Sandhurst. Edition 4 was published in 1870 with a colour plate of the spectra of various elements.

p 63

19 May 1881

Dear Sir

I should much wish to procure from you a Saccharimeter similar to that which you were good enough to prepare for my Colleague Dr Gamgee the price of which was 330 frs. Would you kindly undertake to send me such an instrument & oblige.

Mons  
Leon Laurent  
Rue de L'odéon 28  
Paris

Yours sincerely  
Balfour Stewart  
Prof<sup>r</sup> of Physics  
at the Owens  
College

PS. Would you kindly also send me two small sized tuning forks with sounding boards both exactly in unison –number of (double) vibrations per second 512.

The colleague referred to in this letter was Arthur Gamgee, one of several eminent brothers who achieved academic recognition in the 19th century. Gamgee did biochemical research in Manchester on “protogan” a constituent of the brain and probably felt aggrieved at the regular onslaughts against even the existence of protogan, made, albeit with the politeness of the time, made by J. L. W. Thudichum, e.g. [10] who called it the “so-called protogan”. Gamgee had demonstrated his underlying desire for truth in a letter which he wrote to the British Medical Journal in 1873 [11].

SIR, — On the occasion of the opening of the new buildings of Owens College, Sir James Kay-Shuttleworth, Bart., referred “to the establishment in the College of the first laboratory in England for physiological research”. Although I regretted exceedingly the error into which the speaker had fallen, and wished to have it in my power to correct it, I felt that, on an occasion of so formal a character, when no speeches were made except by those called upon by the President of the College, the Duke of Devonshire, it would have been scarcely becoming had I, unasked, risen to vindicate the honour of the physiological laboratories of Edinburgh, Cambridge and London.

To the part which these laboratories have taken in what may be termed the revival of experimental physiology in England, I hope to direct my marked attention in the introductory address to my course of practical physiology, which I hope to deliver in this College on Thursday, October 23rd.

I am led to address you this letter to express the, to me, apparent negligence in failing to correct a statement

prejudicial to the position of British physiology. I am, etc.,

Arthur Gamgee

Arthur Gamgee's elder brother, surgeon Dr Joseph Sampson (Sam) Gamgee invented a cotton wool and gauze surgical dressing, known by the trademark of Gamgee Tissue. It is widely held that he was the origin (indirectly via the tissue) of the hobbit Sam Gamgee in J. R. R. Tolkien's *The Lord of The Rings*, although this was never confirmed by Tolkien.

p 64

19 May 1881

Dear Sir

In conformity with the pamphlet you have kindly sent me I should like to order a Saccharimeter No 2 of which the price is 365 fr.

The pressure of our gas is about 29 mm of water during the day.

Yours sincerely  
Balfour Stewart

Mons Léon Laurent

p 67

August 16<sup>th</sup> 1881

Gentlemen

Kindly supply our Physical Laboratory with a 12-cell French Bichromator costing £3.3.

I am

Yours Very Truly  
for Dr Balfour Stewart  
W W Haldane Gee

Messrs Wortley & Co

This is likely to be (Colonel) Stuart Wortley (1832–1890) who played a pivotal role in the early history of British photography as an innovator, promoter, and practitioner of the medium. He developed dry photographic techniques especially for astronomical purposes.

p 69

Oct 27<sup>th</sup> 1881

L Oertling Esq

Dear Sir

Please give me an estimate for a standard 100 gramme weight made of platinized metal, also for a set of milligramme weights sufficiently accurate to be used in conjunction with the standard.

I am,

Yours Very Truly  
for Professor Balfour Stewart  
W W Haldane Gee

William Winson Haldane Gee (1857-1928), a demonstrator at the time of this letter, eventually became professor of electric engineering at the University. Physics and electric engineering operated essentially as a unified department.

p 70

Oct 27<sup>th</sup> 1881

Dear Sir

I am obliged for your note and shall be glad if you will supply our Physical Laboratory with a standard 100 gramme weight made of platinized brass fitted in mahogany box for 21/-, also a set of Milligramme weights, price 3/-.

I am,

Yours Very Truly  
for Professor Balfour Stewart  
W W Haldane Gee

L Oertling Esq.

p 70

November 1<sup>st</sup> 1881

Mr Latimer Clark

Dear Sir

You will greatly oblige me by sending a catalogue of your scientific apparatus. If the cost of your cells with a constant electromotive force be not included in the list, please give me an estimate for a battery of six.

I am  
Yours Very Truly  
W W Haldane Gee  
for Professor Balfour Stewart

Josiah Latimer Clark FRS (1822–1898) was a distinguished electrical engineer who carried out research into the propagation of electric currents in submarine cables. He was a member of a government committee to look into the frequent failures of submarine cable projects. He invented the “Clark standard cell”, of which Haldane Gee requested a quote for six in this letter.

p 71

November 1<sup>st</sup> 1881

M Secretan,

Dear Sir,

As we intend to make some additions to our stock of Physical Apparatus you will greatly oblige me by forwarding your “Catalogue et Prix des Instruments.”

I am  
Yours Very Truly  
for Professor Balfour Stewart  
W W Haldane Gee

The firm of Lerebours et Secretan of Paris [12] was one of the finest instruments makers in Europe in the 19th century, renowned for their microscopes. Noël Jean Lerebours (1761-1840) had founded the original optical firm and was succeeded by his adopted son, Noël Marie Paymal Lerebours (1807-1873) in 1839. Noël Marie Paymal is sometimes referred to as Nicholas in the literature and was the son of seamstress, Marie Jeanne Françoise Paymal and unknown father. In 1845, a partnership with Marc Francois Louis Secretan (1804-1867), professor of astronomy at Lausanne, was established and instruments made by the firm were signed “Lerebours et Secretan à Paris”. Secretan ran the firm himself from 1855. By 1881, when Haldane Gee wrote this letter, the firm was in the hands of Georges Secretan, nephew of Marc. Georges himself had taken over from Marc’s son Auguste.

p 71

November 3<sup>rd</sup> 1881

Messrs Elliott Brothers,  
101 St Martin’s Lane  
Gentlemen,

Prof Balfour Stewart desires me to say that he will be in London on Friday evening next (the 4<sup>th</sup> inst) and will stop at the St Pancras Midland Hotel. He will bring with him two electrometers which he desires you to place in thorough working order. If you will kindly send a messenger to the Hotel on Saturday morning he will leave the parcel containing the instruments directed to you in charge of the porter.

I am,  
Yours Very Truly  
W W Haldane Gee  
Demonstrator in the Physical Lab.

P.S. Will you please send me copies of your catalogues for use in the Laboratory.

Haldane Gee’s letter is dated one day before Stewart’s journey so Elliott Brothers were not given much notice and (probably justified) the postal service was trusted.

p 72

Nov 4<sup>th</sup>/81

Messrs Becker & Co.

Please send off on receipt of this order, a Voss’ Induction Electrical machine, best make, with plate 14  $\frac{1}{4}$  inches. Pack securely and address to me.

Owens College  
Oxford Road

Manchester  
I am  
Yours truly  
Thos H Core

The next letter is undated but likely to be Nov 10th 1881, since it shares a page and was therefore copied at the same time as the following letter of that date.

p 73

Sir,

The mercury in the cistern of the barometer, No 936, which you supplied to our Physical Laboratory has become so dirty that the pointer can no longer be accurately set. Will you please advise us what will be the best way to replace the mercury? If it is necessary for you to have the instrument it shall be packed as you direct and Prof Stewart will take it with him when he next goes to London.

I am

Yours Very Truly

W W Haldane Gee

L Casella Esq

p 73

Nov 10<sup>th</sup> 1881

Sir,

I am obliged for the Catalogue and Estimate which you have sent me. Will you at your early convenience supply our Physical Laboratory with one of Mr Latimer Clark's standard cells, price £1.10?

I am

Yours Very Truly

for Prof Balfour Stewart

W W Haldane Gee

Messrs L Clark & Co,

Regency Street;

Westminster. S.W.

p 75

Thursday (sic) 17<sup>th</sup> 1881

Messrs Elliott Brothers,

Gentlemen,

You will receive by this post a letter from Professor Gamgee relating to two galvanometers which he is to bring to you to-morrow (Friday). The high resistance instrument is the property of our Physical Laboratory and it required to be put into thorough working order. There is defective insulation probably between the connecting screws & brass framework causing thre current to be short-circuited. The box of shunts which was supplied with the galvanometer is not correct, the measured resistances not being in the proper proportions. Please remedy this & adapt the resistances to the galvanometer resistance. I shall also be glad if you will make a wooden case in which the galvanometer & shunts may be kept and also if you will provide the glass case with a flat window.

I am,

Yours Very Truly

W W Haldane Gee

for Prof Balfour Stewart

p 75

Dec 6<sup>th</sup> 1881

Messrs Elliott Brothers,

Dear Sir,

Prof Stewart will arrive in London to-morrow evening (Wednesday) at eight o'clock. He will bring with him the barometer which you kindly promised to put into order. He will be glad if you will send some one to meet him at the Kings Cross terminal into whose care the instrument may be left in charge.

I am,

Yours Very Truly

W W Haldane Gee

L Casella Esq  
147 Holborn Bars, London EC

p 76

Dec 18<sup>th</sup> 1881

Messrs Elliott Brothers,  
101 & 102 St Martin's Lane. W.C.  
Gentlemen,

As the instruments which you have now under repairs that belong to the Physical Laboratory will be required immediately after the Christmas vacation, I shall be glad to know when they will be finished. As Prof Stewart will be in London in the second week of the new year he can if you think it requisite make arrangements for bringing the instruments back with him. If the instruments are ready before then and may in safety be sent to him by train please let us have them at as an early date as possible.

I am,  
Yours Very Truly  
W W Haldane Gee  
for Prof Balfour Stewart

p 76

December 20<sup>th</sup> 1881

L P Casella Esq  
47 Holborn Bars E.C.  
Dear Sir,

Sometime ago you supplied the Natural Philosophy Department of this college with a Piezometer. With it came two tubes for holding the experimental liquids. The tubes were of the forms sketched. As these tubes are now broken and as we wish to make accurate measurements of compressibility in the Physical Laboratory I shall be glad to have your estimate of the cost of two such tubes the narrow parts of which are graduated so that the divisions are submultiples of the whole capacity of the cylinder C added to the tube AB. I mean supposing that the actual measured volume of the instruments to be 50 cubic centres (sic) then each division of AB would require to be made equal in capacity  $\frac{1}{100}$ th or  $\frac{1}{1000}$ th or  $\frac{1}{5000}$ th or any other fraction of the 50 cubic centimetres.

I am, Yours Very Truly W. W Haldane Gee

p 76

Wednesday 21<sup>st</sup> Dec 1881

L P Casella Esq

Prof Stewart desires me to say that he would like the Barometer to be standardized at Kew before being returned.

I am  
Yours Very Truly  
W W Haldane Gee

p 77

10<sup>th</sup> Jan 1882

Gentlemen,

If the instruments which you are repairing for our Physical Laboratory be ready by Saturday next, Professor Stewart will be glad to take charge of them when he then returns from St Pancras by the 3.30 P.M. train. I shall be glad to know whether you will be able to fall in with this arrangement.

I am  
Yours Very Truly  
W W Haldane Gee

Messrs Elliott Brothers,  
101 & 102 St. Martin's Lane. W.C.

Elliott Brothers replied by return of post and Haldane Gee finished off the details:

p 77

Thursday, 12<sup>th</sup> Jan 1882

Gentlemen,

In reply to your letter of the 11<sup>th</sup> inst Prof Stewart will be glad if you will send the instrument to St Pancras. Prof Stewart will travel by the 3.30 PM to Manchester by Pullman Car on Saturday next.

I am

Yours Very Truly  
W W Haldane Gee

Messrs Elliott Brothers,  
101 & 102 St. Martin's Lane. W.C.

p 78

Monday 23/Jan 1882

L P Casella Esq.

Dear Sir,

Will you please supply our Physical Laboratory with a graduated tube as described in a previous letter. In the tubes which you previously supplied for the Piezometer the portion AB was not capillary, please let this portion in the new tube be capillary and graduated as has been described.

In the thermometer tubes which you have supplied us with it is extremely difficult to separate the mercury for calibration. Any directions which you can give to enable us to do this more readily will be of great value.

When the Barometer is re-verified Prof Stewart will arrange to bring back.

I am

Yours Very Truly  
W W Haldane Gee

p 79

Feb 6<sup>th</sup> 1882

Messrs Elliott Brothers,  
101 & 102 St Martin's Lane. W.C.

Gentlemen,

Please supply our Physical Laboratory with a Thomson's Galvanometer, No 24 in catalogue, price £10.10, the instrument should be adapted for thermo pile and general resistance work. We require also a Perry-Ayrton Galvanometer giving webers, price about £5 to £6.

You will receive a tangent galvanometer, at present this is far from being suitable for our purposes. Can you either supply it with a needle suspended from a Torsion Head or alter the pivot & needle so as to give a far more sensitive arrangement. The differential Astatic which also will be sent requires to be put into a thorough state of repair. This also applies to the Thomson's reflecting galvanometer. Also please have the commutator cleaned, polished etc.

If you can execute this order at once we shall be greatly obliged, and if you can have the instruments that are under repair ready when Prof Stewart visits London in about a fortnight, it will also be a great convenience.

I am,

Yours Very Truly  
W W Haldane Gee

William Edward Ayrton (1847-1908) studied at University College in London, England, and then was admitted to the recruit course of the Indian Telegraph Department, where he studied with William Thomson at Glasgow. Working in India, Ayrton attained some fame as a telegraph engineer by his research. In 1873, he was appointed Professor of Physics and Telegraphy at the Imperial College of Engineering, an institution newly founded by the Japanese Government Public Works Department. The course eventually evolved into the Department of Electrical Engineering of the University of Tokyo. In the well-equipped physical laboratory of his own design, Ayrton carried out original research in collaboration with John Perry. Ayrton's experience as the first electrical engineering professor in Japan became the stepping-stone to his later career in England. Ayrton and Perry introduced the names ammeter and voltmeter for their instruments.

p 79A

undated

Mr Casatella,  
Dear Sir

I send you the telescope of the Cathetometer belonging to our Physical Laboratory. Please supply it with cross threads. At present eyepiece A and Field Glass 1 are suited for an object 6 feet distant, but eyepiece B and Field Glass 2 are not quite. Will you adapt these fittings so that in both cases there is an entire freedom from parallax especially for the longer distance. I should add that eye piece A and field glass 1 are principally used at about 5 feet distance. You will see that eyepiece A is easily adjustable, eyepiece B should also be made as easily adjustable. This will require that it should more readily slide in the outer tube.

If you can execute this order at once it will be a great convenience.

I am,  
Very Truly Yours  
W W Haldane Gee  
for Prof Balfour Stewart

p 80

17<sup>th</sup> Feb 1882

Mr Dover,  
Charlton,  
Woolwich,

Dear Sir

I send you the needles of our dip circle. Will you please polish the pivots and let us have the needles back at your early convenience?

I am,  
Yours Very Truly  
W W Haldane Gee  
for Prof Balfour Stewart

p 81

Feb 21<sup>st</sup> 1882

L P Casella Esq  
Dear Sir

Professor Stewart will visit London this week & will return by the 3.30 P.M. train from St Pancras on Saturday, so that if you will send the barometer to the station Prof Stewart will bring it back with him.

I am obliged for the information with respect to the thermometers, but we found it so difficult for some reason in the last lot of thermometers to separate the mercury by the ordinary method that a new method has been adopted which appears satisfactory. The mercury which is usually in the tube is now down into the small bulb. Next the thermometer is placed vertically & brought sharply down on the table using the hand as a buffer. In this way after a few times a suitable length may be broken off.

Please supply us with a thermometer suitable for a Regnault's Hygrometer, it should mark quarter degrees and have a range from  $-40^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ . The size of the tube in order to fit the instrument should be about this  $\bullet^{\dagger}$  and the instrument should be as light as possible. If you can supply us with this instrument early we shall be obliged.

I am,  
Yours Very Truly  
W W Haldane Gee

$\dagger$  Here, Haldane Gee sketched a rough circle, 5 mm high and 6 mm wide, thus nearly one quarter of an inch.

p 82

Feb 28<sup>th</sup> 1882

Dear Sir

In reply to your letter of 23<sup>rd</sup> Feb I send further particulars of the Piezometer tube. The measurements are given in the diagram. The portion AB should be made of tubing with a bore as fine as a thermometer tube. The portion AB should be so divided that each division is some very small fraction of the whole volume of the bulb and tube. The whole apparatus should first be filled with mercury and weighed. The weight of mercury in grammes divided by its density gives the volume. The mercury in the portion AB should no be expelled and its volume determined. Suppose the volume of AB to be  $\frac{1}{5000}$  of the whole volume. Then AB might conveniently be divided into 200 parts each of which would be mercury in the portion AB should no be expelled and its volume determined. Suppose the volume of AB to be  $\frac{1}{5000 \times 200} = \frac{1}{1000000}$  of the whole.

In reply to your memorandum the Thermometer required is the long one that is inserted in the silver vessel

of the Regnault's Apparatus.

The Barometer arrived safely and is in good condition.

If you can let us have the tube and thermometer at any early date I shall be obliged.

I am,

Yours Very Truly

W W Haldane Gee

L P Casella Esq

p 83

March 8<sup>th</sup> 1882

Gentlemen

Please supply our Physical Laboratory with 12 filled but ungraduated thermometers such as you supply Kew with. They should be about 18 inches long and have a cylindrical bulb of the usual size and a small chamber at the top of the tube. They should range from  $-5^{\circ}\text{C}$  to  $105^{\circ}\text{C}$ . The glass to be of the usual kind with a whitened back and a ring of glass at the top. I should prefer the bulb as nearly as possible the same diameter as the tube and with no or very little external constriction between the bulb and tube.

I am,

Very Truly Yours

Prof Balfour Stewart

for W W Haldane Gee

Messrs Negretti & Zambra

Messrs Negretti and Zambra were a very successful London firm specialising in photographic equipment, including series of stereoscopic photographs, as well as thermometers.

p 83

24<sup>th</sup> March 1882

Messrs Swan's Electric Light Company Limited

Gentlemen

Please supply (five crossed out) four incandescent lamps and four holders for ditto. This order is given on the condition that the lamps are sent immediately as they are required for exhibition at a Soirée next week.

I am,

Very Truly Yours

W W Haldane Gee

for Prof Balfour Stewart

p 84

12<sup>th</sup> May 1882

Messrs Elliott

Gentlemen

Please supply at as an (sic) early a date as possible our Physical Laboratory with the following apparatus

:-

Discharge Key - Sabine's	£3 . .	10 . .	0
Battery Switch – 4 connections	£1 . .	5 . .	0
Double Plug Key		17 . .	6

Will you please say when we may expect the Tripod Galvanometer that was ordered some months ago?

The Tangent Galvanometer etc arrived safely.

I am,

Yours Very Truly

W W Haldane Gee

The Tangent Galvanometer, extensively used by the British Post Office, was an ammeter consisting of a circular vertical coil surrounding a delicately pivoted magnetic needle. The tangent of the angle of deflection of the needle is directly proportional to the current circulating in the coil.

Elliott's tripod galvanometer had two sets of magnets arranged with poles opposite, to render the instrument independent of the Earth's magnetism.

p 84

Friday May 12<sup>th</sup> 1882

Latimer Clark & Co  
Gentlemen,

Will you please supply at an early date as possible our Physical Laboratory with the following apparatus?

:-

No in Catalogue				
1209	Sulphate Battery with * * * *			
	chambers . 4 cases each of 12			
	cells at 1.12.6 each -	£6 ..	10 ..	0
1211	Battery 1 cell		3 ..	6
1232	Chloride of Silver Battery, 1 cell		3 ..	0
1553	Three coil detector	3 ..	10 ..	0
1783	Simple Contact Key		15 ..	0
1791	* * * Bronze Key	1 ..	1 ..	0
		<hr/>	<hr/>	<hr/>
		12 ..	2 ..	6

If a Morse Direct Writer (316) were ordered would you supply the instrument at once?

I am,

Yours Very Truly

W W Haldane Gee

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Friday May 12<sup>th</sup> 1882

W T Glover & Co  
25 Booth St Manchester  
Gentlemen,

Please give me an estimate for 3000 metres of No 50 B.W.G silk covered wire with Resistance of 3 ohms to the metre suitable for a potential Galvanometer (See Telegraphic Journal, Oct 1<sup>st</sup> 1881).

I am,

Yours Very Truly

W W Haldane Gee

Walter T Glover & Co, a Manchester manufacturing company specialising in electrical wire and cable, was founded in 1868. The company expanded in the 1880s as electric lighting became used in factories and homes and as telegraphy spread world-wide. Some of their overland and submarine cables cost over £1000 per mile [13], a prodigious sum in those days. After briefly being taken over by Vickers Ltd, the company was acquired by British Insulated Cables (BICC) although the name Glover was retained. The wire specified in this letter, 50 B.W.G. corresponds to the "Birmingham Wire Gauge". A copper wire of 3 ohms per metre would have a diameter no less than 3 thousandths of an inch, which in Glover's catalogue is given as 43 B.W.G. The spool of 3000 metres would have weighed about 4 ounces, and so was small fry to Glover.

p 85

May 24<sup>th</sup> 1882

Gentlemen,

Will you please supply as soon as possible the following apparatus to the Physical Laboratory of this College? :-

Will you also send some specimens of carbon paper for high resistances and a price list of German silver and Platinum silver wires?

I am,

Yours Very Truly

Catalogue No				
316	Morse Direct writer	£12 ..	10 ..	0
1203	Globe reservoir battery		3 ..	6
1205	Callendar Gravity Daniell		2 ..	6
1210	Siemens * * battery		2 ..	9
1217	Meidingers Battery		5 ..	6

W W Haldane Gee

Messrs L Clark, Muirhead & Co

Heinrich Meidinger, Professor of Physics at the Technischen Hochschule in Karlsruhe from 1869, devised a standard voltage cell which was being used by the Deutsche Reichstelegraphie at the time of this letter. Meidingerstrasse, just off Kriegstrasse near the city centre of Karlsruhe is named after him.

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Physical Laboratory (Undated)

Messrs Elliott Bros  
Gentlemen,

The Tripod Galvanometer has arrived in apparently good condition.

We send off to-day by the L & N.W. Ry a box containing the following pieces of apparatus to be repaired.

- (1). A Thomson's Galvanometer. This required thoroughly renovating.
- (2). A high resistance coil for the same instrument. To this the ballistic needle, which is returned, requires adapting & the coil itself mounting on an independent framework with \*\*ing screws etc.
- (3). A slide metre bridge. This requires (missing) , wire (missing) changed and providing with an infrared contact piece.
- (4). A Kohlrausch's air condenser. This especially requires far better insulation.

If you can return us these things by the middle of July we should be greatly obliged as there will be a special Technical class in Electricity here next session for which we wish the apparatus all in thorough order before the end of July.

I am,  
Very Truly Yours  
W W Haldane Gee

p 87

26<sup>th</sup> June 1882

Messrs Siemens Brothers  
Gentlemen,

Please send us one of your electro-dynamometers for strong currents, price £5 . 10. An official order is enclosed.

I am,  
Yours Truly  
W W Haldane Gee

p 87

26<sup>th</sup> June 1882

Messrs Apps

I send you an Induction Coil which belongs to our Physical Laboratory. Will you please examine it and say what the probable cost of repairing it will be? The present contact breaker will probably require replacing by an ordinary vertically placed one. The condenser, I believe, also is defective.

I am,  
Yours Truly  
W W Haldane Gee

Demonstrator in the Physical laboratory.

P.S. Will you please send us your catalogue for use in the laboratory.

Alfred Apps was an optician/instrument maker with premises at 433 Strand, London W.C. During the 1860s, he became well known for producing some of the largest induction coils in existence. One of his larger coils, 20 inches in diameter and with over 300,000 turns in the secondary, was constructed in 1876 for mathematician and physicist William Spottiswoode, Fellow and President of the Royal Society. According to the renowned 11th edition of Encyclopædia Britannica [14] of 1910, this coil, was capable of producing 42 inch sparks in air, was by then in the possession of the Royal Institution. It became known as the “famous Spottiswoode coil” [15].

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26<sup>th</sup> June 1882

Messrs Walter T Glover & Co  
Gentlemen,

I send you the order for repairing the wire which has been forwarded to your works. If you can return it at an early date and supply our Physical laboratory with the wire, also more ordered, I shall be obliged. Will you also please send your price lists and specimens of your telephone and electric – light cables for use in the laboratory.

I am, Yours Very Truly

W W Haldane Gee

p 89

30<sup>th</sup> June 1882

Messrs Edward Peters  
Dear Sir,

Next Thursday evening there is to be a soirée here of the Society of Chemical Industry at which there will be a demonstration on Electrical Lighting, so that if you will kindly let me have the following slides at once I shall be greatly obliged:-

710	Portrait of Edison
768	" " Sir H Davy
769	Jablochkoff's electric candle
776	Siemens machine
778	Gramme's machine
780	Brush's machine
785	Electric Light on Thames Embankment
789	(blank)
791	Fall of Gas shares
794	Edisons incandescant lamp. platinum
795	" " " carbon
796	" Generator
797	" central * * * of generator
798	" Electric light meter
160	Cruikshank's trough
220	Dulong's regulator
222	Battery room open house

The slides shall be addressed

W. W. Gee.  
Physical Laboratory  
Owens College  
Manchester

and should arrive here not later than Wednesday morning next

I am,

Yours Very Truly

W W Haldane Gee

The Society of Chemical Industry held its first meeting on 29 January 1880 in Liverpool, under the name “South Lancashire Chemical Society”, having been formed by those with an interest in the chemical industries in Widnes, Runcorn and St Helens. It changed its name to “The Society of Chemical Engineers” at its second meeting in April 1880 and then settled on its current title at a meeting in London on 4 April 1881. Its first President was Manchester’s professor of chemistry, Henry Enfield Roscoe.

An array of Pavel Yablochov’s candles, a type of electric carbon arc lamp, was used to brightly illuminate the Avenue de l’Opera during the 1878 Paris Exposition and triggered a massive sell off of gas utility shares.

Zénobe Théophile Gramme (1826–1901) was a Belgian electrical engineer who invented a high power dynamo capable of generating much higher voltages than the dynamos available hitherto. In 2005, he was voted the 23rd greatest Belgian [16], behind Adolphe Sax (saxophone), Ernest Solvay (chemist) and Georges Simenon (writer of Maigret).

Charles Francis Brush (1849–1929) pioneered the generation of electricity for large lighting systems, especially in the US. He formed the Anglo-American Brush Electric Light Corporation in Lambeth in 1879 and its successor, BRUSH Turbogenerators has become the largest independent manufacturer of turbogenerators in the world. He produced the world’s first automatically operated wind turbine in 1888. With a diameter of 17 metres, weighing over 3.5 tons, it could generate 12 kW of electricity.

### 3 Finale

The Letter Book ends abruptly with this order for lantern slides on the 30th June 1882. A plausible deduction can be made about what happened next. In 1882, the first commercial upper and lower case typewriter was marketed in England and it is hard to imagine that this department would have ignored such a technological advance. In 1900 when the new physics building was opened, honorary degrees were bestowed on such luminaries as Lord Kelvin and J J Thomson. The citations, which are in the University library archives, are beautifully typed even to modern standards.

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- [16] Le plus grand belge. Television show produced by the Belgian TV channel RTBF.