J.P.V.MADSEN & the 1914 B.A.A.S MEETING in AUSTRALIA.

The PERIODIC TABLE 1869-1914: MENDELEEV TO MOSELEY.

CONTENTS.

EXHIBITS 1-26.	**Pages 2-27.**
INTRODUCTION.	**Page 28.**
EXHIBIT DESCRIPTIONS.	**Pages 29-36.**

R.W.MADSEN, OCTOBER 2020.

REPORT

OF THE

EIGHTY-FOURTH MEETING OF THE

BRITISH ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE

AUSTRALIA: 1914

JULY 28—AUGUST 31

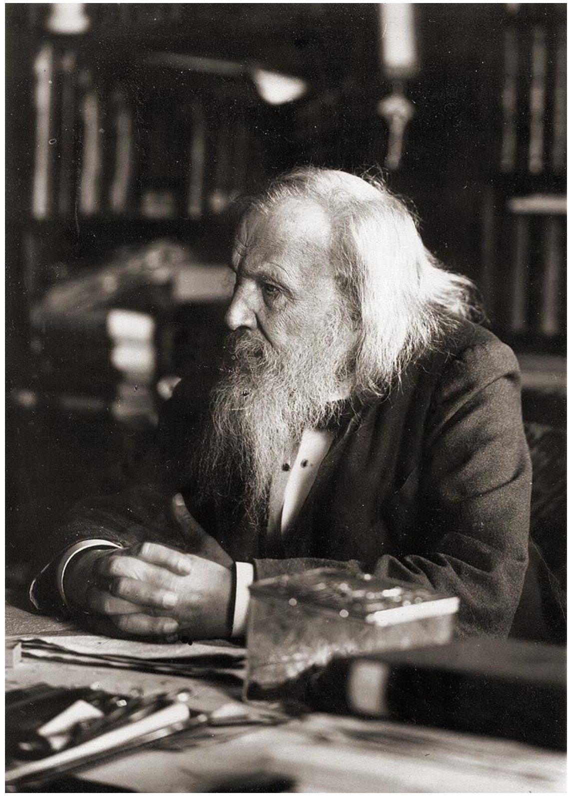
LONDON
JOHN MURRAY, ALBEMARLE STREET
1915

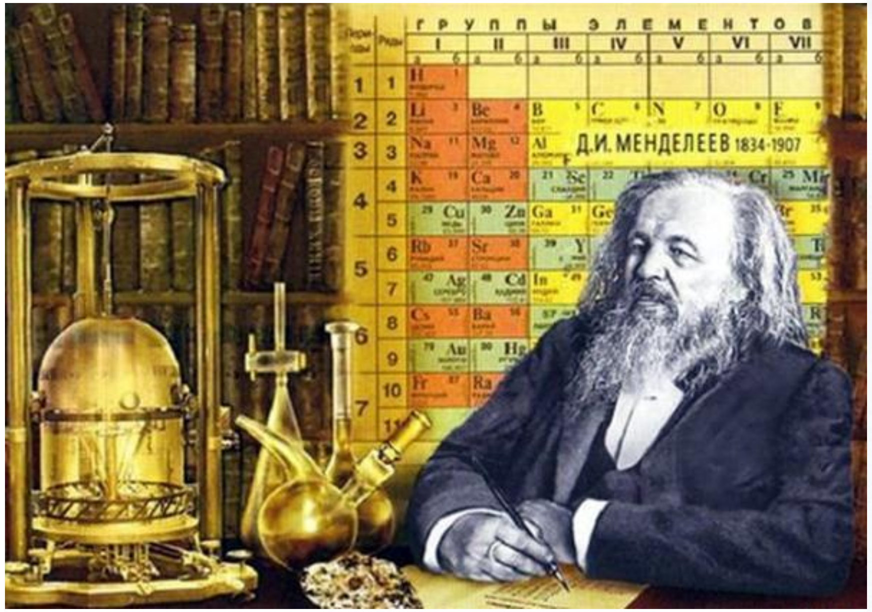
Office of the Association: Burlington House, London, W.

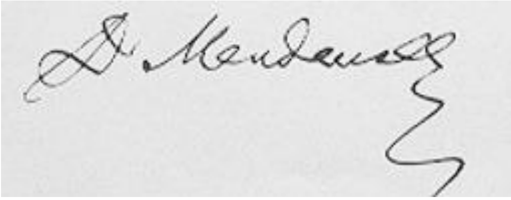
J.P.V. Madsen & the 1914 B.A.A.S Meeting in Australia.

THE PERIODIC TABLE 1869-1914: MENDELE
MOSELEY.

Dmitri I.Mendeleev (1834-1907).







On the Relationship of the Properties of the Elements to their Atomic Weights

D. Mendelejeff, *Zeitschrift für Chemie* **12**, 405-406 (1869); translation by Carmen Giunta

By ordering the elements according to increasing atomic weight in vertical rows so that the horizontal rows contain analogous elements,[1] still ordered by increasing atomic weight, one obtains the following arrangement, from which a few general conclusions may be derived.

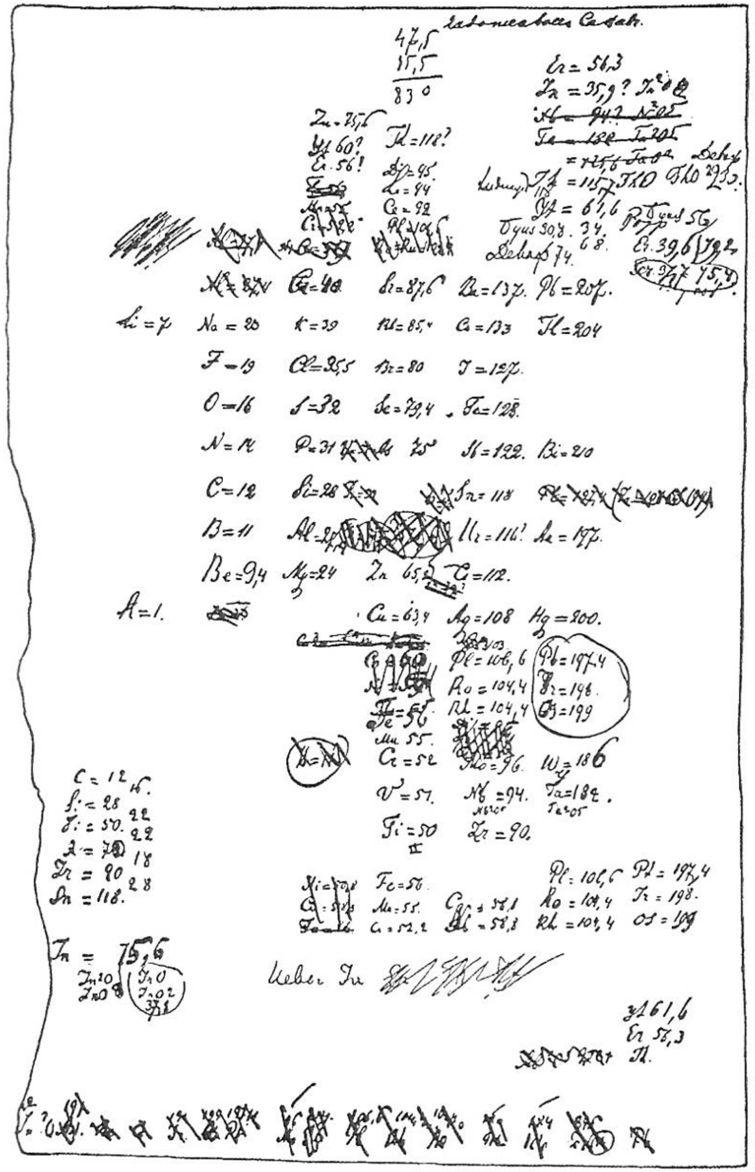
			Ti=50	Zr=90	?[2]=180
			V=51	Nb=94	Ta=182
			Cr=52	Mo=96	W=186
			Mn=55	Rh=104,4[3]	Pt=197,4[4]
			Fe=56	Ru=104,4	Ir=198
			Ni=Co=59	Pd=106,6	Os=199
H=1[5]			Cu=63,4	Ag=108	Hg=200
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?[6]=68	Ur=116[7]	Au=197?
	C=12	Si=28	?[8]=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	J=127[9]	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204
		Ca=40	Sr=87,6	Ba=137	Pb=207
		?[10]=45	Ce=92[11]		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

1. The elements, if arranged according to their atomic weights, exhibit an evident stepwise variation[12] of properties.

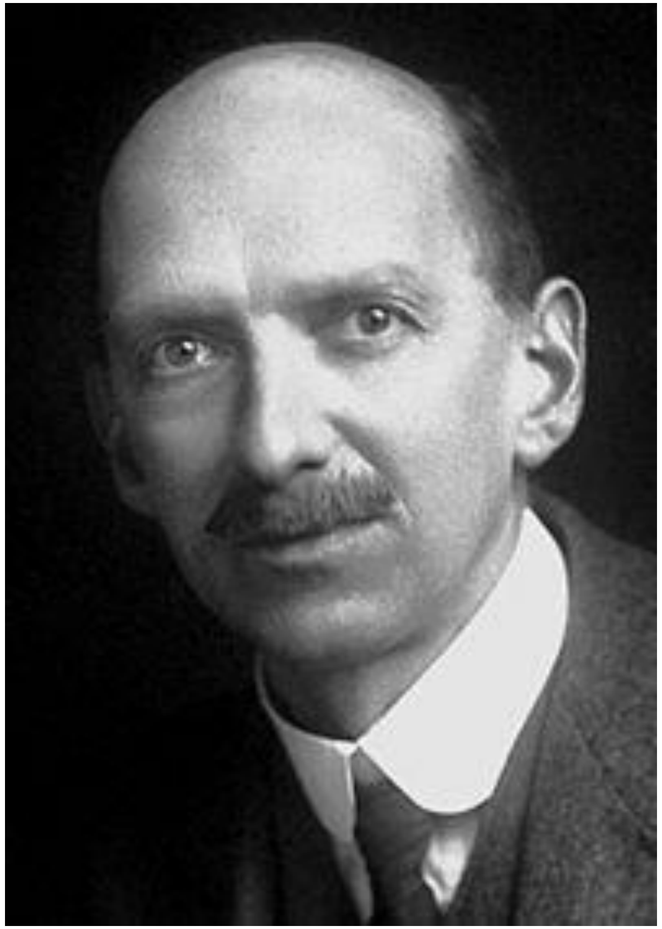
Mendeleev’s Periodic Table.

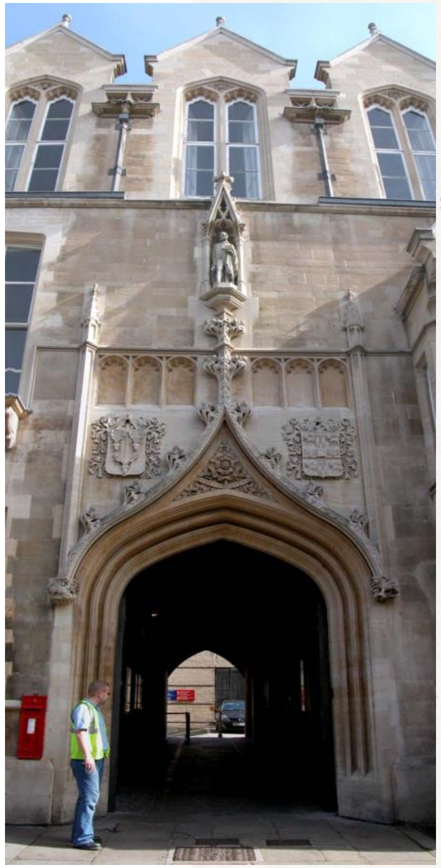
Mendeleev’s Periodic Table (1869)

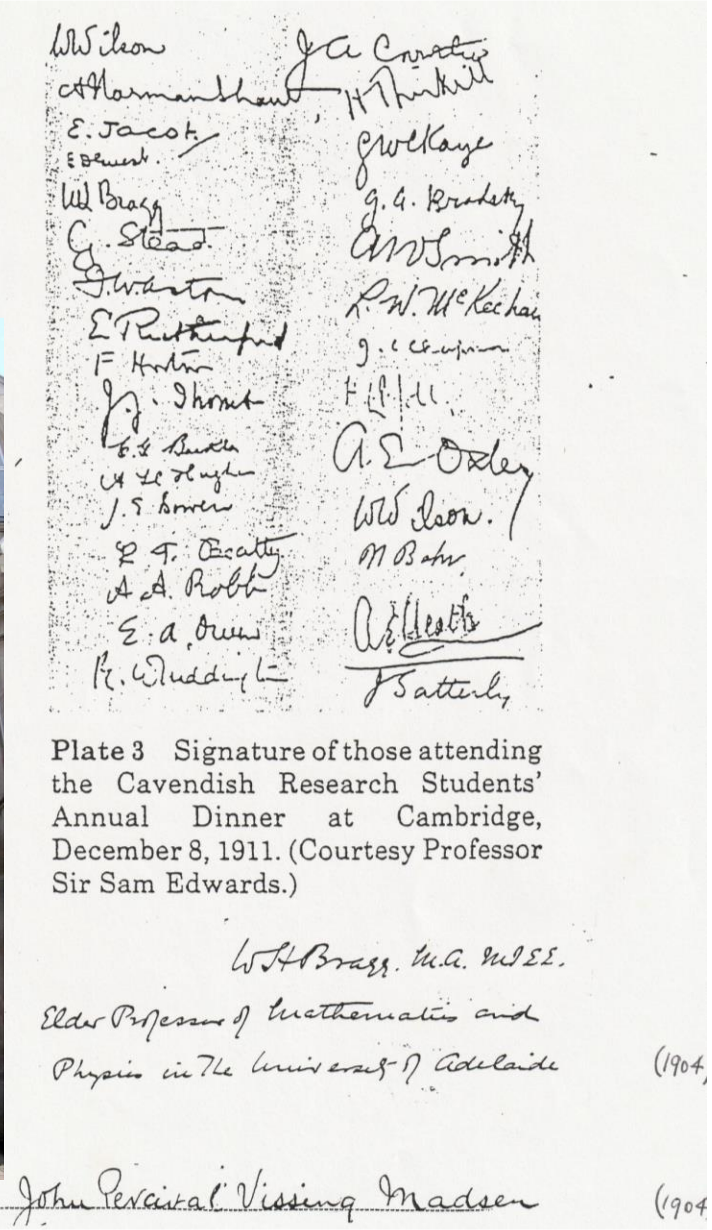
I	II	III	IV	V	VI	VII	VIII		
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Ti 204	Pb 207	Bi 209					
			Th 232		U 238				



Cavendish 1911 Reunion.







E. Jacot

W L Bragg

G. Stead

E Rutherford

J.S. Bowen

A. A. Robb

E. a. Owen

G W C Kaye

A. E. Oxley

W W Ilson.

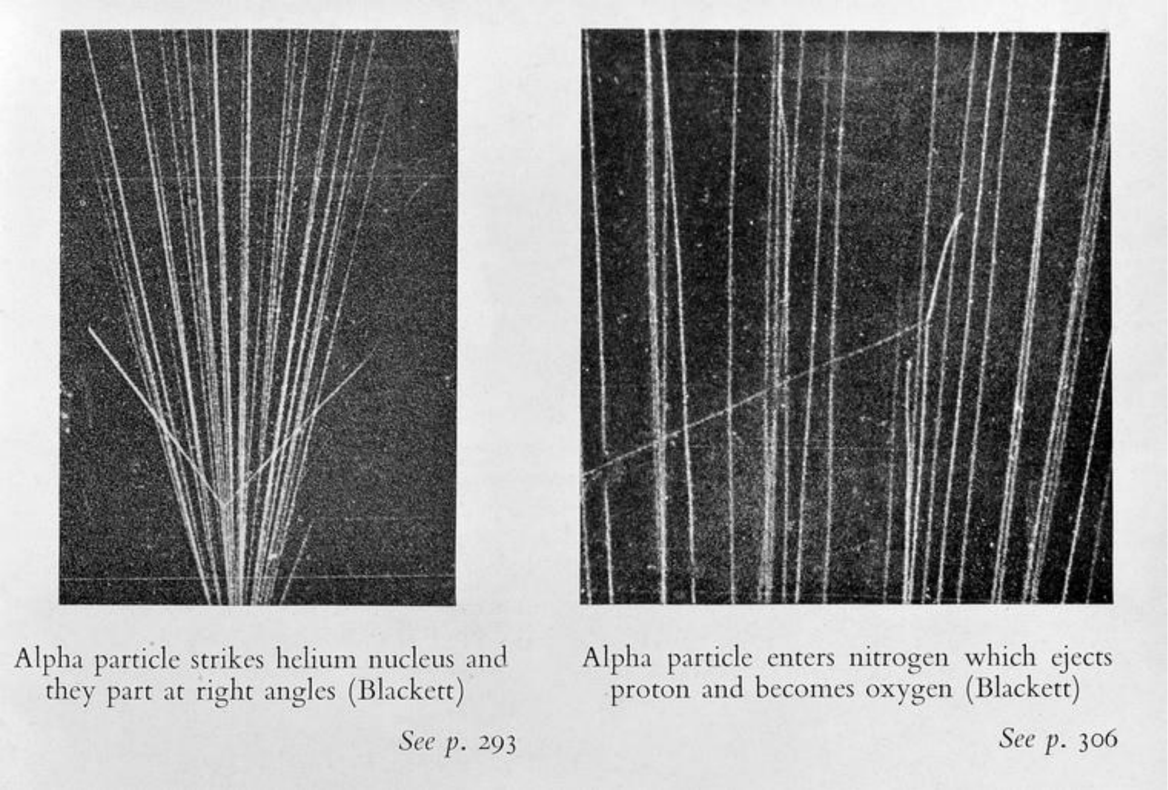
Plate 3 Signature of those attending the Cavendish Research Students' Annual Dinner at Cambridge, December 8, 1911. (Courtesy Professor Sir Sam Edwards.)

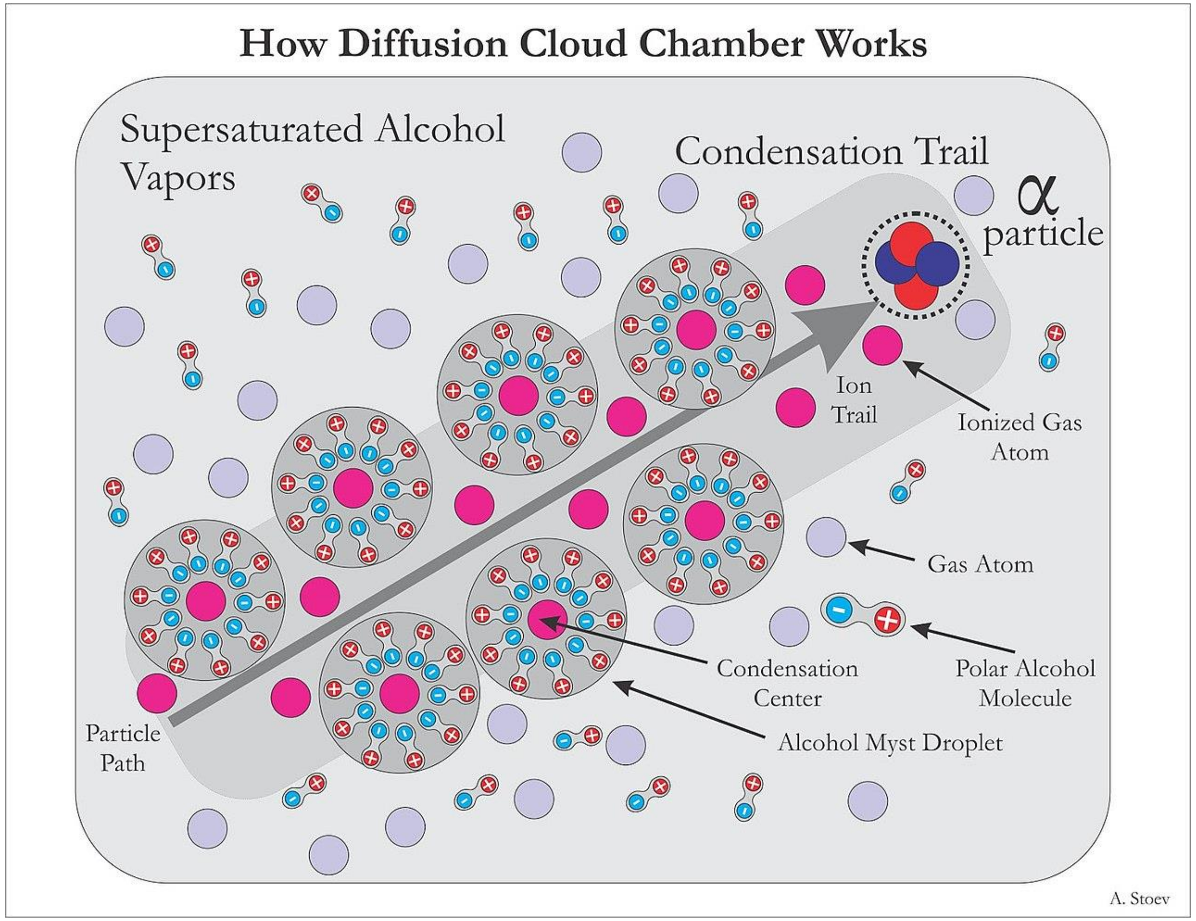
W H Bragg. M.A. M.I.E.E.

Elder Professor of Mathematics and Physics in the University of Adelaide (1904

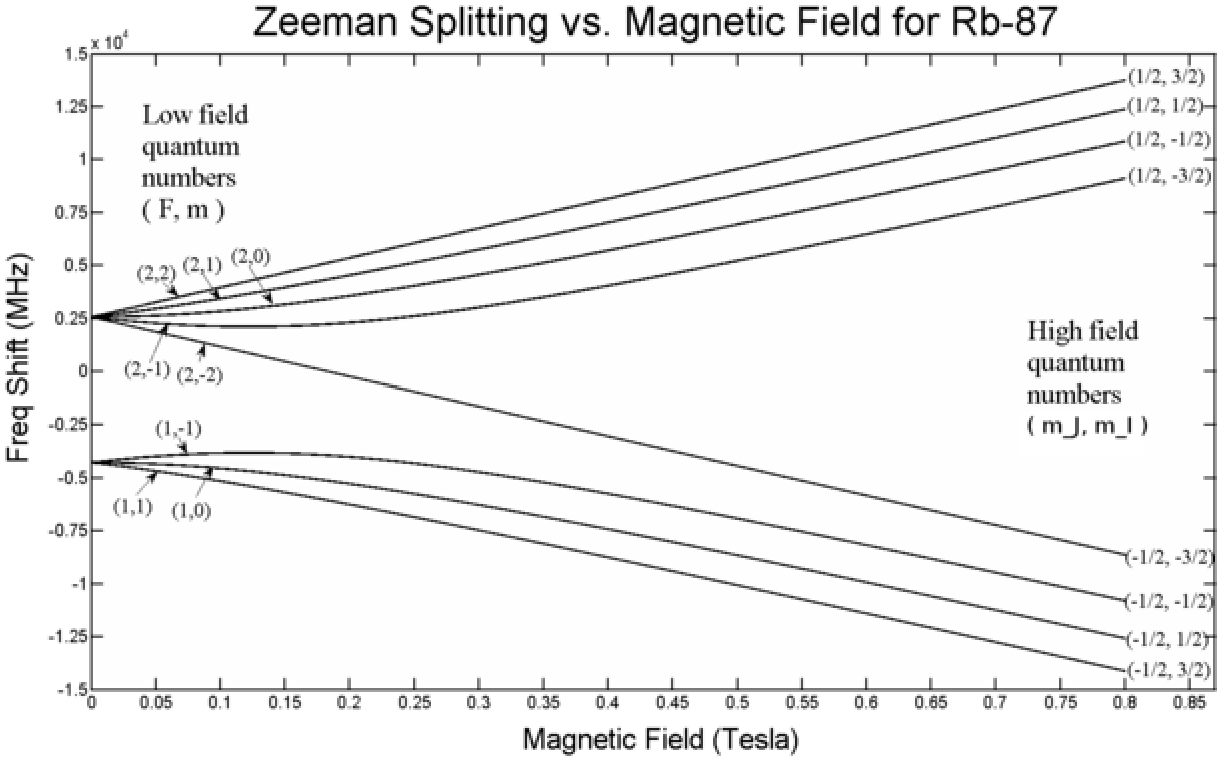
John Percival Vissing Madsen (1904

Wilson Cloud Chamber.

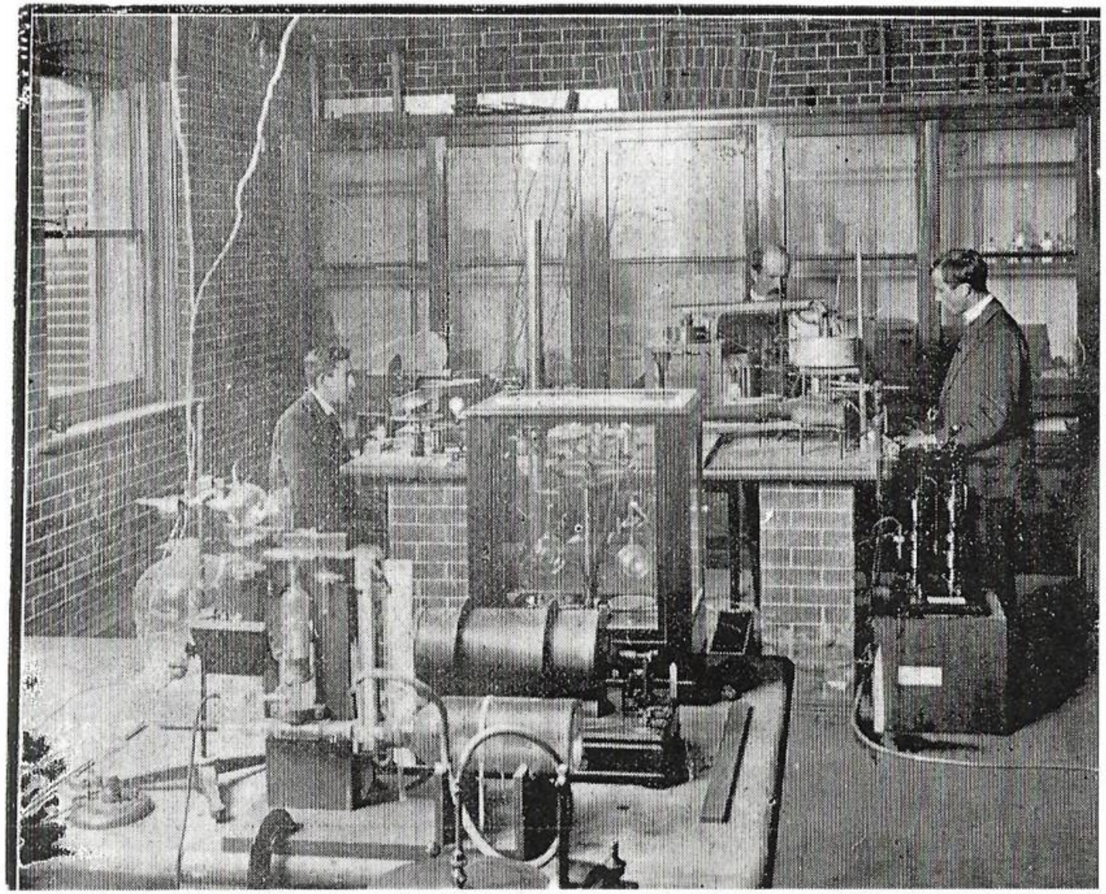


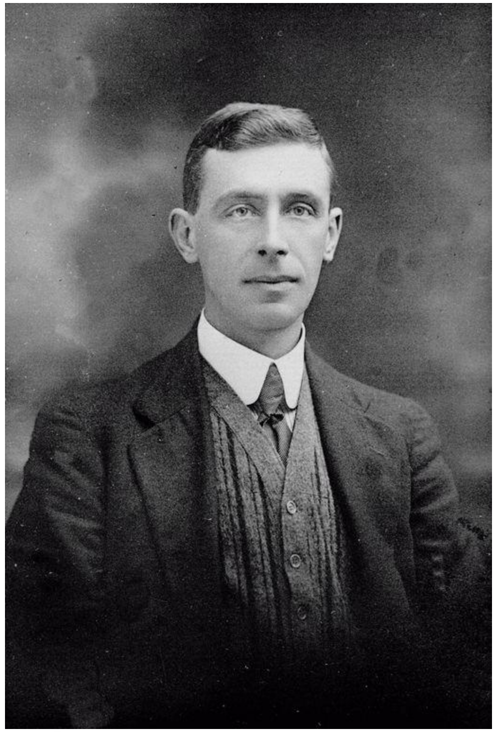


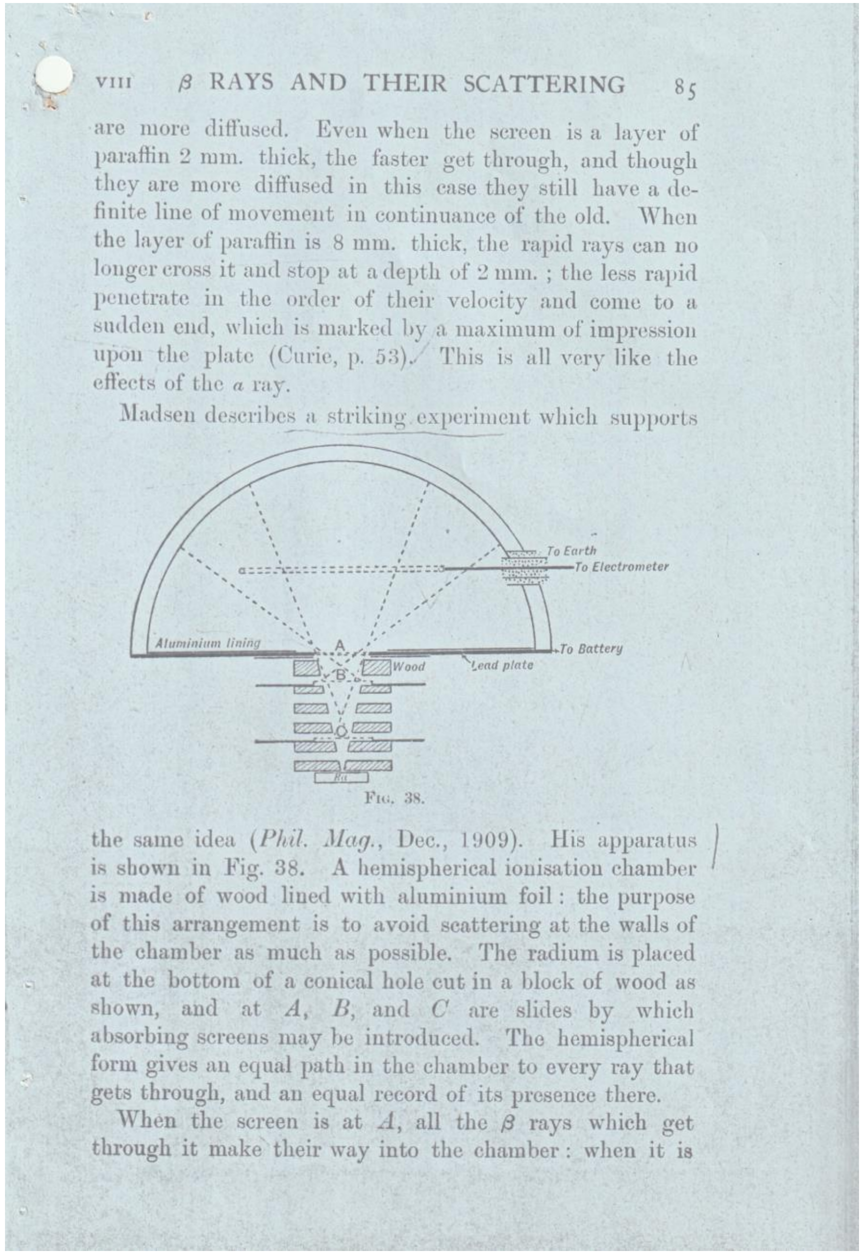
Wilson Cloud Chamber & Zeeman Effect.



W.H.Bragg & J.P.V.Madsen.







are more diffused. Even when the screen is a layer of paraffin 2 mm. thick, the faster get through, and though they are more diffused in this case they still have a definite line of movement in continuance of the old. When the layer of paraffin is 8 mm. thick, the rapid rays can no longer cross it and stop at a depth of 2 mm.; the less rapid penetrate in the order of their velocity and come to a sudden end, which is marked by a maximum of impression upon the plate (Curie, p. 53). This is all very like the effects of the *a* ray.

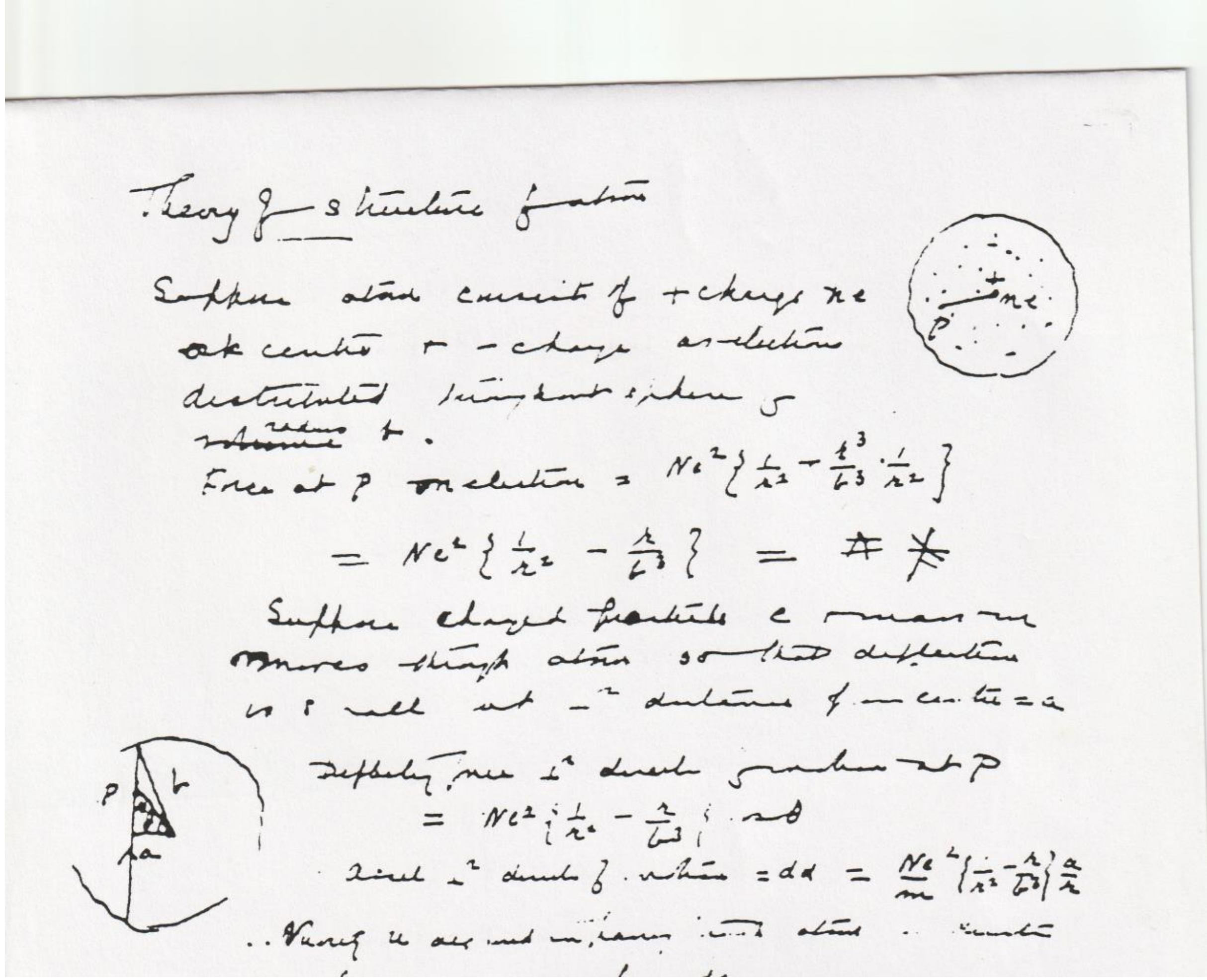
Madsen describes a striking experiment which supports

Fig. 38.

the same idea (*Phil. Mag.*, Dec., 1909). His apparatus is shown in Fig. 38. A hemispherical ionisation chamber is made of wood lined with aluminium foil: the purpose of this arrangement is to avoid scattering at the walls of the chamber as much as possible. The radium is placed at the bottom of a conical hole cut in a block of wood as shown, and at *A*, *B*, and *C* are slides by which absorbing screens may be introduced. The hemispherical form gives an equal path in the chamber to every ray that gets through, and an equal record of its presence there.

When the screen is at *A*, all the β rays which get through it make their way into the chamber: when it is

Rutherford Atom March 1911.



Theory of structure of atom

Suppose atom consist of +charge ne at centre & −charge as electrons distributed throughout sphere of radius b.

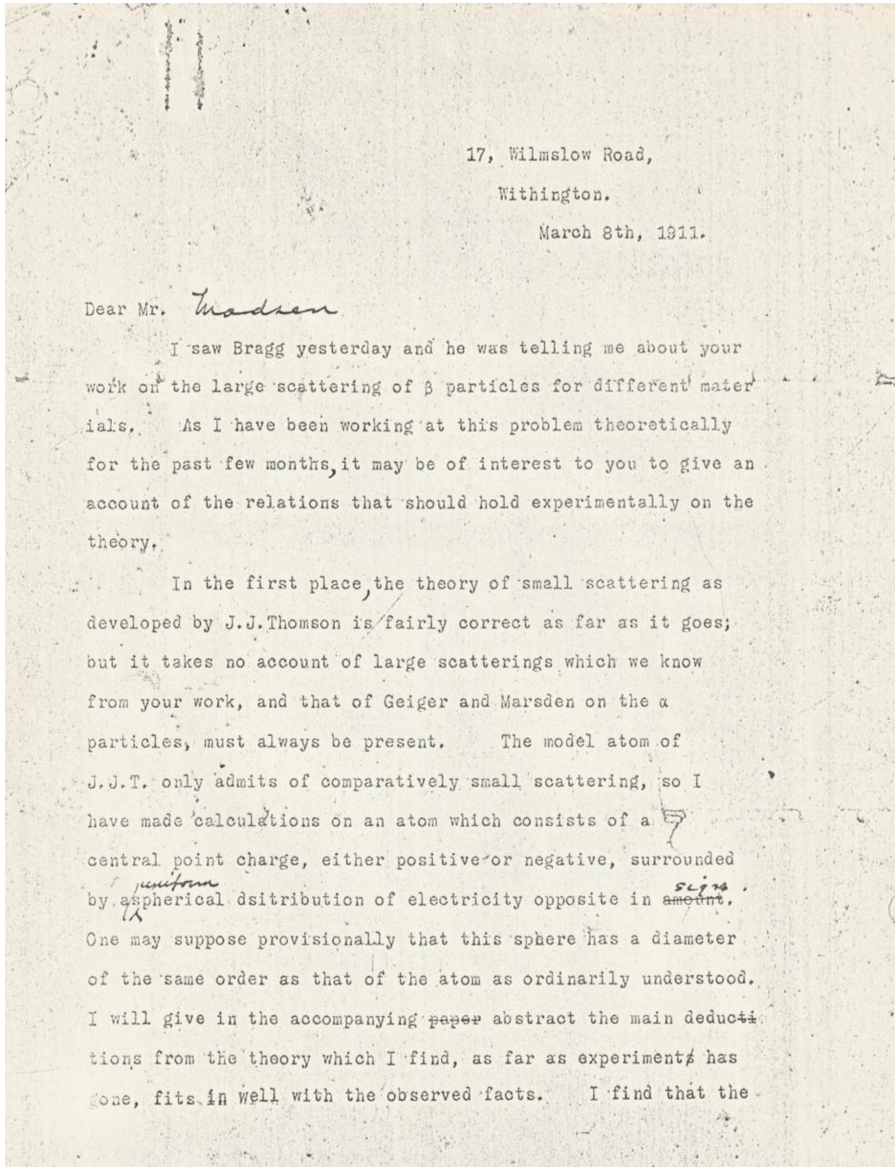
Force at P on electron $= Ne^2\left\{\frac{1}{r^2} - \frac{r^3}{b^3}\cdot\frac{1}{r^2}\right\}$

$= Ne^2\left\{\frac{1}{r^2} - \frac{r}{b^3}\right\} =$

Suppose charged particle e mass m moves through atom so that deflection is small at ... distance from centre = a

Deflecting force in direction ... at P $= Ne^2\left\{\frac{1}{r^2} - \frac{r}{b^3}\right\}$

... $= d\alpha = \frac{Ne^2}{m}\left\{\frac{1}{r^2}-\frac{r}{b^3}\right\}\frac{a}{r}$



17, Wilmslow Road,

Withington.

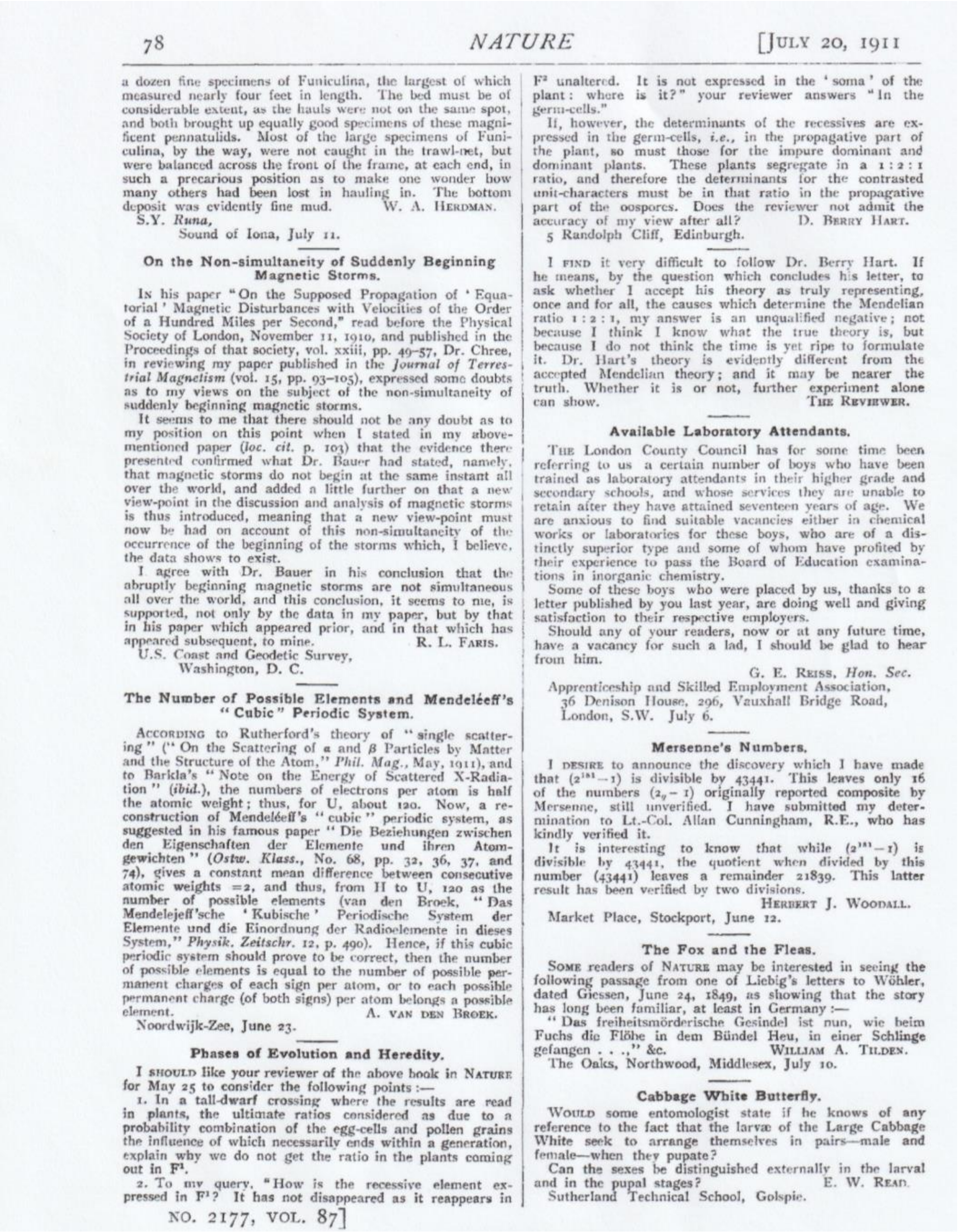
March 8th, 1911.

Dear Mr. Madsen

I saw Bragg yesterday and he was telling me about your work on the large scattering of β particles for different materials. As I have been working at this problem theoretically for the past few months, it may be of interest to you to give an account of the relations that should hold experimentally on the theory.

In the first place, the theory of small scattering as developed by J.J.Thomson is fairly correct as far as it goes; but it takes no account of large scatterings which we know from your work, and that of Geiger and Marsden on the α particles, must always be present. The model atom of J.J.T. only admits of comparatively small scattering, so I have made calculations on an atom which consists of a central point charge, either positive or negative, surrounded by a uniform spherical dsitribution of electricity opposite in ~~amount~~ sign. One may suppose provisionally that this sphere has a diameter of the same order as that of the atom as ordinarily understood. I will give in the accompanying ~~paper~~ abstract the main deductions from the theory which I find, as far as experiments has gone, fits in well with the observed facts. I find that the

Antonius Van Den Broek. (1870-1926).



a dozen fine specimens of Funiculina, the largest of which measured nearly four feet in length. The bed must be of considerable extent, as the hauls were not on the same spot, and both brought up equally good specimens of these magnificent pennatulids. Most of the large specimens of Funiculina, by the way, were not caught in the trawl-net, but were balanced across the front of the frame, at each end, in such a precarious position as to make one wonder how many others had been lost in hauling in. The bottom deposit was evidently fine mud. W. A. HERDMAN.

S.Y. *Runa*,
Sound of Iona, July 11.

On the Non-simultaneity of Suddenly Beginning Magnetic Storms.

IN his paper "On the Supposed Propagation of 'Equatorial' Magnetic Disturbances with Velocities of the Order of a Hundred Miles per Second," read before the Physical Society of London, November 11, 1910, and published in the Proceedings of that society, vol. xxiii, pp. 49–57, Dr. Chree, in reviewing my paper published in the *Journal of Terrestrial Magnetism* (vol. 15, pp. 93–105), expressed some doubts as to my views on the subject of the non-simultaneity of suddenly beginning magnetic storms.

It seems to me that there should not be any doubt as to my position on this point when I stated in my abovementioned paper (*loc. cit.* p. 103) that the evidence there presented confirmed what Dr. Bauer had stated, namely, that magnetic storms do not begin at the same instant all over the world, and added a little further on that a new view-point in the discussion and analysis of magnetic storms is thus introduced, meaning that a new view-point must now be had on account of this non-simultaneity of the occurrence of the beginning of the storms which, I believe, the data shows to exist.

I agree with Dr. Bauer in his conclusion that the abruptly beginning magnetic storms are not simultaneous all over the world, and this conclusion, it seems to me, is supported, not only by the data in my paper, but by that in his paper which appeared prior, and in that which has appeared subsequent, to mine. R. L. FARIS.

U.S. Coast and Geodetic Survey,
Washington, D. C.

The Number of Possible Elements and Mendeléeff's "Cubic" Periodic System.

ACCORDING to Rutherford's theory of "single scattering" ("On the Scattering of α and β Particles by Matter and the Structure of the Atom," *Phil. Mag.*, May, 1911), and to Barkla's "Note on the Energy of Scattered X-Radiation" (*ibid.*), the numbers of electrons per atom is half the atomic weight; thus, for U, about 120. Now, a reconstruction of Mendeléeff's "cubic" periodic system, as suggested in his famous paper "Die Beziehungen zwischen den Eigenschaften der Elemente und ihren Atomgewichten" (*Ostw. Klass.*, No. 68, pp. 32, 36, 37, and 74), gives a constant mean difference between consecutive atomic weights =2, and thus, from H to U, 120 as the number of possible elements (van den Broek, "Das Mendelejeff'sche 'Kubische' Periodische System der Elemente und die Einordnung der Radioelemente in dieses System," *Physik. Zeitschr.* 12, p. 490). Hence, if this cubic periodic system should prove to be correct, then the number of possible elements is equal to the number of possible permanent charges of each sign per atom, or to each possible permanent charge (of both signs) per atom belongs a possible element. A. VAN DEN BROEK.

Noordwijk-Zee, June 23.

Phases of Evolution and Heredity.

I SHOULD like your reviewer of the above book in NATURE for May 25 to consider the following points:—

1. In a tall-dwarf crossing where the results are read in plants, the ultimate ratios considered as due to a probability combination of the egg-cells and pollen grains the influence of which necessarily ends within a generation, explain why we do not get the ratio in the plants coming out in F^1.

2. To my query, "How is the recessive element expressed in F^1? It has not disappeared as it reappears in F^2 unaltered. It is not expressed in the 'soma' of the plant: where is it?" your reviewer answers "In the germ-cells."

If, however, the determinants of the recessives are expressed in the germ-cells, *i.e.*, in the propagative part of the plant, so must those for the impure dominant and dominant plants. These plants segregate in a 1:2:1 ratio, and therefore the determinants for the contrasted unit-characters must be in that ratio in the propagative part of the oospores. Does the reviewer not admit the accuracy of my view after all? D. BERRY HART.

5 Randolph Cliff, Edinburgh.

I FIND it very difficult to follow Dr. Berry Hart. If he means, by the question which concludes his letter, to ask whether I accept his theory as truly representing, once and for all, the causes which determine the Mendelian ratio 1:2:1, my answer is an unqualified negative; not because I think I know what the true theory is, but because I do not think the time is yet ripe to formulate it. Dr. Hart's theory is evidently different from the accepted Mendelian theory; and it may be nearer the truth. Whether it is or not, further experiment alone can show. THE REVIEWER.

Available Laboratory Attendants.

THE London County Council has for some time been referring to us a certain number of boys who have been trained as laboratory attendants in their higher grade and secondary schools, and whose services they are unable to retain after they have attained seventeen years of age. We are anxious to find suitable vacancies either in chemical works or laboratories for these boys, who are of a distinctly superior type and some of whom have profited by their experience to pass the Board of Education examinations in inorganic chemistry.

Some of these boys who were placed by us, thanks to a letter published by you last year, are doing well and giving satisfaction to their respective employers.

Should any of your readers, now or at any future time, have a vacancy for such a lad, I should be glad to hear from him.

G. E. REISS, *Hon. Sec.*

Apprenticeship and Skilled Employment Association,
36 Denison House, 296, Vauxhall Bridge Road,
London, S.W. July 6.

Mersenne's Numbers.

I DESIRE to announce the discovery which I have made that $(2^{181}-1)$ is divisible by 43441. This leaves only 16 of the numbers (2_q-1) originally reported composite by Mersenne, still unverified. I have submitted my determination to Lt.-Col. Allan Cunningham, R.E., who has kindly verified it.

It is interesting to know that while $(2^{181}-1)$ is divisible by 43441, the quotient when divided by this number (43441) leaves a remainder 21839. This latter result has been verified by two divisions.

HERBERT J. WOODALL.

Market Place, Stockport, June 12.

The Fox and the Fleas.

SOME readers of NATURE may be interested in seeing the following passage from one of Liebig's letters to Wöhler, dated Giessen, June 24, 1849, as showing that the story has long been familiar, at least in Germany:—

"Das freiheitsmörderische Gesindel ist nun, wie beim Fuchs die Flöhe in dem Bündel Heu, in einer Schlinge gefangen . . .," &c. WILLIAM A. TILDEN.

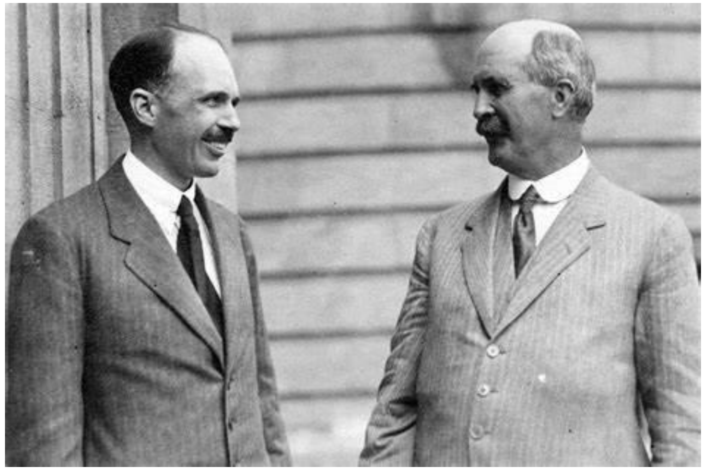
The Oaks, Northwood, Middlesex, July 10.

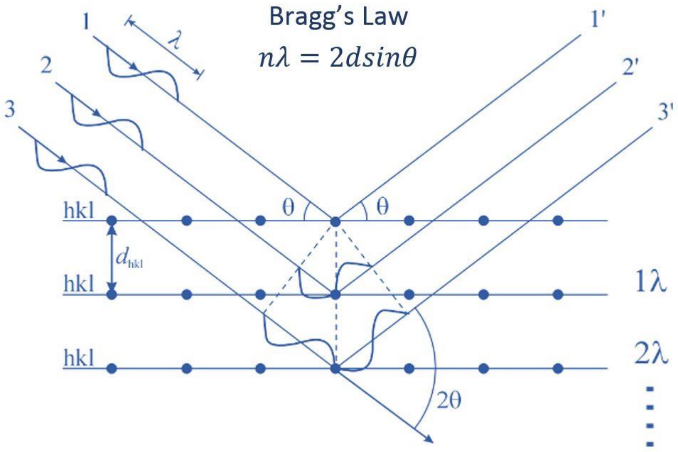
Cabbage White Butterfly.

WOULD some entomologist state if he knows of any reference to the fact that the larvæ of the Large Cabbage White seek to arrange themselves in pairs—male and female—when they pupate?

Can the sexes be distinguished externally in the larval and in the pupal stages? E. W. READ.

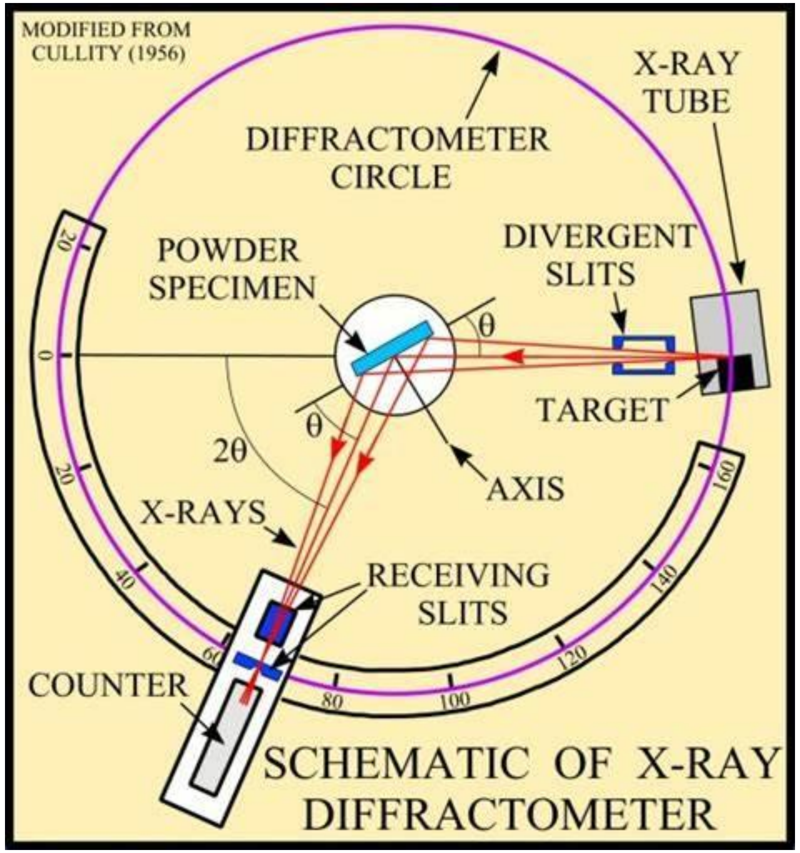
Sutherland Technical School, Golspie.



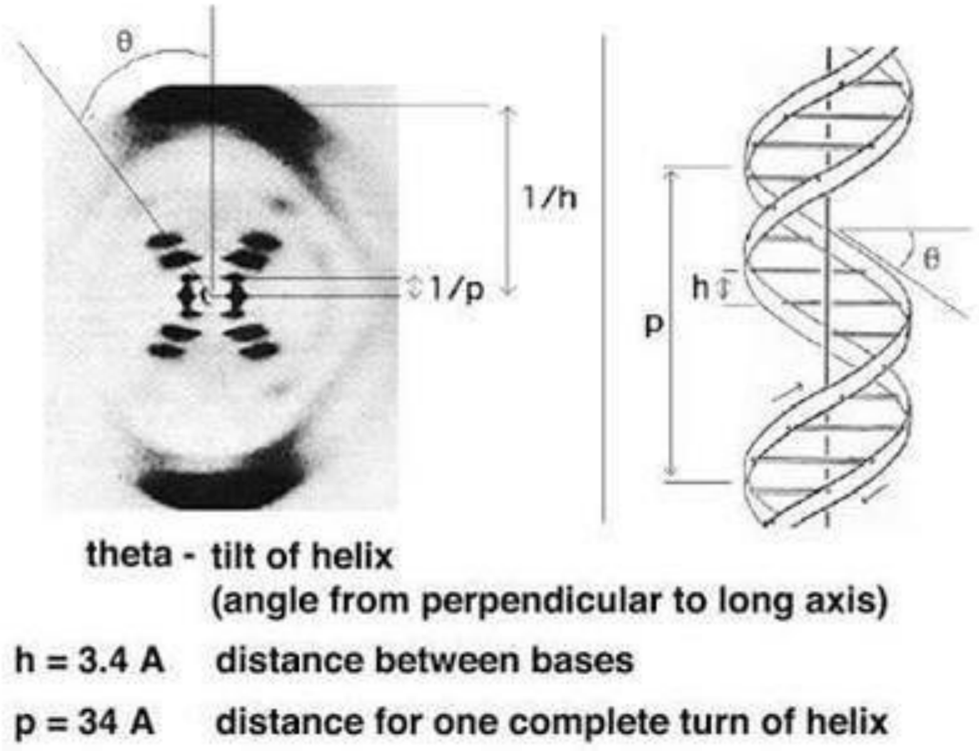


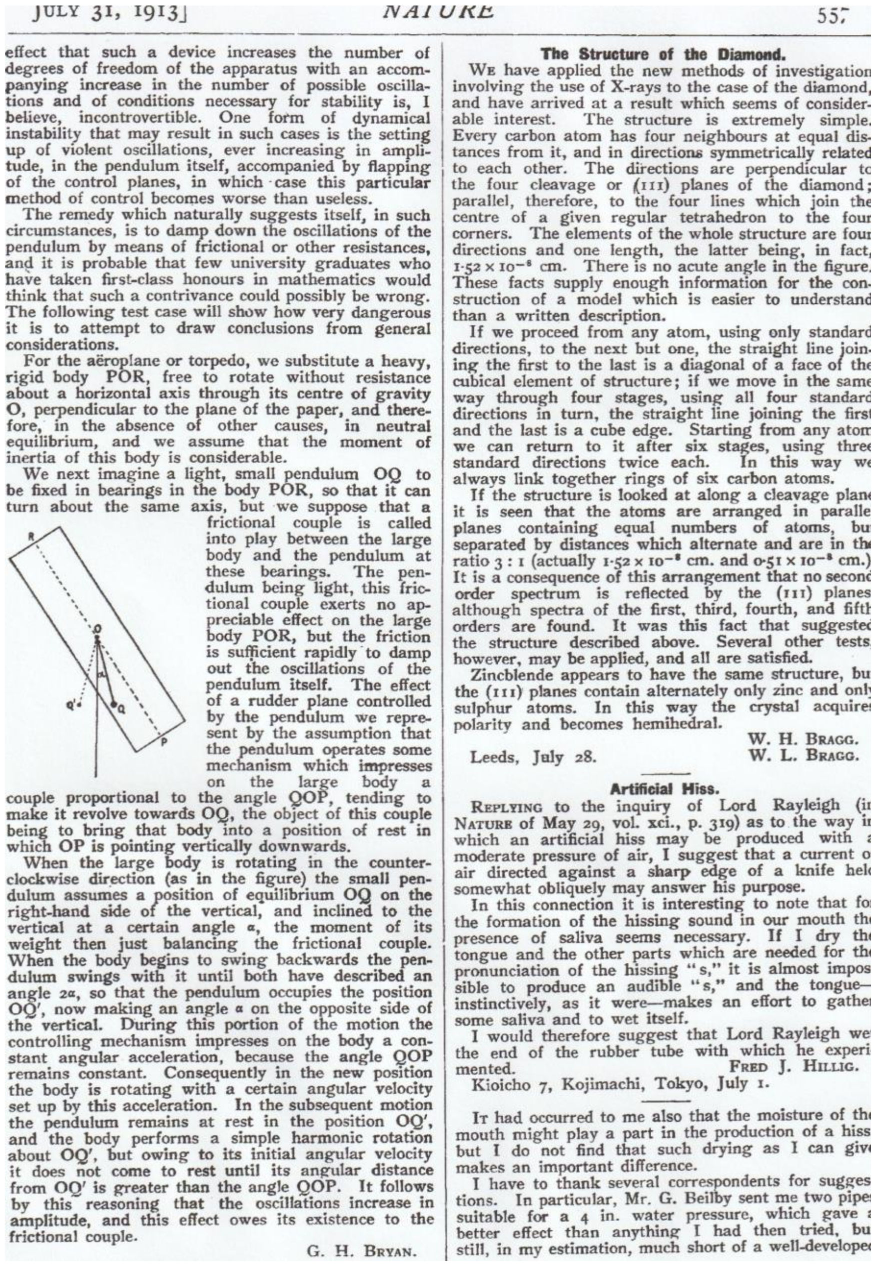
Bragg Snr. & Jnr. X-Ray Crystallography.

Bragg X-Ray Schematic spectrometer.



Diamond Crystal & DNA.





JULY 31, 1913] NATURE 557

effect that such a device increases the number of degrees of freedom of the apparatus with an accompanying increase in the number of possible oscillations and of conditions necessary for stability is, I believe, incontrovertible. One form of dynamical instability that may result in such cases is the setting up of violent oscillations, ever increasing in amplitude, in the pendulum itself, accompanied by flapping of the control planes, in which case this particular method of control becomes worse than useless.

The remedy which naturally suggests itself, in such circumstances, is to damp down the oscillations of the pendulum by means of frictional or other resistances, and it is probable that few university graduates who have taken first-class honours in mathematics would think that such a contrivance could possibly be wrong. The following test case will show how very dangerous it is to attempt to draw conclusions from general considerations.

For the aëroplane or torpedo, we substitute a heavy, rigid body POR, free to rotate without resistance about a horizontal axis through its centre of gravity O, perpendicular to the plane of the paper, and therefore, in the absence of other causes, in neutral equilibrium, and we assume that the moment of inertia of this body is considerable.

We next imagine a light, small pendulum OQ to be fixed in bearings in the body POR, so that it can turn about the same axis, but we suppose that a frictional couple is called into play between the large body and the pendulum at these bearings. The pendulum being light, this frictional couple exerts no appreciable effect on the large body POR, but the friction is sufficient rapidly to damp out the oscillations of the pendulum itself. The effect of a rudder plane controlled by the pendulum we represent by the assumption that the pendulum operates some mechanism which impresses on the large body a couple proportional to the angle QOP, tending to make it revolve towards OQ, the object of this couple being to bring that body into a position of rest in which OP is pointing vertically downwards.

When the large body is rotating in the counterclockwise direction (as in the figure) the small pendulum assumes a position of equilibrium OQ on the right-hand side of the vertical, and inclined to the vertical at a certain angle α, the moment of its weight then just balancing the frictional couple. When the body begins to swing backwards the pendulum swings with it until both have described an angle 2α, so that the pendulum occupies the position OQ′, now making an angle α on the opposite side of the vertical. During this portion of the motion the controlling mechanism impresses on the body a constant angular acceleration, because the angle QOP remains constant. Consequently in the new position the body is rotating with a certain angular velocity set up by this acceleration. In the subsequent motion the pendulum remains at rest in the position OQ′, and the body performs a simple harmonic rotation about OQ′, but owing to its initial angular velocity it does not come to rest until its angular distance from OQ′ is greater than the angle QOP. It follows by this reasoning that the oscillations increase in amplitude, and this effect owes its existence to the frictional couple.

G. H. BRYAN.

The Structure of the Diamond.

WE have applied the new methods of investigation involving the use of X-rays to the case of the diamond, and have arrived at a result which seems of considerable interest. The structure is extremely simple. Every carbon atom has four neighbours at equal distances from it, and in directions symmetrically related to each other. The directions are perpendicular to the four cleavage or (111) planes of the diamond; parallel, therefore, to the four lines which join the centre of a given regular tetrahedron to the four corners. The elements of the whole structure are four directions and one length, the latter being, in fact, $1{\cdot}52 \times 10^{-8}$ cm. There is no acute angle in the figure. These facts supply enough information for the construction of a model which is easier to understand than a written description.

If we proceed from any atom, using only standard directions, to the next but one, the straight line joining the first to the last is a diagonal of a face of the cubical element of structure; if we move in the same way through four stages, using all four standard directions in turn, the straight line joining the first and the last is a cube edge. Starting from any atom we can return to it after six stages, using three standard directions twice each. In this way we always link together rings of six carbon atoms.

If the structure is looked at along a cleavage plane it is seen that the atoms are arranged in parallel planes containing equal numbers of atoms, but separated by distances which alternate and are in the ratio 3 : 1 (actually $1{\cdot}52 \times 10^{-8}$ cm. and $0{\cdot}51 \times 10^{-8}$ cm.). It is a consequence of this arrangement that no second order spectrum is reflected by the (111) planes although spectra of the first, third, fourth, and fifth orders are found. It was this fact that suggested the structure described above. Several other tests, however, may be applied, and all are satisfied.

Zincblende appears to have the same structure, but the (111) planes contain alternately only zinc and only sulphur atoms. In this way the crystal acquires polarity and becomes hemihedral.

W. H. BRAGG.
W. L. BRAGG.

Leeds, July 28.

Artificial Hiss.

REPLYING to the inquiry of Lord Rayleigh (in NATURE of May 29, vol. xci., p. 319) as to the way in which an artificial hiss may be produced with a moderate pressure of air, I suggest that a current of air directed against a sharp edge of a knife held somewhat obliquely may answer his purpose.

In this connection it is interesting to note that for the formation of the hissing sound in our mouth the presence of saliva seems necessary. If I dry the tongue and the other parts which are needed for the pronunciation of the hissing "s," it is almost impossible to produce an audible "s," and the tongue—instinctively, as it were—makes an effort to gather some saliva and to wet itself.

I would therefore suggest that Lord Rayleigh wet the end of the rubber tube with which he experimented.

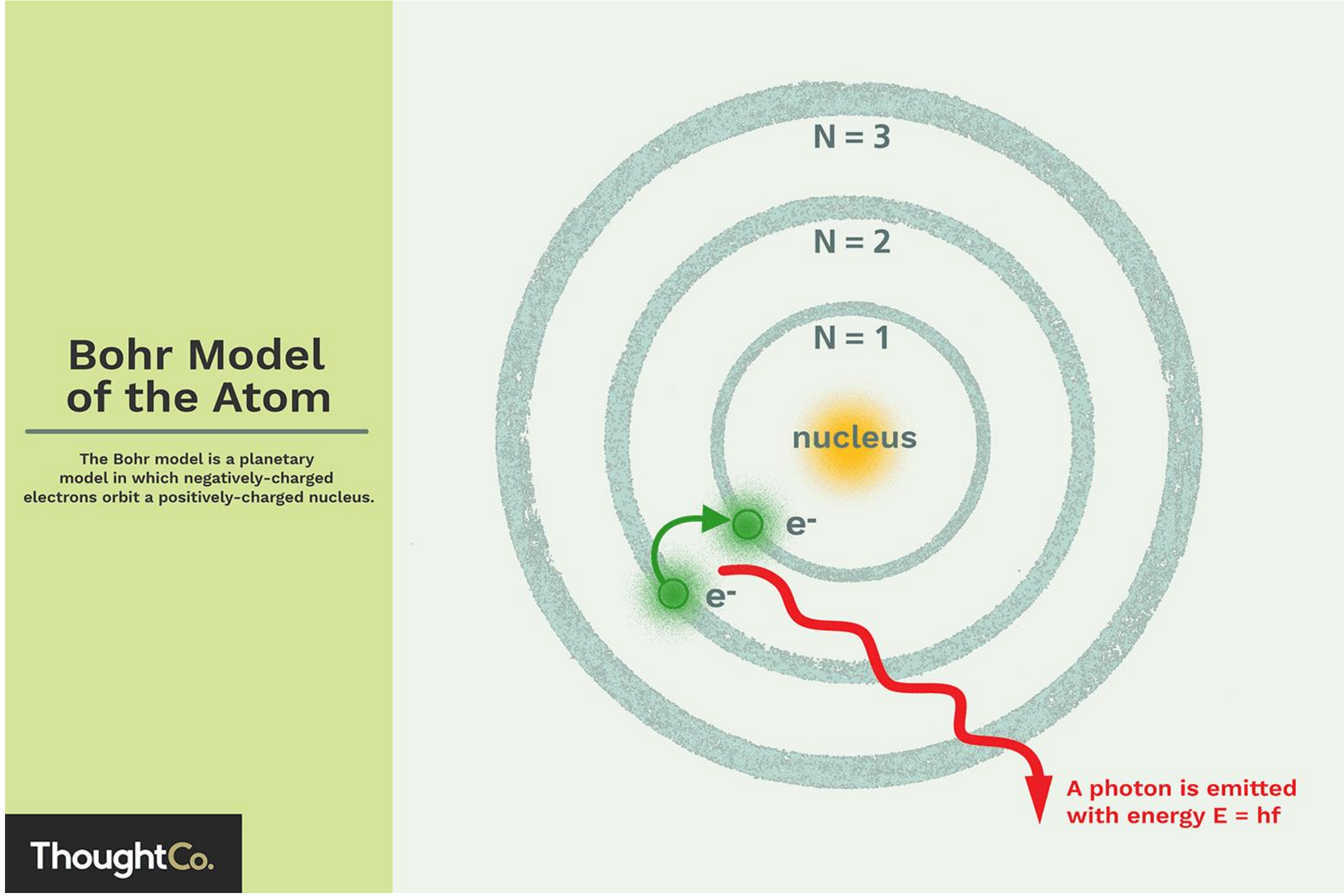
FRED J. HILLIG.

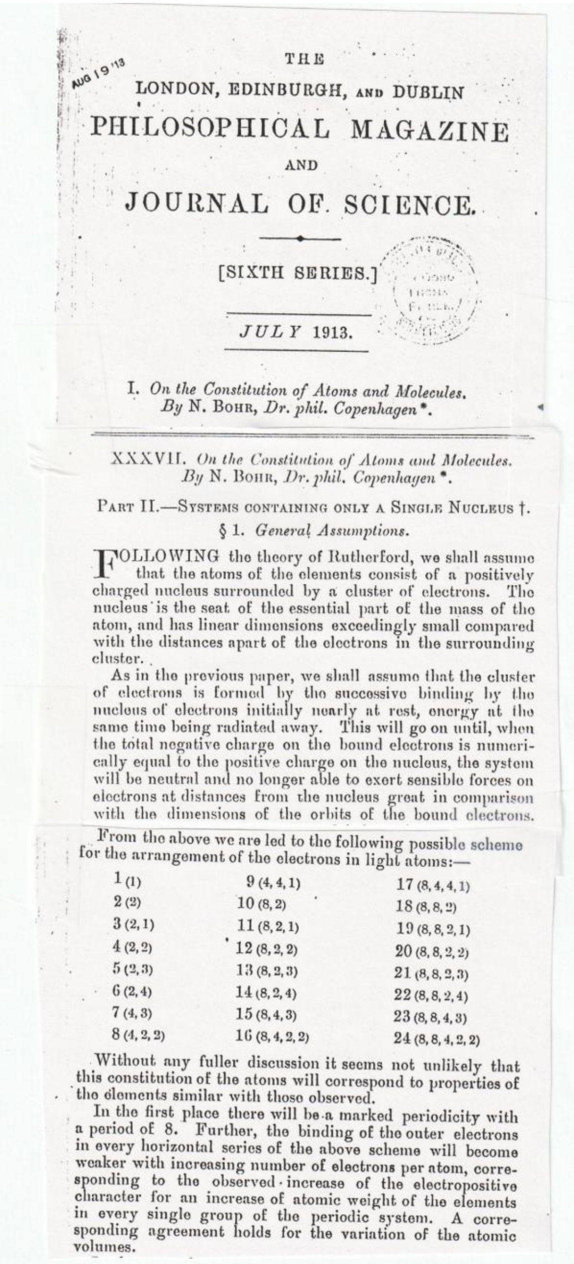
Kioicho 7, Kojimachi, Tokyo, July 1.

IT had occurred to me also that the moisture of the mouth might play a part in the production of a hiss, but I do not find that such drying as I can give makes an important difference.

I have to thank several correspondents for suggestions. In particular, Mr. G. Beilby sent me two pipes suitable for a 4 in. water pressure, which gave a better effect than anything I had then tried, but still, in my estimation, much short of a well-developed

Bohr Electron Shells 1913.





THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[SIXTH SERIES.]

JULY 1913.

I. *On the Constitution of Atoms and Molecules.* By N. BOHR, *Dr. phil. Copenhagen**.

XXXVII. *On the Constitution of Atoms and Molecules.* By N. BOHR, *Dr. phil. Copenhagen**.

PART II.—SYSTEMS CONTAINING ONLY A SINGLE NUCLEUS †.

§ 1. *General Assumptions.*

FOLLOWING the theory of Rutherford, we shall assume that the atoms of the elements consist of a positively charged nucleus surrounded by a cluster of electrons. The nucleus is the seat of the essential part of the mass of the atom, and has linear dimensions exceedingly small compared with the distances apart of the electrons in the surrounding cluster.

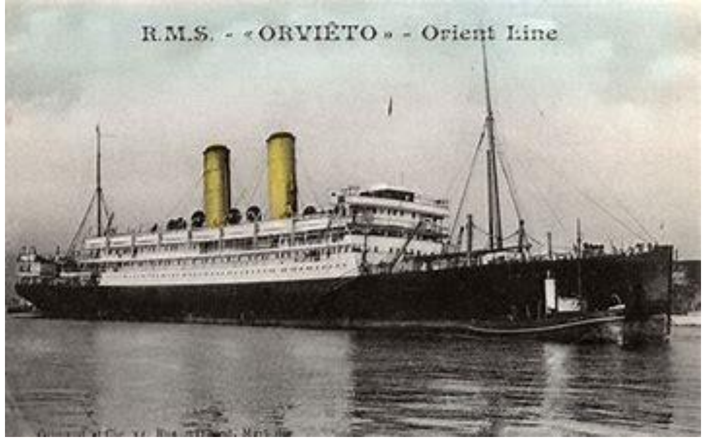
As in the previous paper, we shall assume that the cluster of electrons is formed by the successive binding by the nucleus of electrons initially nearly at rest, energy at the same time being radiated away. This will go on until, when the total negative charge on the bound electrons is numerically equal to the positive charge on the nucleus, the system will be neutral and no longer able to exert sensible forces on electrons at distances from the nucleus great in comparison with the dimensions of the orbits of the bound electrons.

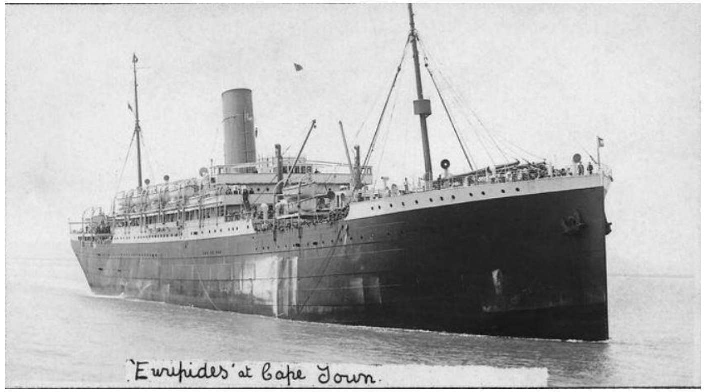
From the above we are led to the following possible scheme for the arrangement of the electrons in light atoms:—

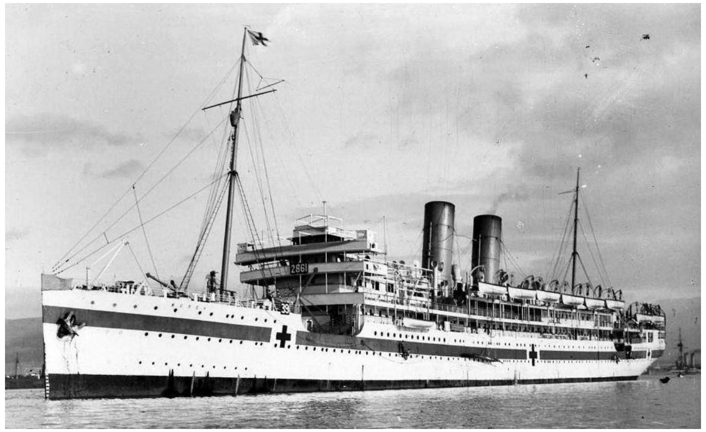
1 (1)	9 (4, 4, 1)	17 (8, 4, 4, 1)
2 (2)	10 (8, 2)	18 (8, 8, 2)
3 (2, 1)	11 (8, 2, 1)	19 (8, 8, 2, 1)
4 (2, 2)	12 (8, 2, 2)	20 (8, 8, 2, 2)
5 (2, 3)	13 (8, 2, 3)	21 (8, 8, 2, 3)
6 (2, 4)	14 (8, 2, 4)	22 (8, 8, 2, 4)
7 (4, 3)	15 (8, 4, 3)	23 (8, 8, 4, 3)
8 (4, 2, 2)	16 (8, 4, 2, 2)	24 (8, 8, 4, 2, 2)

Without any fuller discussion it seems not unlikely that this constitution of the atoms will correspond to properties of the elements similar with those observed.

In the first place there will be a marked periodicity with a period of 8. Further, the binding of the outer electrons in every horizontal series of the above scheme will become weaker with increasing number of electrons per atom, corresponding to the observed increase of the electropositive character for an increase of atomic weight of the elements in every single group of the periodic system. A corresponding agreement holds for the variation of the atomic volumes.

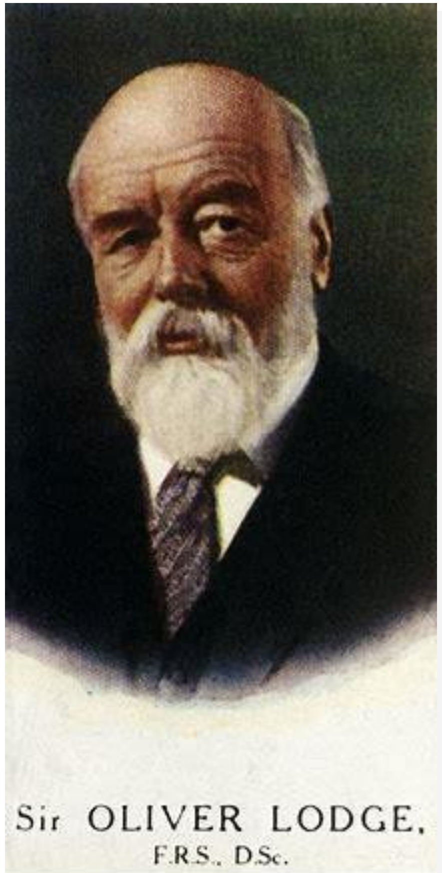


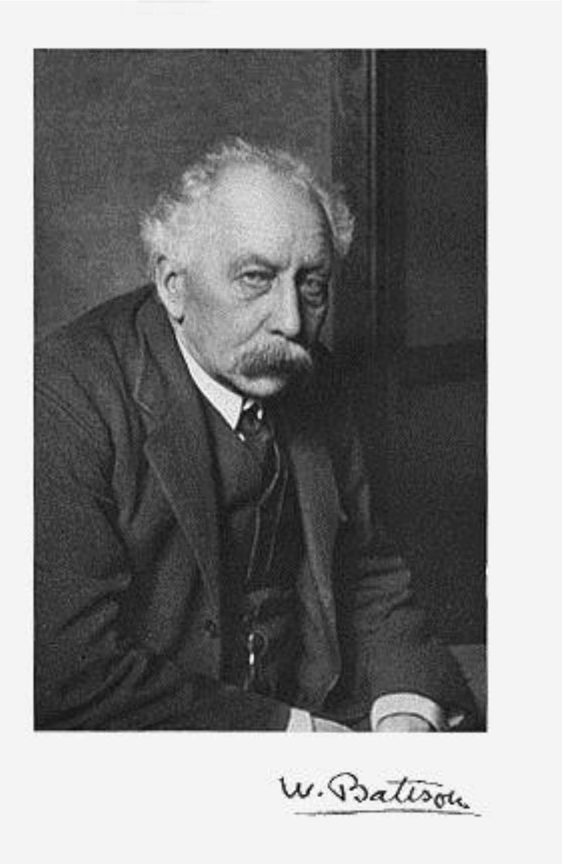


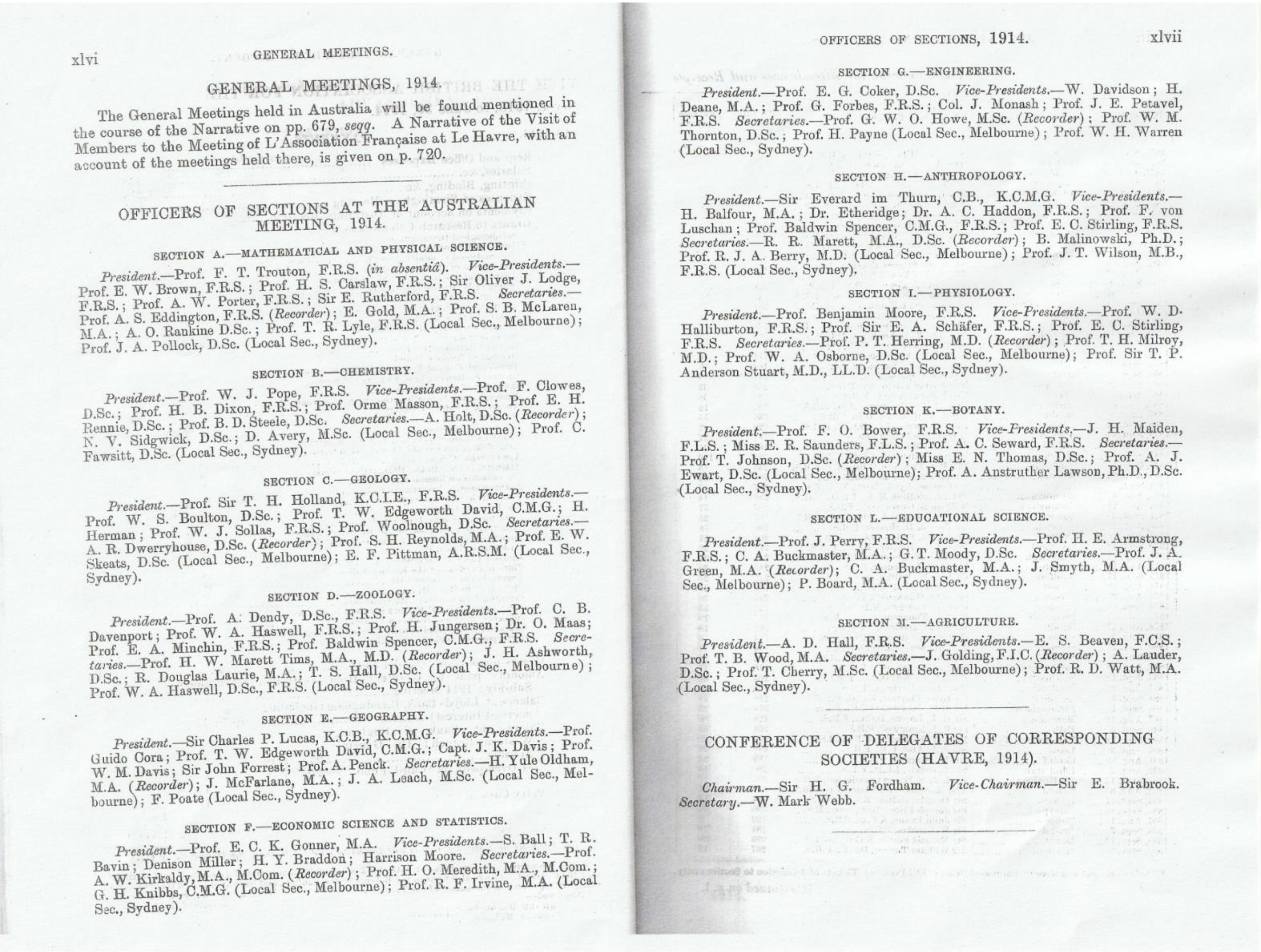


B.A.A.S Australia 1914, by ship from U.K.

B.A.A.S Sections.







xlvi GENERAL MEETINGS.

GENERAL MEETINGS, 1914.

The General Meetings held in Australia will be found mentioned in the course of the Narrative on pp. 679, *seqq.* A Narrative of the Visit of Members to the Meeting of L'Association Française at Le Havre, with an account of the meetings held there, is given on p. 720.

OFFICERS OF SECTIONS AT THE AUSTRALIAN MEETING, 1914.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President.—Prof. F. T. Trouton, F.R.S. (*in absentiâ*). *Vice-Presidents.*—Prof. E. W. Brown, F.R.S.; Prof. H. S. Carslaw, F.R.S.; Sir Oliver J. Lodge, F.R.S.; Prof. A. W. Porter, F.R.S.; Sir E. Rutherford, F.R.S. *Secretaries.*—Prof. A. S. Eddington, F.R.S. (*Recorder*); E. Gold, M.A.; Prof. S. B. McLaren, M.A.; A. O. Rankine D.Sc.; Prof. T. R. Lyle, F.R.S. (Local Sec., Melbourne); Prof. J. A. Pollock, D.Sc. (Local Sec., Sydney).

SECTION B.—CHEMISTRY.

President.—Prof. W. J. Pope, F.R.S. *Vice-Presidents.*—Prof. F. Clowes, D.Sc.; Prof. H. B. Dixon, F.R.S.; Prof. Orme Masson, F.R.S.; Prof. E. H. Rennie, D.Sc.; Prof. B. D. Steele, D.Sc. *Secretaries.*—A. Holt, D.Sc. (*Recorder*); N. V. Sidgwick, D.Sc.; D. Avery, M.Sc. (Local Sec., Melbourne); Prof. C. Fawsitt, D.Sc. (Local Sec., Sydney).

SECTION C.—GEOLOGY.

President.—Prof. Sir T. H. Holland, K.C.I.E., F.R.S. *Vice-Presidents.*—Prof. W. S. Boulton, D.Sc.; Prof. T. W. Edgeworth David, C.M.G.; H. Herman; Prof. W. J. Sollas, F.R.S.; Prof. Woolnough, D.Sc. *Secretaries.*—A. R. Dwerryhouse, D.Sc. (*Recorder*); Prof. S. H. Reynolds, M.A.; Prof. E. W. Skeats, D.Sc. (Local Sec., Melbourne); E. F. Pittman, A.R.S.M. (Local Sec., Sydney).

SECTION D.—ZOOLOGY.

President.—Prof. A. Dendy, D.Sc., F.R.S. *Vice-Presidents.*—Prof. C. B. Davenport; Prof. W. A. Haswell, F.R.S.; Prof. H. Jungersen; Dr. O. Maas; Prof. E. A. Minchin, F.R.S.; Prof. Baldwin Spencer, C.M.G., F.R.S. *Secretaries.*—Prof. H. W. Marett Tims, M.A., M.D. (*Recorder*); J. H. Ashworth, D.Sc.; R. Douglas Laurie, M.A.; T. S. Hall, D.Sc. (Local Sec., Melbourne); Prof. W. A. Haswell, D.Sc., F.R.S. (Local Sec., Sydney).

SECTION E.—GEOGRAPHY.

President.—Sir Charles P. Lucas, K.C.B., K.C.M.G. *Vice-Presidents.*—Prof. Guido Cora; Prof. T. W. Edgeworth David, C.M.G.; Capt. J. K. Davis; Prof. W. M. Davis; Sir John Forrest; Prof. A. Penck. *Secretaries.*—H. Yule Oldham, M.A. (*Recorder*); J. McFarlane, M.A.; J. A. Leach, M.Sc. (Local Sec., Melbourne); F. Poate (Local Sec., Sydney).

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President.—Prof. E. C. K. Gonner, M.A. *Vice-Presidents.*—S. Ball; T. R. Bavin; Denison Miller; H. Y. Braddon; Harrison Moore. *Secretaries.*—Prof. A. W. Kirkaldy, M.A., M.Com. (*Recorder*); Prof. H. O. Meredith, M.A., M.Com.; G. H. Knibbs, C.M.G. (Local Sec., Melbourne); Prof. R. F. Irvine, M.A. (Local Sec., Sydney).

OFFICERS OF SECTIONS, 1914. xlvii

SECTION G.—ENGINEERING.

President.—Prof. E. G. Coker, D.Sc. *Vice-Presidents.*—W. Davidson; H. Deane, M.A.; Prof. G. Forbes, F.R.S.; Col. J. Monash; Prof. J. E. Petavel, F.R.S. *Secretaries.*—Prof. G. W. O. Howe, M.Sc. (*Recorder*); Prof. W. M. Thornton, D.Sc.; Prof. H. Payne (Local Sec., Melbourne); Prof. W. H. Warren (Local Sec., Sydney).

SECTION H.—ANTHROPOLOGY.

President.—Sir Everard im Thurn, C.B., K.C.M.G. *Vice-Presidents.*—H. Balfour, M.A.; Dr. Etheridge; Dr. A. C. Haddon, F.R.S.; Prof. F. von Luschan; Prof. Baldwin Spencer, C.M.G., F.R.S.; Prof. E. C. Stirling, F.R.S. *Secretaries.*—R. R. Marett, M.A., D.Sc. (*Recorder*); B. Malinowski, Ph.D.; Prof. R. J. A. Berry, M.D. (Local Sec., Melbourne); Prof. J. T. Wilson, M.B., F.R.S. (Local Sec., Sydney).

SECTION I.—PHYSIOLOGY.

President.—Prof. Benjamin Moore, F.R.S. *Vice-Presidents.*—Prof. W. D. Halliburton, F.R.S.; Prof. Sir E. A. Schäfer, F.R.S.; Prof. E. C. Stirling, F.R.S. *Secretaries.*—Prof. P. T. Herring, M.D. (*Recorder*); Prof. T. H. Milroy, M.D.; Prof. W. A. Osborne, D.Sc. (Local Sec., Melbourne); Prof. Sir T. P. Anderson Stuart, M.D., LL.D. (Local Sec., Sydney).

SECTION K.—BOTANY.

President.—Prof. F. O. Bower, F.R.S. *Vice-Presidents.*—J. H. Maiden, F.L.S.; Miss E. R. Saunders, F.L.S.; Prof. A. C. Seward, F.R.S. *Secretaries.*—Prof. T. Johnson, D.Sc. (*Recorder*); Miss E. N. Thomas, D.Sc.; Prof. A. J. Ewart, D.Sc. (Local Sec., Melbourne); Prof. A. Anstruther Lawson, Ph.D., D.Sc. (Local Sec., Sydney).

SECTION L.—EDUCATIONAL SCIENCE.

President.—Prof. J. Perry, F.R.S. *Vice-Presidents.*—Prof. H. E. Armstrong, F.R.S.; C. A. Buckmaster, M.A.; G. T. Moody, D.Sc. *Secretaries.*—Prof. J. A. Green, M.A. (*Recorder*); C. A. Buckmaster, M.A.; J. Smyth, M.A. (Local Sec., Melbourne); P. Board, M.A. (Local Sec., Sydney).

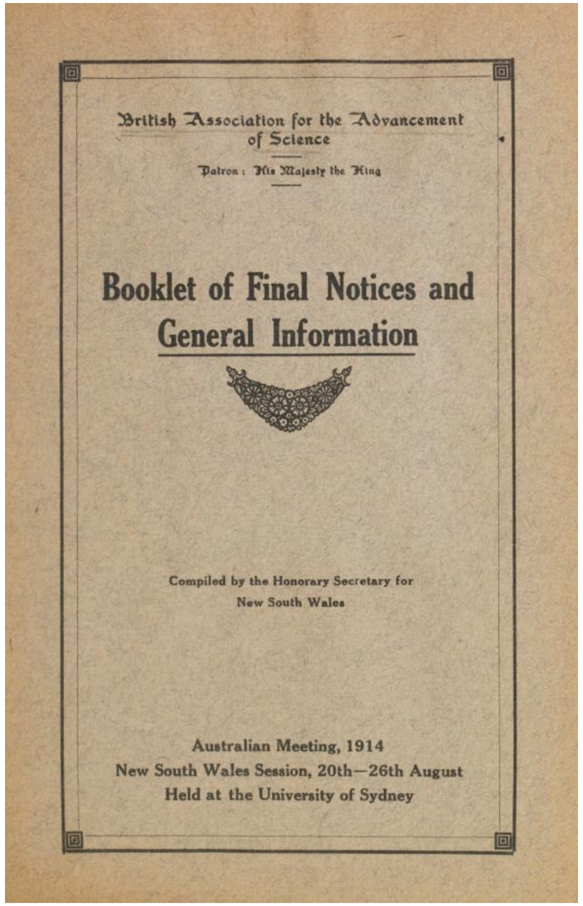
SECTION M.—AGRICULTURE.

President.—A. D. Hall, F.R.S. *Vice-Presidents.*—E. S. Beaven, F.C.S.; Prof. T. B. Wood, M.A. *Secretaries.*—J. Golding, F.I.C. (*Recorder*); A. Lauder, D.Sc.; Prof. T. Cherry, M.Sc. (Local Sec., Melbourne); Prof. R. D. Watt, M.A. (Local Sec., Sydney).

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES (HAVRE, 1914).

Chairman.—Sir H. G. Fordham. *Vice-Chairman.*—Sir E. Brabrook. *Secretary.*—W. Mark Webb.

J.P.V.M June 1914, Electrical Association.



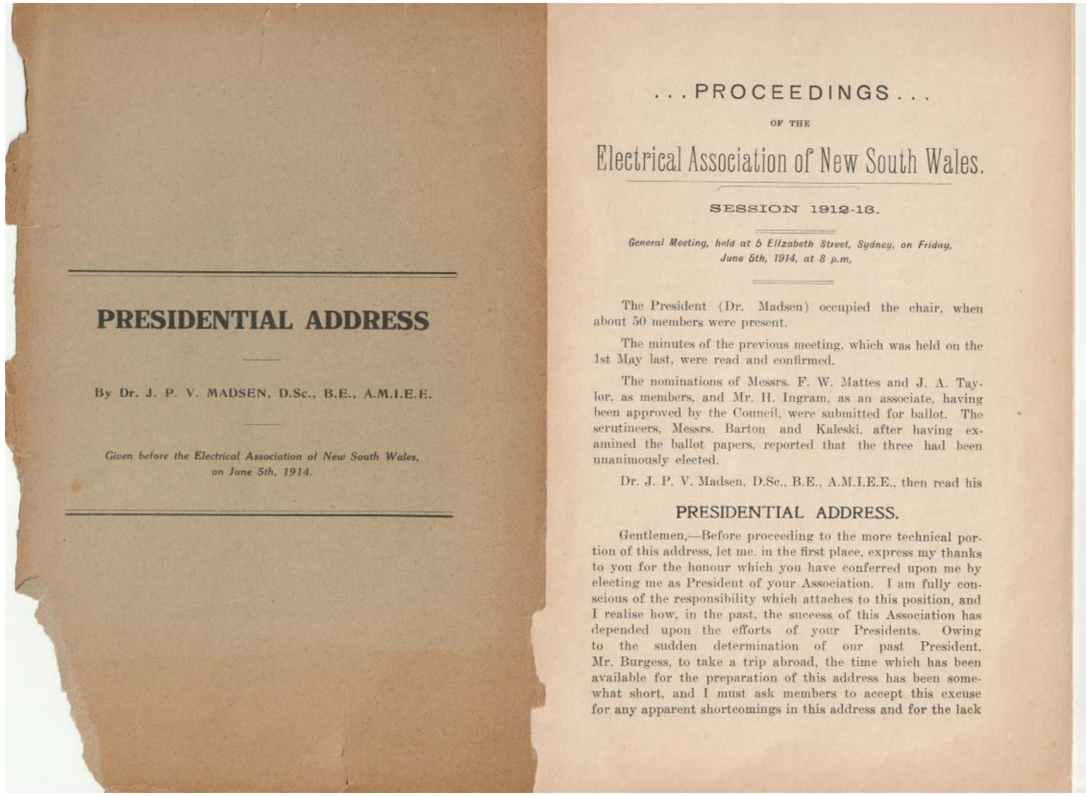
British Association for the Advancement of Science

Patron: His Majesty the King

Booklet of Final Notices and General Information

Compiled by the Honorary Secretary for New South Wales

Australian Meeting, 1914
New South Wales Session, 20th—26th August
Held at the University of Sydney



PRESIDENTIAL ADDRESS

By Dr. J. P. V. MADSEN, D.Sc., B.E., A.M.I.E.E.

Given before the Electrical Association of New South Wales, on June 5th, 1914.

...PROCEEDINGS...

OF THE

Electrical Association of New South Wales.

SESSION 1912-13.

General Meeting, held at 5 Elizabeth Street, Sydney, on Friday, June 5th, 1914, at 8 p.m,

The President (Dr. Madsen) occupied the chair, when about 50 members were present.

The minutes of the previous meeting, which was held on the 1st May last, were read and confirmed.

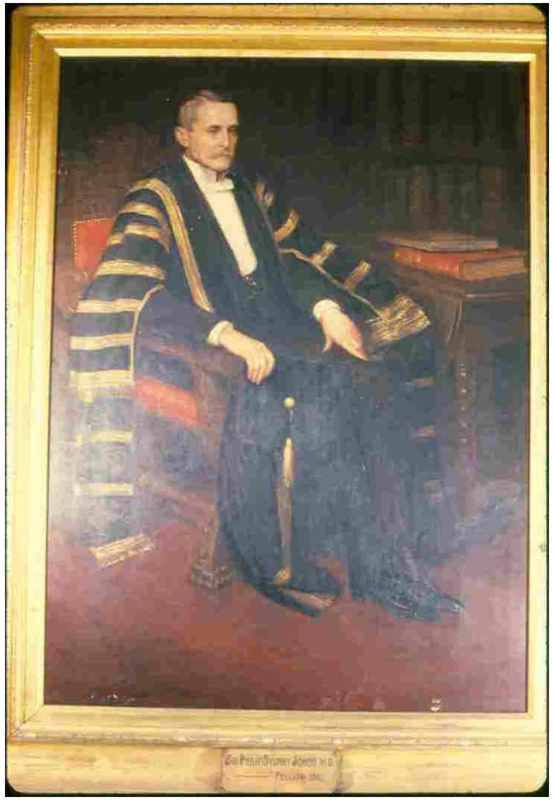
The nominations of Messrs. F. W. Mattes and J. A. Taylor, as members, and Mr. H. Ingram, as an associate, having been approved by the Council, were submitted for ballot. The scrutineers, Messrs. Barton and Kaleski, after having examined the ballot papers, reported that the three had been unanimously elected.

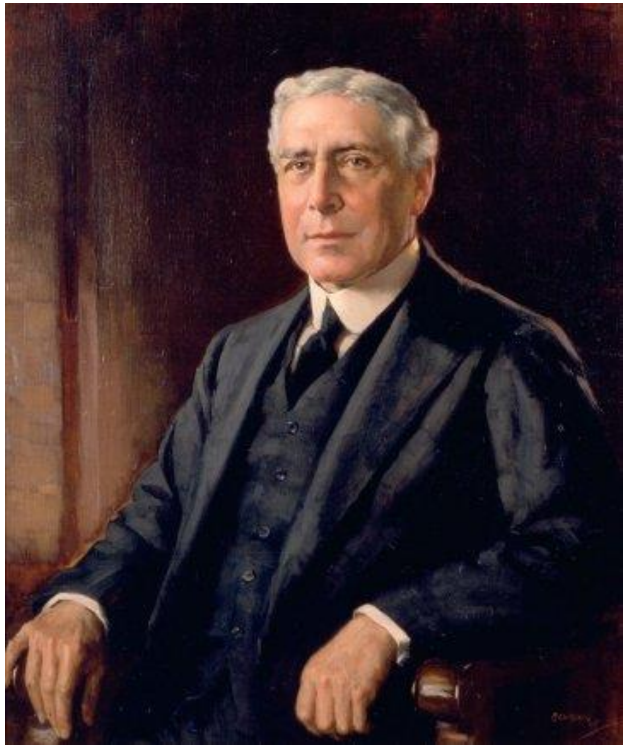
Dr. J. P. V. Madsen, D.Sc., B.E., A.M.I.E.E., then read his

PRESIDENTIAL ADDRESS.

Gentlemen,—Before proceeding to the more technical portion of this address, let me, in the first place, express my thanks to you for the honour which you have conferred upon me by electing me as President of your Association. I am fully conscious of the responsibility which attaches to this position, and I realise how, in the past, the success of this Association has depended upon the efforts of your Presidents. Owing to the sudden determination of our past President, Mr. Burgess, to take a trip abroad, the time which has been available for the preparation of this address has been somewhat short, and I must ask members to accept this excuse for any apparent shortcomings in this address and for the lack

Sydney local members.

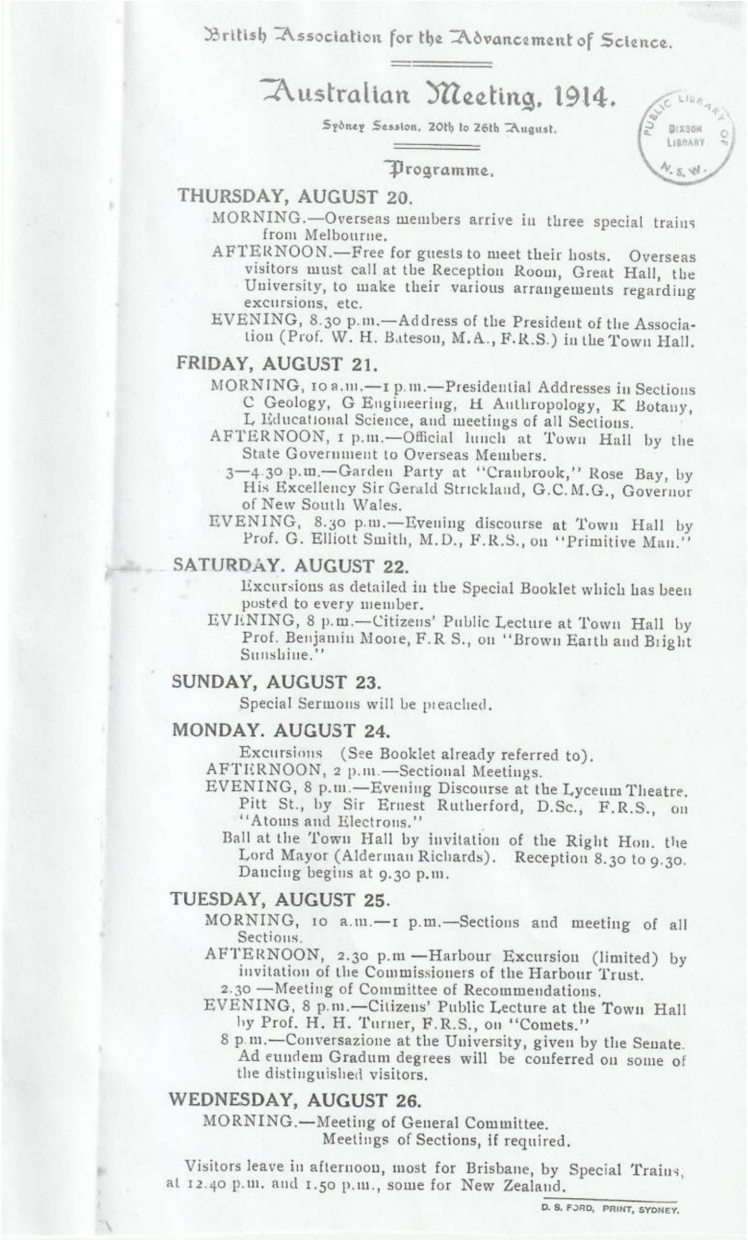




MacCallum, Mrs. M. L. Hakgala, Wolseley-road, Point Piper.
McCarthy, Miss M. Leinster Hall, City-road, Darlington.
McClelland, Dr. W. C. 1 Erskineville-road, Newtown.
McCook, L. Wandabyne, Goldsbury-street, Mosman.
MacCormick, Sir Alexander, M.D., F.R.C.S. 185 Macquarie-street.
McCoy, A. J. Public School, Orange.
McCredie, Miss. Commercial Bank-chambers, George-street.
McCredie, Arthur L. Commercial Bank-chambers, George-street.
McCredie, Miss J. Lawes-street, East Maitland, N.S.W.
McCrory, John, B.A. 78 Thornley-street, Leichhardt.
MacCulloch, Dr. S. H. 24 College-street.
MacCulloch, Mrs. S. H. 24 College-street.
MacCulloch, Miss. 24 College-street.
McCurtin, Very Rev. Father, S.J. Saint Aloysius' College, Pitt-street, Milson's Point.
Macdonald, Miss Louisa, M.A. Principal, Women's College, Newtown.
McDonald, Robert. Lowlands, Double Bay.
McDonall, J. 345 Harris-street, Pyrmont.
McDonnough, Thomas. Elsmore, Evans-street, Waverley.
McDouall, H. C., M.R.C.S., L.R.C.P. Gladesville Hospital, Gladesville.
Mace, Mrs. W. Dene-place, Burlington-road, Homebush.
McEwan, Miss Isabella. District School, Tamworth.
McGrath, D. A. 42 Johnstone-street, Annandale.
MacGregor, Donald Neil, B.A. Newington College, Stanmore.
Machin, J. 20 Quinton-road, Manly.
McIlwraith, H. M. Yass Mechanics' School, Yass.
Macintyre, Professor R. G., M.A., B.D. Cruachan, Bellevue Hill.
McKay, Miss. Onslow-avenue, Elizabeth Bay.
McKay, Miss Frances. William-street, Granville.
Mackay, John. Malahide, Elamang-avenue, Kirribilli Point.
Mackay, Mrs. John. Malahide, Elamang-avenue, Kirribilli Point.
McKay, Miss M. Wycombe-road, Neutral Bay.
McKay, Dr. Stewart. Onslow-avenue, Elizabeth Bay.
McKean, R. Public School, Curlewis.
§McKee, Dr. E. S. Sinton-street, Cincinnati, Ohio, U.S.A.
Mackellar, Sir Chas. K., M.D., M.L.C. 183 Liverpool-street.
Mackellar, Miss D. 183 Liverpool-street, Hyde Park.
Mackenzie, Geo., Ph.D. Morillah, Woolwich-road, Hunter's Hill.
McKelvey, John L., M.B., Ch.M. 171 Macquarie-street.
McKelvey, Mrs. J. L. 171 Macquarie-street.
Mackenzie, H. V. Barregowa, Belmore-road, Arncliffe.
Mackenzie, Mrs. H. V. Barregowa, Belmore-road, Arncliffe.
Mackey, Donald. 89 Pitt-street.
Mackey, E. C. Livingstone-road, Marrickville.
Mackey, Mrs. May. 89 Pitt-street.
McKibbin, Miss Rachel. Koonawarra, Gordon-road, Roseville.
Mackie, Professor Alexr., M.A. University.
Mackie, Mrs. A. University.
McKinney, H. G. Sydney Safe Depot, Paling's-buildings, Ash-street.
MacKinnon, Dr. 509 Alfred-street, North Sydney.
MacKinnon, Mrs. 509 Alfred-street, North Sydney.
Mackinnon, Ewen, B.Sc. Department of Agriculture, Agricultural Museum, George-street North.
MacKinnon, J. T. 37 Morris-street, Summer Hill.
MacKinnon, M. 21 Redan-street, Mosman.
McLachlan, A. Newcastle.
McLachlan, Miss K. The University.
McLaren, Miss P. Hurst-street, Arncliffe.
MacLauren, Dr. C. 155 Macquarie-street.
MacLaurin, Hon. Sir Normand, M.D., LL.D., M.L.C. 155 Macquarie-street.
McLelland, H. D. Department of Public Instruction.
McLeod, Mrs. William. Dunvegan, Musgrave-street, Mosman.

McMahon, Miss A. 140 Redfern-street, Redfern.
McMaster, C. J., J.P. Crona, Point Piper, Edgecliff.
McMillan, Miss J. Braeside, Forth-street, Woollahra.
McMillan, Sir Wm., K.C.M.G. Braeside, Forth-street, Woollahra.
McMillan, Lady. Braeside, Forth-street, Woollahra.
McMullen, F. Hurlstone Agricultural High School, Ashfield.
McMullen, R. V. Prov. School, Stratheden, via Casino.
McMullen, W. H. Prov. School, Busby's Flat, via Rappville.
McMurray, Dr. Wm. Wyoming, Macquarie-street.
McMurray, Mrs. Wyoming, Macquarie-street.
McNiven, Ronald J. High School, Newcastle.
MacPherson, Dr. John. Wyoming, 175 Macquarie-street.
Macpherson, Mrs. Helen Fyfe. 17 Toxteth-road, Glebe Point.
McQuiggin, H. C., B.A. 73 Stanmore-road.
Maddock, E. A., J.P. 88 Pitt-street.
Madsen, Dr. J. V. The University.
Madsen, Mrs. Victoria-street, Roseville.
Maher, Dr. W. Odillo. 185 Macquarie-street.
Maiden, Miss. Botanic Gardens.
Maiden, J. H., F.L.S., J.P. Botanic Gardens.
Maiden, Mrs. J. H. Botanic Gardens.
Maiden, Miss Nellie. Botanic Gardens.
Maitland, Dr. H. L., J.P. 147 Macquarie-street.
Major, H. S. Department of Agriculture.
Makinson, Miss M. 41 High-street, Newcastle, N.S.W.
Mallarky, Miss Esme. Frome, Shirley-road, Wollstonecraft.
Mallarky, Miss Ethel. Frome, Shirley-road, Wollstonecraft.
Marden, Dr. John. Presbyterian College, Croydon.
Mannell, F. W., Inspector of Schools, Wellington, New Zealand.
Marks, Miss Hilda. Cliff Lodge, Victoria-street, North Sydney.
Marks, Miss L. Léontine, Bertha Villa, 39 Queen-street, Ashfield.
Marks, Percy J. City Mutual-chambers, 62 Hunter-street.
Marr, Mrs. H. F. Newnham, Liberty-street, Stanmore.
Marshall, Dr. F. 235 Macquarie-street.
Marshall, Dr. W. Hamilton. Ni-no-van, Wanulla-road, Woollahra Point.
Marshall, Mrs. Hamilton. Ni-no-van, Wunulla-road, Woollahra Point.
Marshall, Miss. Ni-no-van, Wunulla-road, Woollahra Point.
Marshall, T. Tallangatta, Wyagdon-street, North Sydney.
Marshall, Mrs. T. Tallangatta, Wyagdon-street, North Sydney.
Marston, Miss. Infants' Home, Henry-street, Ashfield.
Martin, A. H. Devonport, 28 Union-street, North Sydney.
Martin, Mrs. A. H. 28 Union-street, North Sydney.
Martin, Miss C. Thorn Farm, Ryde.
Mason, W. H. Sydney Technical College, Harris-street, Ultimo.
Mathers, L. M. Melrose, Lennox-street, Mosman.
Mathers, R. M. Melrose, Lennox-street, Mosman.
Mathers, Thos. Melrose, Lennox-street, Mosman.
Mathews, R. H. Hassall-street, Parramatta.
Mathison, Rev. H., B.A. Runnimede, Grosvenor-street, Croydon.
Maughan, D. Nyrangie, Fullerton-street, Woollahra.
Maughan, Mrs. Jean Alice. Nyrangie, Fullerton-street, Woollahra.
Maw, Dr. H. S. Tumbarumba, N.S.W.
Mawson, Mrs. J. L. O. Mulwaree, Cordeaux-street, Campbelltown.
Mawson, Dr. W. Mulwaree, Cordeaux-street, Campbelltown.
Maxwell, Aymer. Myrnong, 23 Mona-road, Darling Point.
Maxwell, Mrs. E. C. Myrnong, 23 Mona-road, Darling Point.
May, J. Trades School, Wollongong, N.S.W.
Mayman, Neville, President of the Benevolent Society of New South Wales, Thomas-street.
Meeks, Hon. A. W., M.L.C. Oranui, Darling Point.
Meggitt, Loxley. Hillside, Tintern-road, Ashfield.
Meldrum, H. J., B.A. Teachers' College, Blackfriars.

Sydney Programme.



British Association for the Advancement of Science.

Australian Meeting, 1914.

Sydney Session. 20th to 26th August.

Programme.

THURSDAY, AUGUST 20.

MORNING.—Overseas members arrive in three special trains from Melbourne.

AFTERNOON.—Free for guests to meet their hosts. Overseas visitors must call at the Reception Room, Great Hall, the University, to make their various arrangements regarding excursions, etc.

EVENING, 8.30 p.m.—Address of the President of the Association (Prof. W. H. Bateson, M.A., F.R.S.) in the Town Hall.

FRIDAY, AUGUST 21.

MORNING, 10 a.m.—1 p.m.—Presidential Addresses in Sections C Geology, G Engineering, H Anthropology, K Botany, L Educational Science, and meetings of all Sections.

AFTERNOON, 1 p.m.—Official lunch at Town Hall by the State Government to Overseas Members.

3—4.30 p.m.—Garden Party at "Cranbrook," Rose Bay, by His Excellency Sir Gerald Strickland, G.C.M.G., Governor of New South Wales.

EVENING, 8.30 p.m.—Evening discourse at Town Hall by Prof. G. Elliott Smith, M.D., F.R.S., on "Primitive Man."

SATURDAY. AUGUST 22.

Excursions as detailed in the Special Booklet which has been posted to every member.

EVENING, 8 p.m.—Citizens' Public Lecture at Town Hall by Prof. Benjamin Moore, F.R.S., on "Brown Earth and Bright Sunshine."

SUNDAY, AUGUST 23.

Special Sermons will be preached.

MONDAY. AUGUST 24.

Excursions (See Booklet already referred to).

AFTERNOON, 2 p.m.—Sectional Meetings.

EVENING, 8 p.m.—Evening Discourse at the Lyceum Theatre. Pitt St., by Sir Ernest Rutherford, D.Sc., F.R.S., on "Atoms and Electrons."

Ball at the Town Hall by invitation of the Right Hon. the Lord Mayor (Alderman Richards). Reception 8.30 to 9.30. Dancing begins at 9.30 p.m.

TUESDAY, AUGUST 25.

MORNING, 10 a.m.—1 p.m.—Sections and meeting of all Sections.

AFTERNOON, 2.30 p.m—Harbour Excursion (limited) by invitation of the Commissioners of the Harbour Trust.

2.30 —Meeting of Committee of Recommendations.

EVENING, 8 p.m.—Citizens' Public Lecture at the Town Hall by Prof. H. H. Turner, F.R.S., on "Comets."

8 p.m.—Conversazione at the University, given by the Senate. Ad eundem Gradum degrees will be conferred on some of the distinguished visitors.

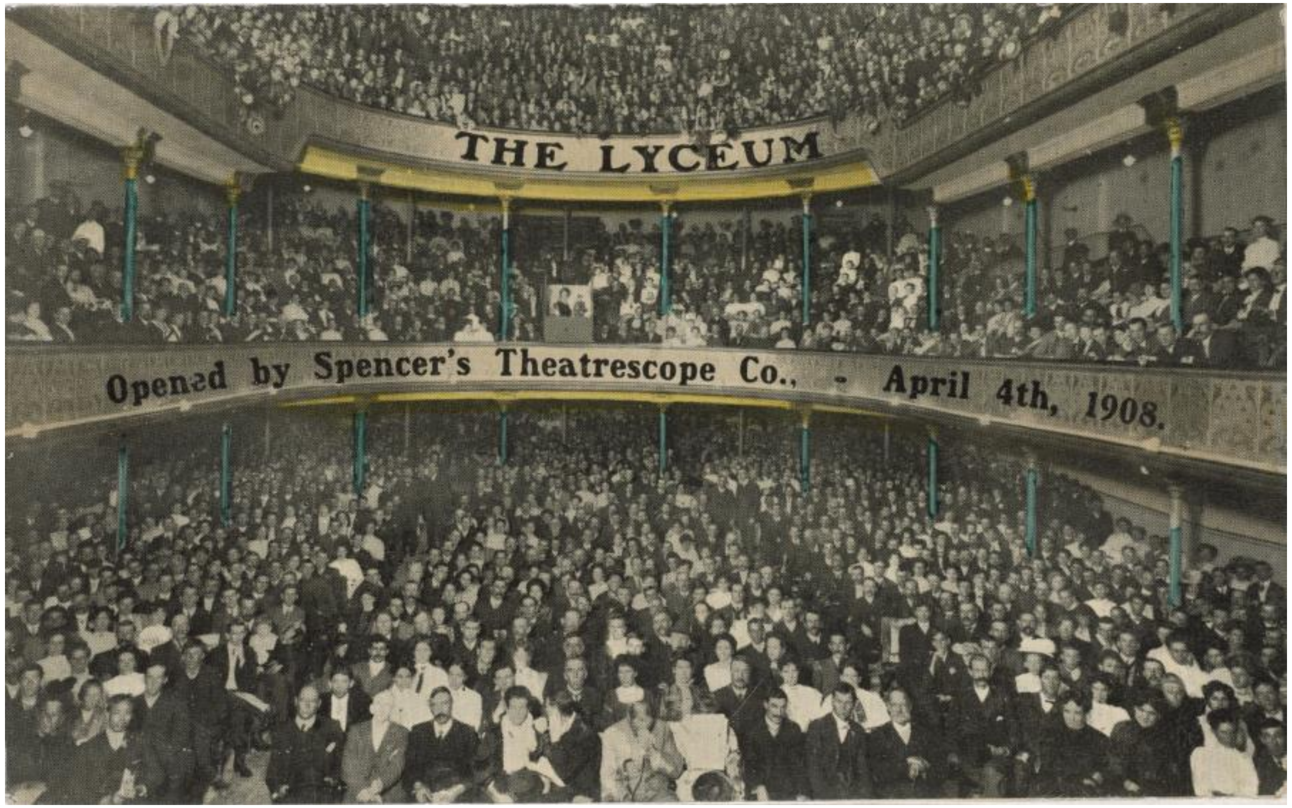
WEDNESDAY, AUGUST 26.

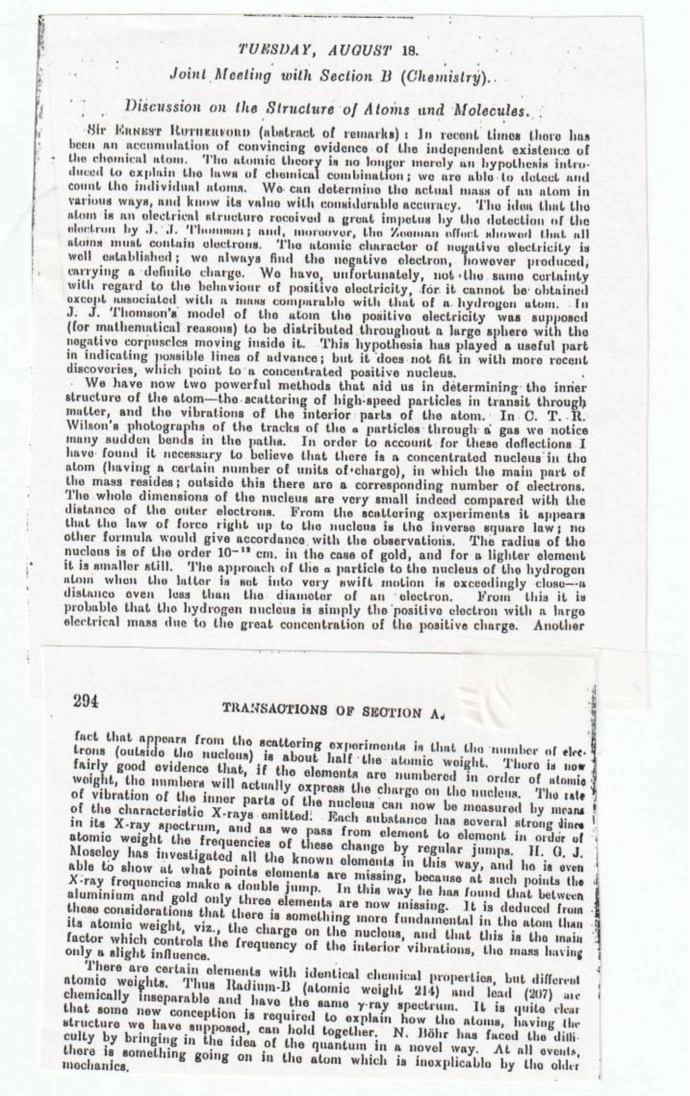
MORNING.—Meeting of General Committee.
Meetings of Sections, if required.

Visitors leave in afternoon, most for Brisbane, by Special Trains, at 12.40 p.m. and 1.50 p.m., some for New Zealand.

D. S. FORD, PRINT, SYDNEY.

Rutherford Talk at Lyceum Theatre on Atoms & Electrons.





TUESDAY, AUGUST 18.

Joint Meeting with Section B (Chemistry).

Discussion on the Structure of Atoms and Molecules.

Sir Ernest Rutherford (abstract of remarks): In recent times there has been an accumulation of convincing evidence of the independent existence of the chemical atom. The atomic theory is no longer merely an hypothesis introduced to explain the laws of chemical combination; we are able to detect and count the individual atoms. We can determine the actual mass of an atom in various ways, and know its value with considerable accuracy. The idea that the atom is an electrical structure received a great impetus by the detection of the electron by J. J. Thomson; and, moreover, the Zeeman effect showed that all atoms must contain electrons. The atomic character of negative electricity is well established; we always find the negative electron, however produced, carrying a definite charge. We have, unfortunately, not the same certainty with regard to the behaviour of positive electricity, for it cannot be obtained except associated with a mass comparable with that of a hydrogen atom. In J. J. Thomson's model of the atom the positive electricity was supposed (for mathematical reasons) to be distributed throughout a large sphere with the negative corpuscles moving inside it. This hypothesis has played a useful part in indicating possible lines of advance; but it does not fit in with more recent discoveries, which point to a concentrated positive nucleus.

We have now two powerful methods that aid us in determining the inner structure of the atom—the scattering of high-speed particles in transit through matter, and the vibrations of the interior parts of the atom. In C. T. R. Wilson's photographs of the tracks of the α particles through a gas we notice many sudden bends in the paths. In order to account for these deflections I have found it necessary to believe that there is a concentrated nucleus in the atom (having a certain number of units of charge), in which the main part of the mass resides; outside this there are a corresponding number of electrons. The whole dimensions of the nucleus are very small indeed compared with the distance of the outer electrons. From the scattering experiments it appears that the law of force right up to the nucleus is the inverse square law; no other formula would give accordance with the observations. The radius of the nucleus is of the order 10^{-12} cm. in the case of gold, and for a lighter element it is smaller still. The approach of the α particle to the nucleus of the hydrogen atom when the latter is set into very swift motion is exceedingly close—a distance even less than the diameter of an electron. From this it is probable that the hydrogen nucleus is simply the positive electron with a large electrical mass due to the great concentration of the positive charge. Another

fact that appears from the scattering experiments is that the number of electrons (outside the nucleus) is about half the atomic weight. There is now fairly good evidence that, if the elements are numbered in order of atomic weight, the numbers will actually express the charge on the nucleus. The rate of vibration of the inner parts of the nucleus can now be measured by means of the characteristic X-rays emitted. Each substance has several strong lines in its X-ray spectrum, and as we pass from element to element in order of atomic weight the frequencies of these change by regular jumps. H. G. J. Moseley has investigated all the known elements in this way, and he is even able to show at what points elements are missing, because at such points the X-ray frequencies make a double jump. In this way he has found that between aluminium and gold only three elements are now missing. It is deduced from these considerations that there is something more fundamental in the atom than its atomic weight, viz., the charge on the nucleus, and that this is the main factor which controls the frequency of the interior vibrations, the mass having only a slight influence.

There are certain elements with identical chemical properties, but different atomic weights. Thus Radium-B (atomic weight 214) and lead (207) are chemically inseparable and have the same γ-ray spectrum. It is quite clear that some new conception is required to explain how the atoms, having the structure we have supposed, can hold together. N. Böhr has faced the difficulty by bringing in the idea of the quantum in a novel way. At all events, there is something going on in the atom which is inexplicable by the older mechanics.

H.G.J.Moseley & H.Tizard fathers both on Challenger Expedition 1872-76.

The Analysis of the γ Rays from Radium B and Radium C

by PROFESSOR E. RUTHERFORD, F.R.S., *and* H. RICHARDSON, B.SC.,
Graduate Scholar, University of Manchester

From the *Philosophical Magazine* for May 1913, ser. 6, xxv, pp. 722–34

IT has long been recognized that the penetrating γ rays emitted by a γ ray salt were complex in character. The examination of the radiation has been made by the electric method in two ways:

(1) by measuring the absorption of the γ rays in different materials over a wide range of thickness;

(2) by an examination of the absorption of the secondary and scattered γ rays which appear when γ rays traverse matter.

Initial experiments on the absorption of the γ rays of radium by different materials were made by Rutherford* and McClelland.† These were extended by later investigations of Eve,‡ Tuomikoski,§ Wigger,‖ and S. J. Allan.¶ The experiments showed that the absorption of the γ rays in lead rapidly decreased for the first two centimetres of thickness, but became approximately exponential for greater thicknesses. The whole question was re-examined with great detail and thoroughness by Mr. and Mrs. Soddy and A. S. Russell,** who determined the absorption of the γ rays in a number of materials and investigated the effect of different arrangements on the apparent value of the absorption coefficient. They found that the absorption of the γ rays by lead was accurately exponential for a very wide thickness, viz. from 2 to 22 cm., and concluded that over this range of thickness the γ rays were to be considered as homogeneous in type. These results were confirmed and extended by Russell, who showed that the γ rays from radium were absorbed by mercury over a range of thickness from 1 to 22·5 cm. strictly according to an exponential law. Over this range of thickness the intensity of the ionization current in the testing vessel, which served as a measure of the intensity of the γ rays, varied in the ratio of 360,000 to 1.

* Rutherford, *Phys. Zeits.* iii. p. 517 (1902). (*Vol. I., p. 410*).
† McClelland, Phil. Mag. viii. p. 67 (1904).
‡ Eve, Phil. Mag. xvi. p. 224 (1908); xviii. p. 275 (1909).
§ Tuomikoski, *Phys. Zeit.* x. p. 372 (1909).
‖ Wigger, *Jahrb. Radioakt.* ii. p. 430 (1905).
¶ Allan, Phys. Rev. xxxiv. p. 311 (1912).
** Soddy and Russell, Phil. Mag. xviii. p. 620 (1909); Mr. and Mrs. Soddy and Russell, Phil. Mag. xix. p. 725 (1910); Russell, Proc. Roy. Soc. A. lxxxvi. p. 240 (1911).

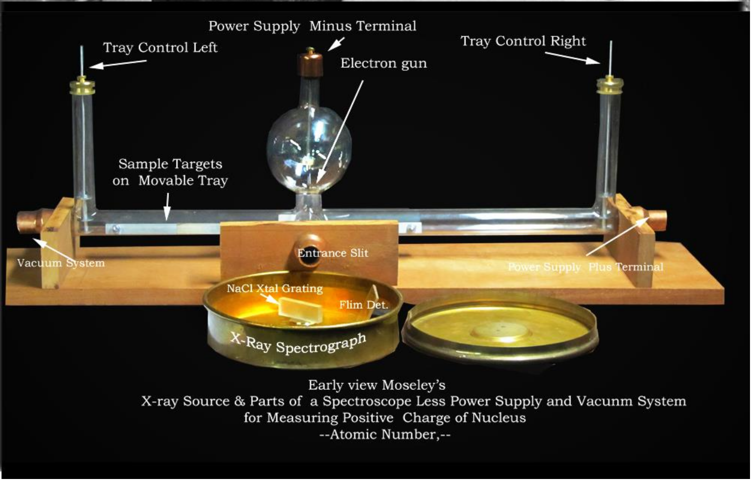
From an examination of the quality of the secondary γ rays set up in different materials by the γ rays, Kleeman* considered that the primary γ rays from radium could be divided into three types of widely different penetrating power. In similar experiments Madsen† found evidence of two types. On the other hand, Florance,‡ who examined the character and intensity of the secondary and scattered γ rays from radiations of different materials at various angles for the primary beam, concluded that the γ rays were very complex in character and that no definite evidence could be obtained by this method of the existence of distinct groups of primary rays.

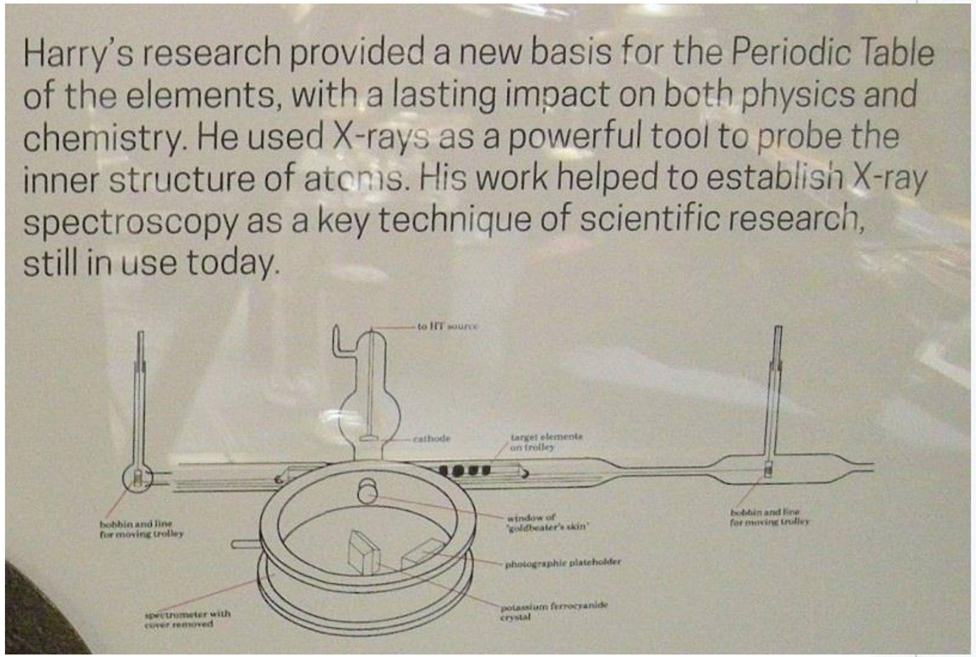
It was at first supposed that the penetrating γ rays emitted by a radium salt arose entirely from the transformation of its product radium C. Moseley and Makower,§ however, showed in 1912 that radium B also emitted γ rays, although weak in intensity and penetrating power compared with those emitted from radium C. Even if radium C emitted only one type of radiation, it was clear from this result that the γ rays from a radium salt must contain at least two types of γ rays. In the meantime, the work of Barkla on X rays had shown conclusively that each of the elements emitted one or more types of characteristic or fluorescent radiations when X rays of suitable penetrating power traversed them. In some of the elements two types of characteristic radiations were observed. J. A. Gray‖ extended these results to γ rays, for he found that the γ rays emitted by radium E were able to excite the characteristic radiations of certain elements. His results showed, as had long been supposed, that the γ rays were identical in general properties with X rays and possessed the fundamental property of exciting characteristic γ rays. In a paper entitled 'The origin of β and γ rays from radioactive substances,' Rutherford¶ put forward the view that the γ rays from radioactive substances were to be regarded as the characteristic radiations of the respective elements set up by the escape of α or β rays from them. On this basis an explanation was given of the numerous groups of homogeneous β rays emitted by radium B and C, and their connexion with the γ rays was outlined. If this were the case, each type of characteristic radiation emitted should be absorbed according to an exponential law by an absorbing substance of low atomic weight like aluminium.

The present experiments were undertaken with a view of testing this hypothesis. It will be seen that this analysis brings out that the γ radiation from radium B consists of at least two and possibly of three distinct types, and from radium C of a single type, probably corresponding in penetrating power to the characteristic radiations to be expected from elements of their atomic weight.

* Kleeman, Phil. Mag. xv. p. 638 (1908).
† Madsen, Phil. Mag. xvii. p. 423 (1909).
‡ Florance, Phil. Mag. xx. p. 921 (1910).
§ Moseley and Makower, Phil. Mag. xxiii. p. 312 (1912).
‖ Gray, Proc. Roy. Soc. A. lxxxvii. p. 489 (1912).
¶ Rutherford, Phil. Mag. Oct. 1912. (*This vol., p. 280.*)

H.G.J.Moseley Spectroscope.





"Moseley's law states that the wavelength of these lines is inversely proportional to the square of the atomic number of the element. Therefore, if we know the atomic number of the element we are looking for, we can predict the wavelength of certain lines in its X-ray spectrum.

"If we set up our X-ray spectrograph so as to catch these lines where we expect them to fall, then, if the element is present in the target which we have chosen to use in our X-ray tube, we should know it. This provides one good way to identify difficult elements, but it is well to have another to use as a check. One of the best of these, and one which is almost as sensitive as the X-ray method, is that of positive ray analysis."

From his paper, The High Frequency Spectra of The Elements, H. G. J. Moseley, M. A. Phil. Mag. (1913), p. 1024, available here:

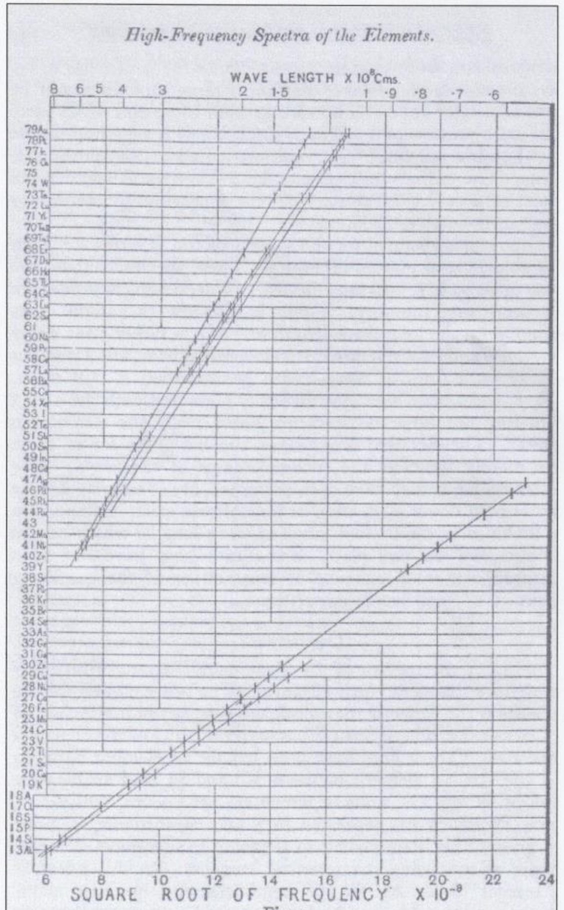


Fig. 3.

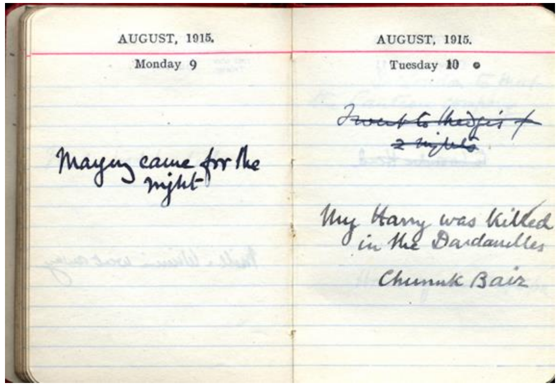
Moseley Atomic Number Calculation

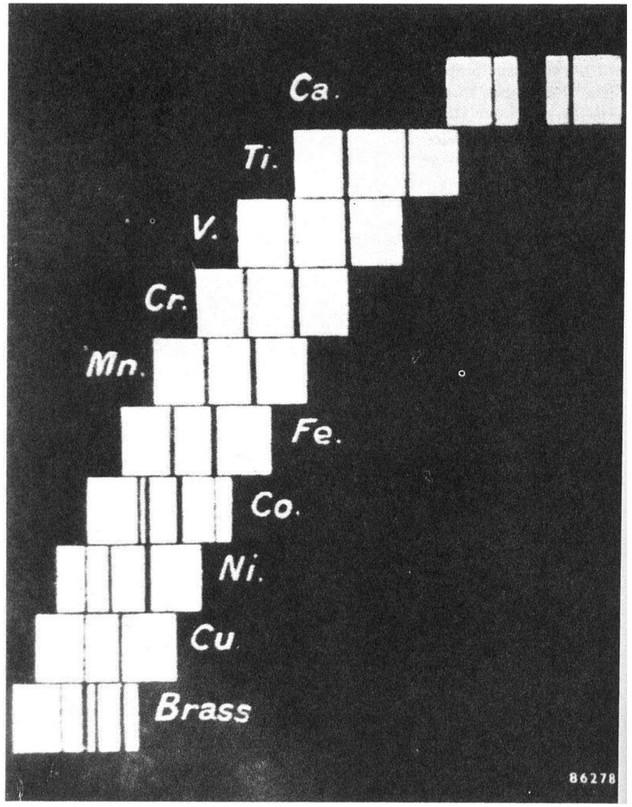
TABLE I.

Element.	Line.	θ_2.	λ.	θ_3.	λ.	$\lambda_\alpha/\lambda_\beta$.	$Q=(\nu/\frac{3}{4}\nu_0)^{\frac{1}{2}}$.	N atomic number.	Atomic weight.
CALCIUM.	α ... β ...	23·4° 21·4	$3·357\times10^{-8}$ 3·035	36·7° 33·3	$3·368\times10^{-8}$ 3·094	1·089	19·00	20	40·09
SCANDIUM.	...	...	...	...	...	...	...	21	44·1
TITANIUM.	α ... β ...	19·1 17·4	2·766 2·528	29·3 26·6	2·758 2·524	1·093	20·99	22	48·1
VANADIUM.	α .. β ...	17·35 15·8	2·521 2·302	26·55 24·05	2·519 2·297	1·097	21·96	23	51·06
CHROMIUM.	α ... β ...	15·75 14·3	2·295 2·088	24·1 21·8	2·301 2·093	1·100	22·98	24	52·0
MANGANESE.	α ... β ...	14·5 13·15	2·117 1·923	22·0 19·9	2·111 1·918	1·101	23·99	25	54·93
IRON.	α ... β ...	13·3 12·05	1·945 1·765	20·2 18·25	1·946 1·765	1·103	24·99	26	55·85
COBALT.	α ... β ...	12·25 11·15	1·794 1·635	18·6 16·8	1·798 1·629	1·104	26·00	27	58·97
NICKEL.	α ... β ...	11·35 10·25	1·664 1·504	17·15 15·5	1·662 1·506	1·104	27·04	28	58·68
COPPER.	α ... β ...	10·55 9·55	1·548 1·403	15·95 14·4	1·549 1·402	1·105	28·01	29	63·57
ZINC.	α ... β ...	9·85 not	1·446 found	14·85 13·4	1·445 1·306	1·106	29·01	30	65·37

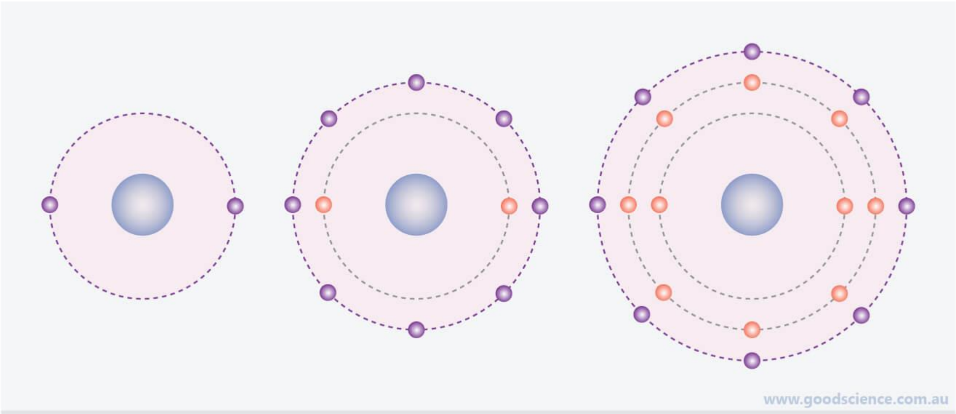
Moseley Periodic Table.

Group 0	I a	I b	II a	II b	III a	III b	IV a	IV b	V a	V b	VI a	VI b	VII a	VII b	VIII
	H 1														
He 2	Li 3		Be 4		B 5			C 6		N 7		O 8		F 9	
Ne 10	Na 11		Mg 12		Al 13			Si 14		P 15		S 16		Cl 17	
Ar 18	K 19	Cu 29	Ca 20	Zn 30	Sc 21	Ga 31	Ti 22	Ge 32	V 23	As 33	Cr 24	Se 34	Mn 25	Br 35	Fe 26, Co 27, Ni 28
Kr 36	Rb 37	Ag 47	Sr 38	Cd 48	Y 39	In 49	Zr 40	Sn 50	Nb 41	Sb 51	Mo 42	Te 52	–	I 53	Ru 44, Rh 45, Pd 46
Xe 54	Cs 55	Au 79	Ba 56	Hg 80	57-71*	Tl 81	Hf 72	Pb 82	Ta 73	Bi 83	W 74	Po 84	Re 75	–	Os 76, Ir 77, Pt 78
Rn 86	–		Ra 88		Ac 89		Th 90		Pa 91		U 92				

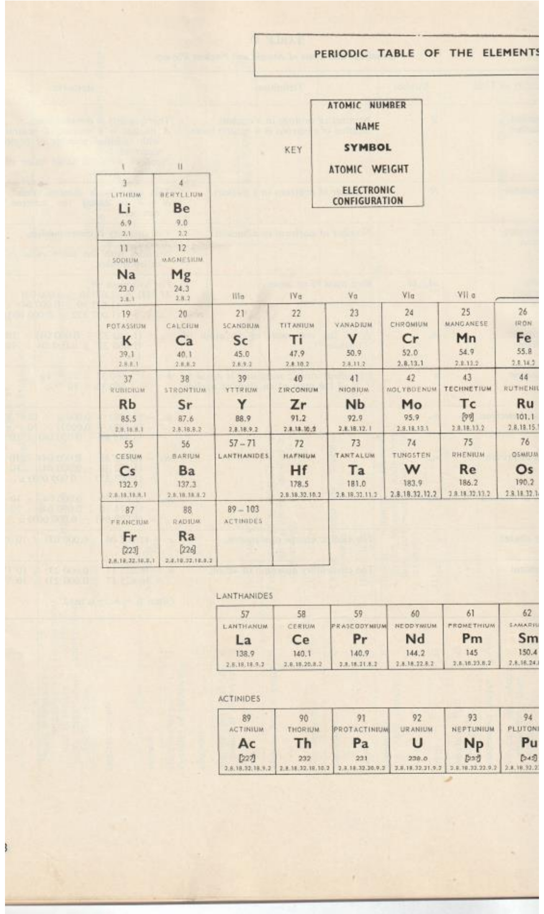




Modern Periodic Table.



Valence Shells and Valence Electrons



Legend

1s 2s 2p 3s 3p 3d 4s 4p 4d 4f 5s 5p 5d 5f 5g 6s 6p 6d 6f 7s 7p 7d 8s 8p 9s

1 H hydrogen: $1s^1$
$1s^1$ — 1

2 He helium: $1s^2$
$1s^2$ — 2

3 Li lithium: [He] $2s^1$
$1s^2$ $2s^1$ — 2, 1

4 Be beryllium: [He] $2s^2$
$1s^2$ $2s^2$ — 2, 2

5 B boron: [He] $2s^2$ $2p^1$
$1s^2$ $2s^2$ $2p^1$ — 2, 3

6 C carbon: [He] $2s^2$ $2p^2$
$1s^2$ $2s^2$ $2p^2$ — 2, 4

7 N nitrogen: [He] $2s^2$ $2p^3$
$1s^2$ $2s^2$ $2p^3$ — 2, 5

8 O oxygen: [He] $2s^2$ $2p^4$
$1s^2$ $2s^2$ $2p^4$ — 2, 6

9 F fluorine: [He] $2s^2$ $2p^5$
$1s^2$ $2s^2$ $2p^5$ — 2, 7

10 Ne neon: [He] $2s^2$ $2p^6$
$1s^2$ $2s^2$ $2p^6$ — 2, 8

11 Na sodium: [Ne] $3s^1$
$1s^2$ $2s^2$ $2p^6$ $3s^1$ — 2, 8, 1

12 Mg magnesium: [Ne] $3s^2$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ — 2, 8, 2

13 Al aluminium: [Ne] $3s^2$ $3p^1$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^1$ — 2, 8, 3

14 Si silicon: [Ne] $3s^2$ $3p^2$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^2$ — 2, 8, 4

15 P phosphorus: [Ne] $3s^2$ $3p^3$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^3$ — 2, 8, 5

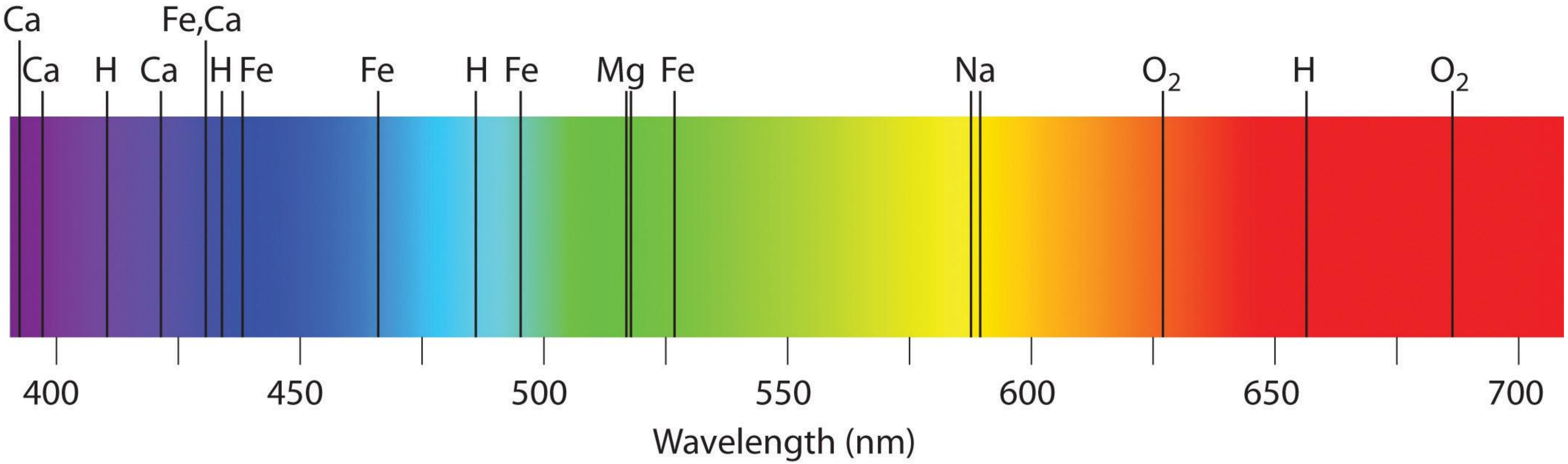
16 S sulfur: [Ne] $3s^2$ $3p^4$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^4$ — 2, 8, 6

17 Cl chlorine: [Ne] $3s^2$ $3p^5$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^5$ — 2, 8, 7

18 Ar argon: [Ne] $3s^2$ $3p^6$
$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ — 2, 8, 8

https://en.wikipedia.org/wiki/Electron_configurations_of_the_elements_(data_page) 2/12

Spectra of Light Elements. (Visible Light).



J.P.V.MADSEN & THE 1914 BRITISH ASSOCIATION FOR ADVANCEMENT OF SCIENCE MEETING IN AUSTRALIA.

THE PERIODIC TABLE 1869-1914: MENDELEEV TO MOSELEY.

Prepared by: R.W.Madsen. October 2020.

INTRODUCTION.

As early as March 8, 1911, Ernest Rutherford (1871-1937) writing to J.P.V.Madsen (1879-1969) in Sydney from Manchester, indicated that he planned to attend the B.A.A.S Meeting to be held in Australia in August 1914 & also with the intention of visiting his family in New Zealand. The decision to hold the Australian Meeting had been made several months earlier. In his March letter Rutherford set out his new theory of the structure of the nuclear atom which he had publicly announced the previous evening to the Manchester Literary & Philosophical Society & which was followed up by further verification experiments & a paper published in May 1911 titled "The scattering of alpha & beta particles by matter & the structure of the atom" in the Philosophical Magazine. In this paper Rutherford refers to J.P.V.M's beta scattering work published in 1909 as evidence of his new nuclear atom theory & this recognition had come about by the efforts of W.H. Bragg (1862-1942) who had relocated from Adelaide University to Leeds University in 1909 & had collaborated with J.P.V.M in Adelaide on a number of experiments & was in a good position to confidently describe to Rutherford J.P.V.M's "striking experiment" & JPVM's plans for further work on thinner foils.

W.H.Bragg had embarked on a career of research in Physics in 1904 when he attended the Australasian Association for the Advancement of Science in Dunedin. Knowing that Rutherford would be there visiting from Montreal, Bragg presented the President's Address for Section A (Maths & Physics) on "Some recent advances in the theory of the ionisation of gases" & Rutherford delivered a paper on "The heating effect of Radium emanation". The subsequent research work back in Adelaide by Bragg & Madsen was to further Rutherford's ideas & they sought Rutherford's approval to do this.

At first Rutherford's new theory was not accepted as it was not understood why the electrons within the atom would not collapse on to the nucleus & it was the work of Rutherford's student Niels Bohr (1885-1962) at Manchester , who had returned to Copenhagen & in 1913 published three papers on "The Constitution of Atoms & Molecules" in which he introduced the quantum in a novel way suggesting energy shells of electrons. This provided a step forward for the theory of atomic structure. One prompt response to Rutherford's theory came in July 1911 in Nature from an amateur Dutch physicist, Antonius Van Den Broek (1870-1926) who raised the idea of an atomic number for elements being equal to the number of permanent positive & negative charges per atom. Experimental work following up on this idea was carried out by another Rutherford student, Henry Moseley (1887-1915), working in Manchester who had further developed the X-ray crystal diffraction technique of 1912-1913 pioneered by WH Bragg & his son from Adelaide, Lawrence (1890-1971). Moseley was able to establish a physical relationship between the energy of the atomic nucleus & the atomic number of each element in the form of an updated periodic table originally proposed by the Russian Chemist/Physicist Dmitri Mendeleev (1834-1907) in 1869. This work of Moseley's was carried out shortly before the start of WW1 & was referred to by Harry (&

Rutherford) at the B.A.A.S Meeting in Australia which he attended with his Mother, Mrs H N Moseley. [Moseley was killed in the Dardenelles on August 10, 1915 at Chunuk Bair, Gallipoli].[Robert Bragg (1891-1915), the younger son of WH Bragg was also killed at Gallipoli, Suvla Bay on September 2, 1915].

Acceptance of these new concepts of the atom was further aided by the cloud chamber work of C.T.R.Wilson (1869-1959) which was used for the first time for alpha particle tracking in March ,1911. J.P.V.M & wife Maud were both members of the Sydney Session of the B.A.A.S (August 20-26) at which Rutherford delivered two papers on Gamma radiation, & Atoms & Electrons (a joint presentation with the Chemistry Section). Prof James Pollock (1865-1922) & Prof. William Warren (1852-1926) were the Sydney local Secretaries from Sydney University for Section A -Maths/Physics & Section G-Engineering. Some 1800 local Sydney Members of the BAAS attended lectures & excursions out of a total 4,500 local members for the whole of Australia with Sessions in Adelaide, Melbourne, Sydney & Brisbane.

Slide 1. J.P.V.Madsen & the 1914 B.A.A.S Meeting in Australia.

The B.A.A.S was founded in 1831 with its first Meeting in York to redress the decline in British science as highlighted by Charles Babbage (1791-1871) at Cambridge after the exhaustion of the Napoleonic Wars & to follow a German model. Four early Sections of the B.A.S were Physics (Mathematics), Chemistry, Geology & Natural History. Meetings were designed to improve the perception of science & scientists in the UK & membership was open to all & many FRS members joined. Annual Meetings since 1831 have been held within the UK in England, Scotland, Wales & Ireland. On six occasions meetings have been held in Canada, Sth. Africa & Australia (Montreal 1884, Toronto 1897, Sth Africa 1905, Winnipeg 1909, Australia 1914 & Sth Africa 1929).

Slide 2. Dmitri I. Mendeleev (1834-1907).

Mendeleev was born in Siberia & to get a better education his mother travelled all the way across Russia to St. Petersburg in 1849 where he was able to enrol at the University where he obtained a Masters degree in Chemistry in 1856. In the early 1860's Mendeleev wrote the names of the 65 known elements on cards with their atomic weights & properties & was inspired to arrange them in a table which allowed him to predict the properties of 8 elements which had yet to be discovered. Mendeleev's 1869 paper was translated into German & then into English which date wise was after the English chemist John Newlands (1837-1898) work in 1865 on the "Law of Octaves" & the German work of Lothar Meyer (1830-1895) in 1864 on 28 elements classified by valence. It was the completeness of Mendeleev's Table & ability to predict missing elements which was different from these other two.

Mendeleev was a chemist of genius & a 1st class physicist involved with many areas of research including chemical technology (explosives, petroleum, fuels) & was responsible for introducing the metric system to the Russian Empire (in 1892 he was the Head of the Archive of Wights & Measures in St. Petersburg).

Slide 3. Mendeleev's Periodic Table.

From the hand written notes & the stepwise properties in Mendeleev's paper (Slide 2) it appears that he originally had an arrangement of 6 columns accounting for 60 elements shown & 8 gaps (Including elements 21, 31, 32 & 43-Scandium, Gallium, Germanium & Technetium). Subsequent development of the Periodic Table now have Group 0, Groups I-VII & sub Groups for I-VIII & also the 15 elements each in the Lanthanides & Actinides. It appears in the current day electron configuration there is a 9th valence spin shell also. Just as Rutherford should have received a Physics Nobel Prize for his Structure of the Atom, Mendeleev should have received a Chemistry Prize for his Periodic Table.

<u>Slide 4.</u> Cavendish 1911 Reunion.

The Cavendish Laboratory at Cambridge University opened in 1874 with James Clerk Maxwell (1831-1879) a founder & the 1st Cavendish Professor of Physics, named after Henry Cavendish (1731-1810) an English Scientist/Chemist who discovered hydrogen as a distinct element in 1766 & also William Cavendish (7th Duke of Devonshire: 1808-1891) a relative & Chancellor of Cambridge University who donated funds. J J Thomson became the Cavendish Professor of Physics in 1884 & in 1897 discovered the electron, the 1st sub atomic particle to be discovered & who had the concept of the atom as a "plum pudding" model which was disproved by the large alpha & beta particle scattering found by Rutherford & J.P.V.Madsen. A very large number (30+) Nobel prizes have been won by scientists who have worked at the Cavendish & include, from the signatures shown of the 1911 reunion, W L Bragg (#5. LH), E Rutherford (#8 LH), JJ Thomson (#10. LH), N Bohr (#11. RH).[For information the signatures of W H Bragg & J P V Madsen are shown} Charles Wilson of the Cloud Chamber who received a Nobel Prize in 1927 did work at the Cavendish but not as a student, as he had been at Manchester University. Ernest Rutherford succeeded J J Thomson as the Cavendish Professor of Physics in 1919.

<u>Slide 5.</u> The Wilson Cloud Chamber Photographs & Schematic.

In March 1911, C T R Wilson was able to give his first demonstration of particle paths in his cloud chamber. In a letter to JPVM of May 18, 1911 W H Bragg advises "C T R Wilson has given a paper at the RS on a method of making visible the tracks of ionising particles. He is very excited about it: he has been working at it for 2 years & has just been successful. He flashes the rays (Alpha, Beta, Gamma & X) through the gas & takes an instantaneous picture of the fog caused by a simultaneous expansion. The ions have not had time to spread & so you see the tracks. The photos for Alpha particles they say are gorgeous. My boy (Bob) has seen them". In the photograph shown an Alpha particle is striking a Helium nucleus (ie. Another 2 Protons & Neutrons) which part at right angles. The Schematic gives a further explanation of how the visible tracks are formed.

<u>Slide 6.</u> Wilson Cloud Chamber & Zeeman Effect.

At Slide 19 Ernest Rutherford's Lecture in Melbourne on the atom for the BAAS is summarised & he points out that the Wilson Cloud Chamber paths & the Zeeman Effect were 2 crucial sources of evidence for his nuclear theory of the structure of the atom. Electrons had been discovered in 1897 by J J Thomson & the Zeeman Effect showed that all atoms must contain electrons. An exhibit of Wilson's Cloud Chamber apparatus is shown. In 1896 a Dutch physicist Pieter Zeeman (1865-1943) measured the splitting of spectral lines by a strong magnetic field which was before Thomson's discovery of the electron & quickly became an important tool for elucidating the structure of the atom. (Zeeman won the 1902 Nobel Prize for Physics).

<u>Slide 7.</u> W.H.Bragg & J.P.V.Madsen.

In September 1902 JPVM was appointed at Adelaide University to the position of Lecturer in Electrical Engineering, teaching post graduate honours students & for the previous 18 months he had been a Demonstrator & assistant Lecturer in Physics & Mathematics under Prof. W.H.Bragg. To equip himself thoroughly for the responsibility of this new position for a high standard, he undertook at his own expense, amounting to several hundred pounds, a trip through England & America to obtain full advantage of both teaching & organisation of laboratories. JPVM's Report of April 24, 1903 to the University Council refers to having visited Universities, Higher Technical Colleges & the more important manufactories & installations in England & America. JPVM had identified that the general type of course was much the same throughout consisting of groundwork in Mathematics, Physics & Chemistry of 3 or 4 years duration with a specialisation in Electric Engineering taking place in the latter portion. A thesis on an approved portion of work was required to be written up during vacations. In the States there was a tendency towards large machines, large currents & high EMFs whereas in England small size plant was considered sufficient for instructional purposes.

In 1904 JPVM applied for the position of Lecturer in Electrical Engineering at Sydney University with very high references from W H Bragg & others but the role was given to Kilburn Scott from the UK so JPVM remained in Adelaide (having married his wife Maud in Sydney) but with the opportunity to work with W H Bragg on research experiments following WHB's new found enterprise after the 1904 Dunedin ANZAAS, to work on Rutherford's alpha particle investigations. Over the next 4 years W.H.B. published 11 papers by himself or jointly with J.P.V.M., A.Kleeman & W.T.Cooke dealing with alpha particles, ionisation, Roentgen rays, gamma rays & beta rays. J.P.V.M. published 3 papers in his own name in 1908 & 1909 on ionisation, gamma rays & beta particle scattering. (It has been suggested that in the photograph shown, Herbert Priest is with Bragg & JPVM in 1906. Priest was a BA. BSc & Rhodes Scholar applicant in 1906 from Adelaide University who was appointed Acting Professor of Physics at Adelaide in 1909 with Kerr Grant, a Melbourne University graduate). [W.L. Bragg went to the University of Adelaide in 1906 at the age of 16 to study mathematics, chemistry & physics graduating in 1908 & went to England with his family & entered Trinity College Cambridge in the Autumn of 1909 excelling in mathematics & later transferring to Physics. At Adelaide University it appears W. L. Bragg was taught Physics & Mathematics by his father & J.P.V.Madsen]

J.P.V.M took up the position of Lecturer in Electrical Engineering at Sydney University in March 1909 (appointed by Prof. W. H. Warren) & borrowed some apparatus from Adelaide University (electrometer, chronograph, 2 samples of Radium & samples of Thorium & Uranium) for up to 6 months so that he could complete experiments before being replaced. From Leeds in 1909, where WHB was now the Cavendish Professor of Physics, W.H.B wrote 4 lengthy letters to JPVM to encourage him in his researches & a further 3 letters in 1911 whilst he was keeping in close contact with Ernest Rutherford at Manchester, culminating in Rutherford's March 8, 1911 letter & the May 1911 publication of his famous paper on Alpha & Beta particle scattering & the structure of the atom, including reference to J.P.V.M's Beta scattering. In May 1911 W H Bragg , with the assistance of Rutherford, posted 30 mg of Radium to JPVM obtained at great expense from Braunschweig in Germany.

In 1912, W.H.B. published a book "Studies in Radioactivity" in which he gives a detailed account of J.P.V.M's 1909 paper on Beta Scattering with which he was familiar & referred to by Rutherford anticipating that further similar work using ultra thin foils was to be carried out by J.P.V.M but which unfortunately did not succeed. J.P.V.M's Beta scattering paper is noted for his observation that for the thinnest foils he used (Aluminium, Silver, Gold & paper) that a beta particle would be scattered only once which was contrary to J.J.Thomson's theory of the atom as a "plum pudding" model where a beta particle passing through an atom would be deflected multiple times.

Slide 8. Rutherford Atom March 1911.

The hand written note by Rutherford on the "Theory of Structure of Atom" & his initial proposal on March 8,1911 of a model atom with a " central point charge (either +ve or -ve) & is surrounded by a spherical distribution of electricity opposite in sign. One may suppose provisionally that this sphere has a diameter of the same order as that of the atom as ordinarily understood. Theory as outlined fits in well with observed facts." In a handwritten footnote to his letter & abstract Rutherford says: "Give my rememberances to Professor Pollock. I am hoping to visit Australia at the time of the B.A.A.S Meeting".

Slide 9. Antonius Van Den Broek (1870-1926).

In a letter dated June 23 to Nature (published July 20, 1911) A.Van den Broek in Holland wrote on the subject of "The number of possible elements in Mendeleff's "Cubic" Periodic System". He notes that a reconstruction of Mendeleff's "cubic" periodic system gives a constant mean difference between consecutive atomic weights. He states that according to Rutherford's recent paper on the structure of the atom, the number of electrons per atom is half the atomic weight. The number of possible elements is equal to the number of possible permanent charges of each sign per atom or to each possible permanent charge (of both signs) per atom belongs a possible element. This letter gave recognition to Rutherford's new theory & set the stage for experimental work by H.G.Moseley in 1913.

Slide 10. Bragg Snr. & Jnr. X-Ray Crystallography.

W. H. Bragg had for many years been interested in the nature of X-rays & as to whether they were a particle or wave or even a combination of both & in June 1912 it came as sensational news from Germany of the work of Max von Laue (1879-1960) in showing that X-rays could be diffracted in passing through crystals.ie. that X-rays were waves. Bragg was greatly interested in this experiment & in order to recreate Laue's experiment designed & built an X-ray spectrometer (a hybrid of an ordinary spectrometer but with an ionization chamber: it is on display at the RI London) & was ready for use by late 1912.

In the latter part of 1912, W.L.Bragg used a simpler interpretation of Laue's phenomena by considering the reflection of waves from parallel layers of atoms or diffracting points, where each typical set of parallel crystal planes acts as a reflecting surface for radiation whose wavelength fulfilled the Bragg Law ny=2 dsin a (d=distance between parallel crystal planes & a is the glancing angle ie. The complement of the angle of incidence. Bragg Law as defined by W.L Bragg).In early 1913 the father & son published their 1st joint paper on the reflection of X-rays. In the early experiments WHB made use of the ionisation chamber to detect & measure rays & was strikingly successful with the ionisation spectrometer. The photographic method by 1914 had already been used by H.G.J Moseley in his researches, but it was only later that WHB adopted it. (Laue received the 1914 Physics Nobel & the Braggs the 1915 Physics Nobel).

Slide 11. Bragg X-Ray Schematic Spectrometer.

A schematic of the Bragg x-ray spectrometer is shown with the RI exhibit. It would appear that WHB's use of an ionisation chamber was inspired by his experience (& also of JPVM's) with it in Adelaide.

Slide 12. Diamond Crystal & DNA.

With the new X-ray technique available from early 1913 the Braggs quickly looked to the diamond crystal for examination & their results were published in Nature on July 31, 1913 identifying an extremely simple structure with every carbon atom having 4 neighbours. Much later in 1952 when WLB was Director of the Cavendish Lab the double helix of DNA was discovered using an X-ray photograph by Rosalind Franklin (1920-1958) & collaborators F.Crick (1916-2004), J.D Watson (1928-) & M Wilkins (1916-2004).

<u>Slide 13.</u> Bohr Electron Shells 1913.

Niels Bohr (1885-1962) was interested in electrons & he went to the Cavendish under J.J.Thomson in September 1911 but failed to impress Thomson & was able to have Rutherford invite him to Manchester where he became familiar with the new atomic structure devised by Rutherford & in July 1912 Bohr returned to Denmark. In 1913 Bohr published a trilogy (July, September, November) of papers in the Phil. Mag on the constitution of atoms adapting Rutherford's nuclear structure to Max Planck's quantum theory & created his own model with definite electron shells as indicated in the abstract from the Phil.Mag. When a negatively charged electron jumps between orbits an amount of electromagnetic radiation is emitted or absorbed. As can be seen the electron configurations he proposed have since been modified with 1st shell 2 electrons max, 2nd shell 8 electrons max, 3rd shell 18 electrons max & 4th shell 32 electrons max.

<u>Slide 14.</u> B.A.A.S Australia 1914, by ship from UK & return.

The Australian Government paid 15,000 pounds stg to the BAAS to provide 1st class passage of prominent English scientists to come to Australia for the Sessions in Adelaide, Melbourne, Sydney & Brisbane. Some 300 English & some German delegates came & in a lot of instances wives & daughters also came on what was really a major 3 month social event. As war had broken out at the end of July 1914 passenger ships were requisitioned for troops so the return voyages had to be reorganised but typically ships of around 10,000 tons such as the Euripides (which Rutherford came on), Orvieto outbound & the Morea (which left Sydney on September 5, had 63 delegates on board) which became a hospital ship. Of the 35 scientists from overseas countries 8 came from Germany including a noted geologist Johannes Walther (1860-1937) who was allowed to return to England with some of the others not detained in Australia for security but were immediately interned on landing in Plymouth. Albrecht Penck (1858-1945) a noted German Geographer was a vice-president in that Section & in Sydney stayed with the Consul General at the German Club. Rutherford continued to New Zealand with his family & then returned to Manchester University to work on anti U-Boat acoustic detection as did W H Bragg (who had remained in England) which was very successful. [W L Bragg during the War in the Army carried out acoustic detection of artillery].

<u>Slide 15.</u> B.A.A.S Sections.

The BAAS President at the time of the Australian Meeting was W.Bateson (1861-1926) a noted Biologist on genetics & hereditary who gave his address at the Town Hall . Section A (Maths & Physics) involved Sir Oliver Lodge (1851-1940) & Ernest Rutherford as Vice Presidents with Prof. J.A.Pollock (1865-1922) of Sydney University the local Sydney Secretary. Section B (Chemistry) had joint Sessions with Section A for the purpose of talks by Rutherford & Section G (Engineering) had Col. J. Monash as a Vice President & Prof. W.H.Warren (1852-1926) as the Sydney local Secretary.

<u>Slide 16.</u> J.P.V.M. June 1914, NSW Electrical Association.

In the Sydney Session of Section G (Engineering) some 12 presentations were made including 5 of an electrical nature (Electric Railways for Sydney- J C Bradfield,(1867-1943) Conditions for safe use of electricity-W.Thornton, The Balsillie system of wireless telegraphy-J G Balsillie (1885-1924) The capacity of radio telegraph aerials- G W Home, Irrigation Dams & Hydro Electric power- E. Kilburn Scott). Two months earlier JPVM had delivered a comprehensive Presidents address to the NSW Electrical Association.

JPVM undoubtedly attended the 2 presentations by Rutherford at Sydney University & the Lyceum Theatre. A crystal radio detector of 1913 invented by J G Balsillie & made by Shaw Works Randwick is shown.

Slide 17. Sydney Local Members.

Many of the overseas visitors were hosted by Sydney Local Members, who generally lived fairly close to the Central Railway & Sydney University. JPVM & wife Maud living in Roseville were among some 1800 local members for the purpose of the Sydney Session. Sir Philip Sydney Jones (1836-1918) a former Vice Chancellor of Sydney University hosted H.G.J Moseley & his mother, Mrs H N Moseley (the 1913 Womens chess champion in Britain: Harry's father had died when he was very young) at the Hotel Sydney, on Pitt St near Central. Sir James Fairfax (1863-1928) hosted Sir Oliver Lodge (1851-1940), Lady Lodge & 2 daughters at Bellevue Hill. In Sydney Rutherford, Lady Rutherford & their daughter were hosted by Dr.Gordon Craig at Centennial Park. Henry Tizard (1885-1959) stayed at Potts Point with a Mrs Jamieson.

Slide 18. Sydney Programme.

The main events of the 7 day programme in Sydney from arrival by train from Melbourne to departure by train to Brisbane centred on Sydney University but with various excursions out of Sydney & functions at the Town Hall. Prof. W H Warren of Sydney University Engineering is shown & a BAAS Members ticket used in Melbourne but probably something similar was used in Sydney as well.

Slide 19. Rutherford Talk at the Lyceum Theatre on Atoms & Electrons.

In the BAAS Report there is an abstract of Rutherford's talk to a joint Section A & Section B Session in Melbourne on The Structure of Atoms & Molecules & it appears that a similar presentation was given in Sydney on" Atoms & Electrons". Rutherford highlights the compelling evidence of his nuclear atom from the Wilson Cloud Chamber photographs & the Zeeman Effect initially & later experiments subsequent to May 1911. He refers to the novel way in which Bohr has used quantum theory in his development of the atom & also H G J Moseley's work with the Periodic Table & identifying where jumps have occurred indicating missing elements. For the general science community Moseley's results gave the strongest impetus to recognition of the new Rutherford-Bohr atom.

Slide 20. H.G.J.Moseley & H.Tizard Fathers' both on Challenger Expedition 1872-76.

It is noted as a matter of interest that the father's of both Henry Tizard (1885-1959) & H G J Moseley were both together on the Challenger Expedition of 1872-76. Henry Tizard attributed great value to his trip out to Australia for the B.A.A.S for the contacts & long lasting friendships that he made. Henry Nottidge Moseley (1844-91) & Thomas Henry Tizard (1839-1924) would be amongst the group photo shown on HMS Challenger.

Slide 21. Rutherford at Sydney University on Gamma rays.

On Friday August 21 Rutherford gave a talk "On the origin & nature of Gamma rays from Radium." There is no abstract in the BAAS Report for this talk but I would imagine it would follow the lines of his May 1913 research paper in the Phil.Mag part of which is shown & including a reference to JPVM's 1909 Phil Mag paper on "Secondary Gamma Radiation". It would seem that there are 2 references by Rutherford in his published papers referring to JPVM viz. the May 1911 Structure of the Atom & this Analysis of Gamma Radiation.

<u>Slide 22.</u> H.G.J. Moseley Spectroscope.

From the BAAS Report:

" Mr. H G J Moseley explained the results of his classification of elements by their X-ray spectra. The frequency of the principal line in the X-ray spectrum is represented very closely by the formula y1/2 =K(N-B) where K & B are constants, & N an integer increasing by a unit as we pass from element to element up the periodic table. If we take this atomic number N as ordinate, & the square root of the principal frequency as abscissa, the different elements will therefore give points lying approximately on a straight line. The secondary frequencies will at the same time give points on other straight lines. The order of the elements determined by N is nearly that of increasing atomic weight, is evidently the correct order corresponding to chemical properties. For example, the atomic weight gives the order Cl,K, A, whereas the X-ray frequency gives the order Cl,A, K. The latter is the order required by the Periodic Table. There are between aluminium & gold, 4 missing elements, indicated by the double jump of N required to make the formula fit. These correspond generally to gaps indicated also by the periodic law." The missing Moseley elements were 43, 61, 72 & 75.

<u>Slide 23.</u> Moseley Atomic Number Calculation.

The table shown is reproduced from Moseley's first paper in 1913 showing his atomic number calculations for 10 elements (Calcium to Zinc) deriving atomic numbers 20 to 30. Evidently his formula had become more refined by the time of the BAAS.

<u>Slide 24.</u> Moseley's Periodic Table.

A complete list of Moseley's atomic numbers that he identified by the "step ladder" process is shown. The diary entry of Harry's Mother, Mrs H.N.Moseley records the tragic news that Harry was killed at Chunuk Bair, Gallipoli in the Dardenelles on August 10, 1915. Harry had enlisted with the Engineers & August 10 was the day the Turks mounted a counter attack to recapture the hill at Chunuk Bair which NZ & other forces had taken 3 or 4 days earlier.

<u>Slide 25.</u> Modern Periodic Table.

The valence shells for Helium, Neon & Argon are shown & according to the current method of defining electron structures subshells ie. s, p, d & f which have a maximum of 2, 6, 10 & 14 electrons respectively so that : 2 He Helium is 1s^2, 10 Ne Neon is [He] 2s^2 2p^6 & 18 Ar Argon is [Ne]3s^2 3p^6. These 3 elements have a closed shell where the valence shell is completely filled & are very stable.

<u>Slide 26.</u> Spectra of Light Elements .(Visible Light).

In the spectra shown for light elements, Calcium appears to have a range of 400-440 nanometres (a nm is 10^-9 mtre).