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THIRD SERIES. VOL. III. FASCICULUS No. 1.

PROCEEDINGS

OF

THE CANADIAN INSTITUTE,

TORONTO,

BEING A CONTINUATION OF THE "CANADIAN JOURNAL" OF SCIENCE, LITERATURE, AND HISTORY.

MARCH, 1885.

Whole No., Vol. XXI.] [No. 142.

CONTENTS:

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1885.

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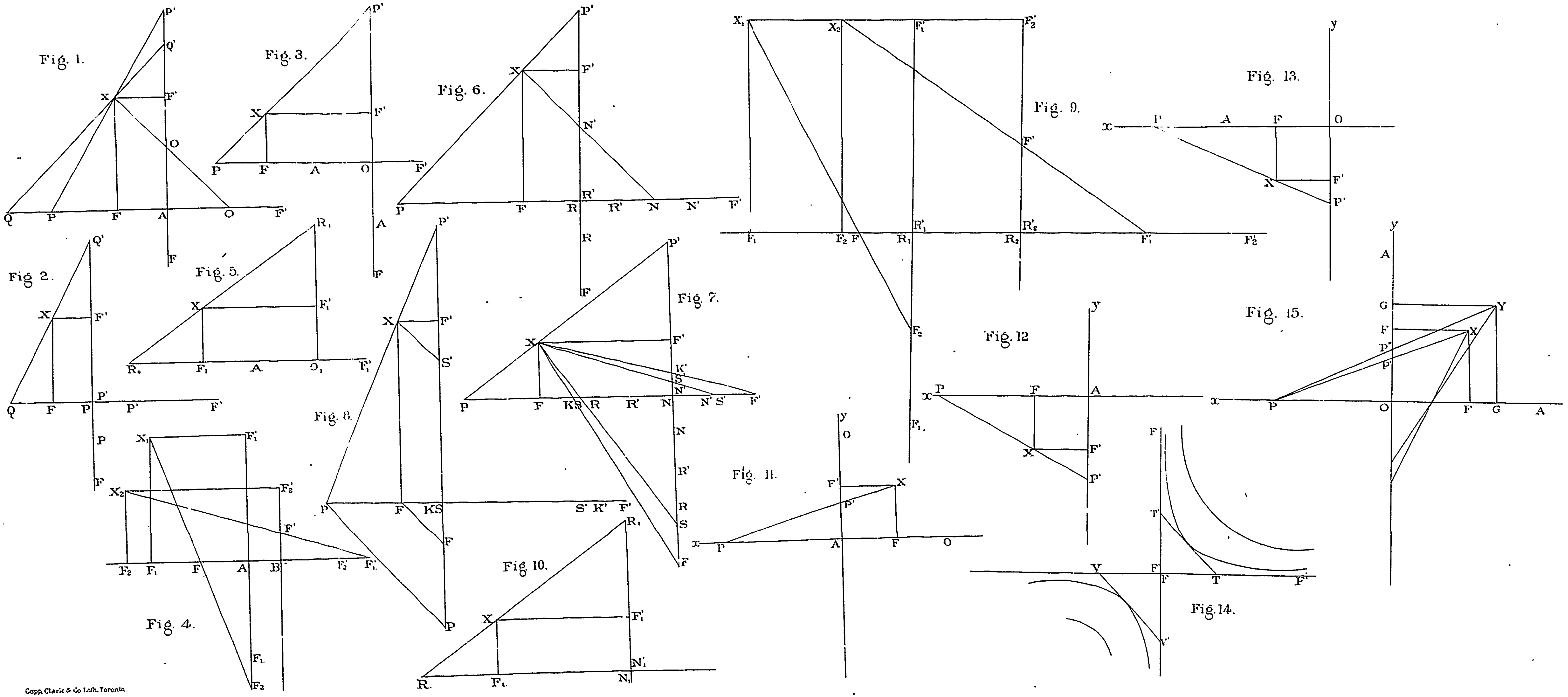

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10. Fig. 11. Fig. 12. Fig. 13. Fig. 14. Fig. 15.

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PROCEEDINGS

OF

THE CANADIAN INSTITUTE,

SESSION 1884.

FIRST ORDINARY MEETING.

The First Ordinary Meeting of the Session 1884-'85, was held on Saturday, November 1st., in the Lecture Room of the Institute, the Second Vice-President, Dr. George Kennedy, in the Chair.

The minutes of last ordinary meeting were read and confirmed.

The following list of donations and exchanges was read :

I.—CANADIAN.

1. Proceedings and Transactions of the Nova Scotia Institute of Natural Sciences of Halifax, N.S., Vol. VI., No. 1, 1882-83.
2. Report on Canadian Archives for 1883, by Douglas Brymner, Archivist.
3. The Canadian Practitioner, June, July, August, September and October, 1884, 5 numbers.
4. Second Annual Report of the Provincial Board of Health of Ontario for 1883, 2 copies.
5. Monthly Weather Review for May, June, July, August and September, 1884, 5 numbers.
6. The Canadian Entomologist, Vol. XVI., Nos. 4, 5, 6, 7, April to July, 1884, 4 numbers.
7. Statutes of Ontario, 47th Victoria, 1st Session, 5th Legislature of Ontario held at Toronto, 25th July, 1884, 1 copy.
8. Manitoba Historical and Scientific Society :
   (1) Annual Report for the year 1883-84.
   (2) Transactions, No. 3, season 1883-84. Notes and Comments on Harmon's Journal, 1800-1820, by Rev. Prof. Bryce.
   (3) Transactions, No. 4. Fragmentary Leaves from the Geological Records of the Great North-West, by J. Hoyes Panton, M.A.

(4) Transactions, No. 5, season 1883-84. "Our Water Supply," by Dr. Agnew.

(5) Transactions, 12, 13, 14. "The Red River," by W. Murdoch, Esq., C.E. "The Red River," by J. H. Rowan, Esq., C.E. "The Prairie Chicken," by Ernest E. T. Seton, Esq.

9. The Monthly Health Bulletin for Ontario, June, July and August, 3 numbers.

10. Inaugural Address delivered at the opening of the Law School in connection with Dalhousie University, Halifax, N.S., at the beginning of the first Term in 1883.

11. Report of the Meteorological Service of the Dominion of Canada, for the year ending December 31st, 1882, 2 copies.

12. Catalogue of the Central Circulating Library, Toronto, July 1st, 1884.

13. Ottawa Field Naturalists' Club, Transactions, No. 5, Vol. II., No. 1.

14. Label List of Insects of the Dominion of Canada, compiled by the Natural History Society of Toronto.

15. The Canadian Record of Science, Vol. I., No. 1.

16. On the Development of Physiological Chemistry and its Significance for Medicine. by Prof. Felix Hoppe-Seyler, translated by T. Wesley Mills, Esq., M.A., M.D., McGill College, Montreal.

Total Canadian, 36 numbers.

II.—UNITED STATES EXCHANGES.

1. Reports of the Peabody Museum of American Archaeology and Ethnology in connection with Harvard University, Vol. I., 1869-1876. Vol. II., Nos. 1, 2, 3, 4, 1877-80. Vol. III., Nos. 1, 2, 3, 4, 1881-84, 9 numbers.

2. Science Record, Vol. II., Nos. 7, 10, 11, 3 numbers.

3. Science, No. 68-90, 23 numbers.

4. Harvard University Bulletin for May, 1884, No. 28.

5. Proceedings of the Boston Society of Natural History, Vol. XXII., Part III.

6. Journal of the Franklin Institute for June, July, August, September and October, 1884, 5 numbers.

7. Annals of the New York Academy of Science, Vol. III., Nos. 1 and 2, 3 and 4, 2 numbers.

Transactions of the New York Academy of Science, Vol. II., 1882-83.

8. Proceedings of the Academy of Sciences of Philadelphia, Part I., January to April, 1884.

9. Papers Concerning Early Navigation on the Great Lakes, by William Hodge. (From the Buffalo Historical Society).

10. Seventeenth Annual Report of the Peabody Institute of the City of Baltimore, June 1st, 1884.

11. Proceedings of the American Academy of Arts and Sciences. The Phases of the Moon, by Arthur Searle, April 9th, 1884.

12. The Workshop Companion, New York, 1879.

13. Preparation and Use of Concrete and Glue, New York, 1881.

14. Hints and Practical Information for Cabinet Makers, Upholsterers and Furniture men generally, New York, 1884.

15. Essex Institute Historical Collections for January, February and March, 1884, 1 number.

16. Bulletin of the Essex Institute :

Vol. 15, Nos. 1-6, January to June, 1883.

" 16, " 1-3, January to March, 1884, 3 numbers.

17. Appleton's Literary Bulletin, July, 1884.
18. Transactions of the Academy of Sciences of St. Louis, Vol. IV., No. 3, 1884.
19. United States Coast and Geodetic Survey. Report for the year ending June, 1882.
20. Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. XI., No. 10.
21. Proceedings of the Newport Natural History Society for 1883-84.
22. Transactions and Proceedings of the American Society of Civil Engineers :

Proceedings, Vol. X.

Transactions, Vol. XIII., January to July, 1884.

" August, 1884, 8 numbers.

23. Proceedings of the American Antiquarian Society, N. S., Vol. III., Part 2, April 1884.
24. Mineral Resources of the United States, by Albert Williams, jun., of the U. S. Geological Survey.
25. First Annual Report of the U. S. Geological Survey for the year ending June 30th, 1880.
26. Annual Report of the Board of Regents of the Smithsonian Institution for 1882.
27. Bulletin of the United States National Museum, No. 25. Contributions to the Natural History of the Bermudas, Vol. 1.
28. The Artesian Wells of Denver. (From the Colorado Scientific Society).

Total United States, 75 numbers.

III.—BRITISH EXCHANGES.

1. Transactions and Proceedings of the Botanical Society of Edinburgh, Vol. XV., Part 1, 1884.
2. Journal of the Anthropological Institute of Great Britain and Ireland, Vol. XIII., No. 4.

   Journal of the Anthropological Institute of Great Britain and Ireland, Vol. XIV., No. 1.
3. Proceedings of the Society of Antiquaries of Scotland, Vol. IV., N. S., 1881-82.

   Proceedings of the Society of Antiquaries of Scotland, Vol. V., N. S., 1882-83.

   Also to complete the set :

   Vol. I., Parts 1, 2 and 3, 1851-54.

   Vol. II., Parts 1 and 3, 1854-57.

   Vol. V., Part 2, 1863-64.

   Vol. IX., Part 1, 1870-71.

   Vol. XI., Part 2, 1875-76.

   Vol. XII., Parts 1 and 2, 1876-78. 12 numbers.
4. Journal of the Transactions of the Victoria Institute, Vol. XVIII., Nos. 69 and 70.

5. Archaeologia Aeliana, Vol. X., No. 1, N. S.
6. Proceedings of the Royal Geographical Society, N. S., Vol. 6, Nos. 6, 7, 8, 9 and 10, June to October, 5 numbers.
7. Proceedings of the Society for Psychical Research, Parts 1 to 5.
8. Journal of the Royal Microscopical Society, Series II., Vol. IV., Parts 3, 4 and 5, June to October, 3 numbers.
9. Minutes and Proceedings of the Institution of Civil Engineers, Vol. 76.
   " " " " " " Vol. 77.
10. Journal of the Quekett Microscopical Club, Series II., Vol. 1, Nos. 1–9, March, 1882, to July, 1884.
11. Trübner's American, European and Oriental Literary Record, Nos. 197 to 200.
12. Annual Report of the Leeds Philosophical and Literary Society, for 1883–84.
13. Monthly Notices of the Royal Astronomical Society, Vol. XLIV., Nos. 1 to 8, November, 1883, to June, 1884.
14. Proceedings of the Royal Colonial Institute, Vol. XV., 1883-84.
15. Transactions of the Manchester Geological Society, Vol. XVII., Parts 16, 17 and 18.
16. Memoirs of the Literary and Philosophical Society of Manchester :

    2 Series, Vol. II.
    3 Series, Vols. VII and VIII.
    Proceedings of same Society, Vol. XX., 1880-81.
    " " " Vol. XXI., 1881-82.
    " " " Vol. XXII., 1882-83.

Total Great Britain and Ireland, 63 numbers.

IV.—BRITISH COLONIES (EXCLUSIVE OF CANADA).

1. Papers and Proceedings of the Royal Society of Tasmania for 1882.
2. Records of the Geological Survey of India, Vol. XVII., Parts 2 and 3.
   Memoirs of the Geological Survey of India, Vol XX., Parts 1 and 2.
   Palæontologia Indica :

    Series X., Vol. III., Part 1.
    " " " 2.
    " " " 3.
    Series XIV., Vol. 1-3, Fas. III.

3. Proceedings of the Asiatic Society of Bengal, No. II., February, 1884.
   " " " " " Nos. III., IV., and V., March to May, 1884.
   Journal of the Asiatic Society of Bengal, Vol. LII., Part I., Nos. 1, 2, 3 and 4, 1883.

    Vol. LIII., Part I., No. 1, 1884.
    Vol. LIII., Part II., No. 1, 1884.

4. Transactions and Proceedings of the New Zealand Institute for 1883, Vol. XVI.
5. Journal of the Royal Society of New South Wales for 1882, Vol. XVI.

Total British Colonies, 20 numbers.

V.—FOREIGN EXCHANGES.

1. Mittheilungen der Anthropologische Gesellschaft in Wien, XIV. Band, 1 Heft, 1884.
2. Atti del Società Toscana di Scienze Naturali :
   Memoirs, Vol. VI., Fas. 1, Processi Verbali. Indici dei Volumi II., III. and IV., pp. 53 to 70.
3. Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils, Mars, Avril et Mai, 1884.
4. Mémoires de la Société Royale des Antiquaires du Nord, N. S., 1880.
5. Revista Trimensal do Instituto Historico Geographico e Ethnographico do Brazil, Tomo XLVI., Parte 1 e 2.
6. Correspondenz-Blatt der Deutschen Gesellschaft fur Anthropologie, Ethnologie, und Urgeschichte, XV. Jahrgang, for April, May, June, July and August, 1884, 5 numbers.
7. Oversigt over det K. Danske Videnskabernes Selskabs Forhandlinger, 1883.
   Bulletin, No. 3, October to December, 1884.
   Bulletin, No. 4, January to March, 1884.
8. Le Globe, Tome III. :
   Bulletin, No. 1.
   Bulletin, No. 2.
   Mémoires, Septembre, 1884.
9. Bulletin de la Société Géologique de France :
   3 Série t. X., No. 7, Feuilles 33–44, 1882.
   " t. XI., No. 8, " 40–48, 1883.
   " t. XII., No. 7, " 26–32, 1884.
10. Astronomische, Magnetische und Meteorologische, Beobachtungen an der K. K. Sternwarte, zu Prag, 1883.
11. Boletin de la Academia Nacional de Ciencias in Cordoba (Republica Argentina), Tomo VI., Entrega 1*a*, 1884.
12. Verhandlungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, Sitzung vom 19 Januar, 1884.
    Sitzung vom 16 Februar ; vom 15 März und 19 April, 4 numbers.
13. Archivio per L'Antropologia e la Etnologia e Psicologia Comparata, Quattordicesimo Volume, Firenze, Fasicolo Primo, 1884.
14. Ymer Tidskrift Utgifven af Svenska Sällskapet för Anthropologi Och Geografi, 1884, 1 to 4 Häftet.
15. Archives Néerlandaises des Sciences Exactes et Naturelles, Vol. XIX., No. 2.
    Do., to complete a set:
    Tomes I. to VIII.
    " IX., Livraisons, 1, 2, 3.
    " XIII., " 4, 5.
    " XVI., " 3, 4, 5.
    " XVIII., " 2, 3, 4, 5.
    " XIX., " 1.
16. Bulletin de la Société d'Anthropologie de Paris, Tome Septieme (III. Série) 1 and 2, Fascicules, Janvier à Mars, 1884, et Mars à Mai, 1884.

17. Bulletin de la Société Royale de Botanique de Belgique, Tome Vingt-deuxième.
18. Sitzungsberichte der Naturforschende Gesellschaft zu Leipzig, Neunter Jahrgang, 1882, und Zehnter Jahrgang, 1883.
19. Arbók hins Islenzka Fornleifafélags. 1883, (Icelandic Archaeological Society) Reykjavik, 1884.
20. Verhandlungen der Naturhistorischen Vereines der Preussischen Rheinlande und Westfalens.
    Vierzigster Jahrgang, Zweite Hälfte.
    Ein und vierzigster Jahrgang, Erste Hälfte, Bonn, 1883–84.
21. Allgemeine Grundzüge der Ethnologie. von Prof. Dr. Adolf Bastian, Berlin, 1884.
22. Archives du Musée Teyler, Série II., Vol. I., Quatrième Partie.
23. Programme de la Société Hollandaise des Sciences à Harlem, 1883.
24. Verhandlungen der K. K. Zoologisch-Botanische Gesellschaft in Wien, Jahrgang 1883, Band XXXIII.
25. Brasilische Säugethiere Beiheft zu Band XXXIII.
26. Mittheilungen der K. K. Geographischen Gesellschaft in Wien, 1883, XXVI. Band.
27. Nachrichten von der K. Gesellschaft der Wissenschaften und der Georg Augusts Universität zu Göttingen, 1883, 1 to 13.
28. Dreiundzwanzigster Bericht der Oberhessischen Gesellschaft für Natur und Heilkunde, Giessen im Juni, 1884.
29. Jahrbuch der K. K. Geologischen Reichsanstalt. Jahrgang 1883, XXXIII. Band.
    No. 4, October, November und December.
    Do., Jahrgang 1884, XXXIV. Band, Hefte 1, 2, 3, Wien, 1884.
30. Sitzungsberichte der philosophisch-philologischen und historischen Classe der K. B. Akademie der Wissenschaften zu München, 1883, Hefte 1, 2, 3, 4.
31. Sitzungsberichte der mathematisch-physikalischen Classe der K. B. Akademie der Wissenschaften zu München, Hefte 1, 2, 3.
32. Anales del Museo Nacional de México. Tomo III., Entrega 6a.
33. Ueber Herkunft und Sprache der Transgangetischen Völker, Von Ernst Kulm.
    Akademie der Wissenschaften zu München, am 25th Juli, 1881.
34. Gedächtnissrede auf Karl Von Halm, Von Eduard Wölfflin, 28 März, 1883.
35. Ueber die Methoden in der botanischen Systematik insbesondere die anatomische Methode, Von Ludwig Radlkofer, 25 Juli, 1883.
36. Schriften der physikalisch-ökonomischen Gesellschaft, zu Königsberg, vierundzwanzigster Jahrgang, 1883, Abtheilungen 1 und 2.
37. Verhandelingen der K. Akademie van Wetenschappen, XXIII. Deel, Amsterdam, 1883.
38. Verslagen en Mededeelingen der K. Akademie van Wetenschappen. Adfeeling Natuurkunde. Tweede Reeks, Deel XVIII., Amsterdam, 1883.
39. Jaarboek van de K. Akademie van Wetenschappen, Amsterdam, 1882.
40. Verhandlungen der Gesellschaft für Erdkunde zu Berlin, Band XI., Nos. 1, 2, 3, 4, 5.

Total Foreign, 93 numbers.

Professor Young then read a paper on the "Solutions of Equations of the Fifth Degree" The object of the paper was, in the first place, to determine the criterion of the solubility of the quintic equation; and next, assuming the conditions of solubility to exist, to solve the equation

A short discussion followed, in which Mr. Livingston and Prof. Galbraith took part.

Prof. J. Loudon also read a paper entitled :—

GEOMETRICAL METHODS CHIEFLY IN THE THEORY OF THICK LENSES.

1. In cases of reflection or refraction at a spherical surface, or a combination of spherical surfaces, or lenses, if F, F′ be the primary and secondary principal foci of the surface, lens, or combination, and (P, P′), (R, R′) pairs of conjugate points, it is known that

$$\frac{f}{p}+\frac{f'}{p'}=1 \qquad \qquad (1)$$

where $f = \mathrm{RF}$, $p = \mathrm{RP}$, $f' = \mathrm{R'F'}$, $p' = \mathrm{R'P'}$; and where the positive direction from R for f and p is opposite to, whilst that from R′ for f' and p' is the same as, the direction of the incident pencil.

Now since the relation (1) expresses the condition that the line $\frac{x}{p}+\frac{y}{p'}=1$ passes through the point (f, f'), it follows that if the coincident lines FRR′F′, FRR′F′ be separated so that R on the x or object-axis coincides with R′ on the y or image-axis, the line joining P on the former to P′ on the latter will always pass through the fixed point (f, f'). Hence we derive a geometrical method for determining the point conjugate to any given one.

The points R, R′ from which distances are measured, it is to be observed, are any two conjugate points, such, for example, as the principal points, or nodal points; and they may in particular cases coincide when they are self-conjugate.

It is proposed in the following paper to employ the method indicated chiefly in discussing certain propositions in the theory of thick lenses.

I.

2. In the case of refraction at a single spherical surface

$$\frac{f}{p}+\frac{f'}{p'}=1$$

where f, f' are the distances of the primary and secondary principal foci F, F', and p, p' the distances of the object and image P, P', from A, the point where the principal axis meets the sphere.

Let the standard case be that of refraction into a denser medium, whose surface is convex, the direction of the light being from left to right. Then drawing axes AF, AF', and taking the point X (f, f'), as in Fig. 1, we see that the point conjugate to P on one axis is the intersection of PX with the other.

It appears from the figure that A is a self-conjugate point, as also O, FO being equal to FX.

3. From similar triangles PFX, XF'P', it is immediately seen that

$$ff' = dd',$$

where $\mathrm{PF} = d$, $\mathrm{P'F'} = d'$.

If the rule of signs (§ 1) be applied to the measurement of d, d' on the two axes, it is to be observed that they are of the same sign, both being negative, for example, in Fig. 1.

4. If P, P' are conjugate points, as also Q, Q', then drawing PXP', QXQ', as in Fig. 1, we have

$$dd' = (d + \mathrm{PQ})\,(d' - \mathrm{P'Q'})$$

which reduces at once to

$$-\frac{d}{\mathrm{PQ}} + \frac{d'}{\mathrm{P'Q'}} = 1.$$

This is of the form

$$\frac{d}{\mathrm{D}} + \frac{d'}{\mathrm{D'}} = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where the distances d, D are measured from P, and d', D' from its conjugate P', the rule of signs being that already referred to in § 1.

5. Fig. 2 exhibits the construction adapted to formula (2). P in the x axis coincides with its conjugate P' in the y axis, and the line joining any other two conjugate points (Q, Q') on the two axes passes through the point (d, d').

If the origin be the self-conjugate point O, the centre of the sphere, the relation (2) becomes

$$\frac{f'}{p} + \frac{f}{p'} = 1,$$

where (Fig. 3) $\mathrm{OF} = f'$, $\mathrm{OP} = p$, &c.

As in § 3 we have $dd' = f'f$.

6. The following proposition which is employed by Helmholtz (*vide* Optique Physiologique, p. 72), I have modified by changing his notation and applying the rule of signs (§ 1), in order to exhibit the result of the elimination in a symmetrical form.

Let there be any number of spherical refracting surfaces whose principal foci are (F_1, F'_1), (F_2, F'_2), &c., and which cut the common principal axis in A, B, C, . . . Let (R_0, R_1), (R_1, R_2) . . . be pairs of conjugate points, such that $R_0F_1 = d_0$, $R_1F'_1 = d'_1$, . . . In like manner let (P_0, P_1), (P_1, P_2) . . . be any other set of conjugate points. such that $R_0P_0 = p_0$, $R_1P_1 = p'_1$, . . . Then by § 4

$$\frac{d_0}{p_0} + \frac{d'_1}{p'_1} = 1.$$

$$\frac{d_1}{p_1} + \frac{d'_2}{p'_2} = 1, \text{ \&c.}$$

Also by the rule of signs (§ 1) we have $p_1 = -p'_1$, $p_2 = -p'_2$, . . . Hence, on eliminating these quantities, the position of P_n, the point conjugate to P_0 with reference to the system, is determined from an equation of the form

$$\frac{f}{p_0} + \frac{f'}{p'_n} = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $f = R_0F$, $f' = R_nF'$, F, F′ being the principal foci of the system.

The values of $\dfrac{f}{d_0}$ for 2, 3, 4 . . . refractions are, respectively,

$$\frac{d_1}{d_0 + d'_1}, \quad \frac{d_1 d_2}{d_1 d_2 + d'_1 d_2 + d'_1 d'_2}, \quad \frac{d_1 d_2 d_3}{d_1 d_2 d_3 + d'_1 d_2 d_3 + d'_1 d'_2 d_3 + d'_1 d'_2 d'_3}, \ldots$$

and the corresponding values of $\dfrac{f'}{d'_2}, \dfrac{f'}{d'_3}, \dfrac{f'}{d'_4}$, are

$$\frac{d'_1}{d_1 + d'_1}, \quad \frac{d'_1 d'_2}{d_1 d_2 + d'_1 d_2 + d'_1 d'_2}, \quad \frac{d'_1 d'_2 d'_3}{d_1 d_2 d_3 + \ldots}, \ldots$$

7. The construction of § 5 (Fig. 2) applies to equation (3), and from the figure we at once deduce, as in §§ 3, 4, the general relations

$$dd' = ff', \ \frac{d}{D} + \frac{d'}{D'} = 1.$$

The latter, it may be observed, also follows from (3), since R_0, R_n are *any* conjugate points.

8. The principal foci F, F′ of a system of two surfaces S_1, S_2 constituting a lens may be found as follows :—

Let (F_1, F'_1), (F_2, F'_2) be the principal foci of S_1 and S_2, which cut the principal axis in A, B, respectively, so that $AF_1 = f_1$, $AF'_1 = f'_1, \ldots$ In Fig. 4 take the points X_1 (f_1, f'_1) referred to A as origin, and X_2 (f_2, f'_2) referred to B. Then since parallel rays on emergence from the system come from F_2, F_2 is the image of F in S_1. Therefore the line joining X_1 and F_2 on the y axis will cut the x axis in F.

Again, since parallel rays on incidence go to F'_1 and thence to F′, F′ is the image of F'_1 in S_2. Therefore the line joining X_2 and F'_1 on the x axis will give F′ on the y axis.

The principal foci of any system of surfaces may be determined in like manner.

9. In the case of a lens the distances AF, BF′ may be readily found as follows in terms of $f_1, f_2, \ldots$

From the similar triangles FAF_2, $X_1F'_1F_2$ (Fig. 4) we have

$$\frac{AF}{AF_2} = \frac{F'_1X_1}{F'_1F_2}, \text{ that is } \frac{AF}{f_2 - e} = \frac{f_1}{f'_1 + f_2 - e};$$

where $AB = e$.

Also from the similar triangles $F'BF'_1$, $X_2F_2F'_1$

$$\frac{BF'}{BF'_1} = \frac{F_2X_2}{F_2F'_1}, \text{ or } \frac{BF'}{f'_1 - e} = \frac{f'_2}{f'_1 + f_2 - e}.$$

These values can also be deduced from the relation of § 3. Thus, taking the x axis of the figure,

$$F_1F \,.\, F'_1F_2 = f_1 f'_1, \text{ \&c.}$$

10. In the system referred to in § 6 the lengths of the images $(\omega_1, \omega_2 \ldots)$ which an object ω_0 at R_0 produces at R_1, $R_2 \ldots$ may be determined as follows :—

Let O_1 be the centre and f_1, f'_1 the principal focal lengths of S_1, &c.

Then (Fig. 5)

$$\frac{\omega_1}{\omega_0} = \frac{O_1R_1}{O_1R_0} = \frac{F_1X}{F_1R} = \frac{f_1}{d} = \frac{d}{f}$$

In like manner,

$$\frac{\omega_2}{\omega_1} = \frac{f}{d} = \frac{d'_2}{f}, \text{ \&c.}$$

From these relations we find

$$\frac{\omega_2}{\omega_0} = \frac{d'_1 d'_2}{f'_1 f'_2} = \frac{f_1 f_2}{d_0 d_1},$$

$$\frac{\omega}{\omega_0} = \frac{d'_1 d'_2 d'_3}{f'_1 f'_2 f'_3} = \frac{f_1 f_2 f_3}{d_0 d_1 d_2}, \text{ \&c.}$$

Hence if $\omega_0 = \omega_n$, each of the nth equalities becomes equal to 1, and the points R_0, R_n the principal points of the system.

Thus, if $n = 2$, $d_0 d_1 = f_1 f_2$, and $d'_1 d'_2 = f'_1 f'_2$.

Also, since $AR_1 = f'_1 - d'_1$, $BR_1 = f_2 - d_1$, we have

$$d_1 + d'_1 = f'_1 + f_2 - e;$$

and the values of the principal focal lengths become

$$f = \frac{f_1 f_2}{f'_1 + f_2 - e}, \quad f' = \frac{f'_1 f'_2}{f'_1 + f_2 - e}.$$

11. Now let R, R′ be the principal points, F, F′ the principal foci of a thick lens; so that we have

$$\frac{f}{p} + \frac{f'}{p'} = 1. \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Fig 6, in which X is the point (f, f'), exhibits the method of finding the conjugate of a given point.

12. Conjugate points will be nodal points N, N′ when on the x axis we have NN′ = RR′. This will evidently happen when (Fig. 6) the line through X makes FN = FX. RN $(= f' - f)$ on the x axis will then be equal to R′N′ on the y axis.

If distances are measured from the nodal points N, N′, equation (4) becomes $\frac{f'}{p} + \frac{f}{p'} = 1$, in which f', p are measured from N, and f, p' from N′; and the conjugate points are determined as in Fig. 7.

13. These figures make the existence of self-conjugate points manifest. Thus in Fig. 7, if S is such a point, we have

$$\text{FS}.\ \text{F'S} = ff', \quad \text{FS} + \text{F'S} = \text{FF'} = 2h.$$

Hence FS, F′S are the roots of $s^2 - 2hs + ff' = 0$, and the self-conjugate points are at equal distances from F, F′.

14. Fig. 8 exhibits the construction when one of the self-conjugate points is taken as origin.

From the similar triangles PP′P, S′P′X, and also PSP, FSF, we obtain the relations

$$\frac{\text{PSP'}}{\text{S'P}} = \frac{\text{PP}}{\text{S'X}} = \frac{\text{PP}}{\text{FF}} = \frac{\text{SP}}{\text{SF}}.$$

15. If F is the image of K, and K′ of F′, then on the x axis of Fig. 8 we have

$$FK \, . \, FF' = FS \, . \, F'S = FF' \, . \, F'K'$$

Hence

$$FK = F'K' = \frac{ff'}{2h}.$$

Also, if T, T′ are conjugates such that FT = F′T′, then

$$FT^2 = FT \, . \, F'T' = ff'.$$

It thus appears that the middle point of FF′ also bisects the lines KK′, SS′, RN′, R′N, TT′ and (*vide* § 28) VV′.

16. The method of § 6 may be applied as follows to a system of lenses.

Let there be any number of lenses L_1, L_2, . . . whose principal foci are (F_1, F'_1), (F_2, F'_2) . . . , and whose principal planes cut the common axis in (A, A′), (B, B′) . . .

Let (R_0, R_1), (R_1, R_2) . . . be pairs of conjugate points such that $R_0F_1 = \delta_0$, $R_1F'_1 = \delta'_1$, $R_1F_2 = \delta_1$, . . . In like manner let (P_0, P_1), (P_1, P_2), . . . be any other set of conjugate points such that $R_0P_0 = p_0$, $R_1P_1 = p'_1$, . . .

Then (§ 7)

$$\frac{\delta_0}{p_0} + \frac{\delta'_1}{p'_1} = 1.$$

$$\frac{\delta_1}{p_1} + \frac{\delta'_2}{p'_2} = 1. \text{ \&c. ;}$$

from which by eliminating $p_1 = -p'_1$, $p_2 = -p'_2$, . . . we get an equation of the form

$$\frac{f}{p_0} + \frac{f'}{p'_n} = 1.$$

where $f = R_0F$, $f' = R_nF'$, F, F′ being the principal foci of the system.

17. The principal foci F, F′ of a system of lenses may be determined geometrically as in § 8.

Thus, let there be two lenses L_1, L_2, whose principal foci are (F_1, F'_1), (F_2, F'_2), and principal points (R_1, R'_1), (R_2, R'_2). Then (Fig. 9), since parallel rays on emergence come from F_2, F_2 is the image of F in L_1. Hence the line joining X_1 and F_2 on the y axis gives F on the x axis.

Again, since parallel rays on incidence go to F'_1, and thence to F', F' is the image of F'_1 in L_2. Hence the line joining X_2 and F'_1 on the x axis gives F' on the y axis.

In the construction, of course, any pairs of conjugate points may be employed instead of the principal points.

18. In the system of § 16 the lengths of the images $(\omega_1, \omega_2 \ldots)$ which an object ω_0 at R_0 produces may be determined as follows :—

Let (f_1, f'_1), $(f_2, f'_2) \ldots$ be the principal focal lengths of L_1, $L_2, \ldots$

Then, since (§ 20) in a thick lens the ratio of the lengths of object and image is that of their respective distances from the nodal points, we have (Fig. 10),

$$\frac{\omega_1}{\omega_0} = \frac{N'_1R_1}{N_1R_0} = \frac{F_1X}{F_1R_0} = \frac{f_1}{\delta_0} = \frac{\delta'_1}{f'_1}.$$

In like manner we have

$$\omega_2 = \omega_1\frac{f_2}{\delta_1} = \omega_1\frac{\delta'_2}{f'_2}$$

$$= \omega_0\frac{f_1f_2}{\delta_0\delta_1} = \omega_0\frac{\delta'_1\delta'_2}{f'_1f'_2}\text{; \&c.}$$

Hence if $\omega_0 = \omega_n$, R_0, R_n become the principal points of the system, and

$$\delta_0\delta_1 \ldots = f_1f_2 \ldots$$

$$\delta'_1\delta'_2 \ldots = f'_1f'_2 \ldots$$

19. The equation for the system of lenses being $\dfrac{f}{p} + \dfrac{f'}{p'} = 1$, referred to principal points, the corresponding equation, when the nodal points are origins, becomes $\dfrac{f'}{p} + \dfrac{f}{p'} = 1$, in which f', p are measured from N, and f, p' from N'.

20. The lengths of object and image at various pairs of conjugate points may now be compared.

Thus (Fig. 7), if ω at P gives ω' at P', we have †

$$\frac{\omega + \omega'}{\omega'} = \frac{PR}{RF} = \frac{PF}{RF} + 1.$$

† *Vide* Croullebois, *Lentilles épaisses*, p. 32.

Therefore

$$\frac{\omega}{\omega'}=\frac{\mathrm{PF}}{\mathrm{FX}}=\frac{\mathrm{PN}}{\mathrm{P'N'}},$$

the relation on which is based the definition of nodal points.

It would seem preferable, however, after having proved the existence of nodal points †, to reverse these steps, and from $\frac{\omega}{\mathrm{PN}}=\frac{\omega'}{\mathrm{P'N'}}$, to deduce $\frac{\omega}{\omega'}=\frac{\mathrm{PF}}{\mathrm{FX}}$, &c.

21. Again, if ω at N gives ω' at N′,

$$\frac{\omega f}{\mathrm{RN}}=\frac{\omega' f'}{\mathrm{R'N'}}.$$

Therefore

$$\frac{\omega}{f'}=\frac{\omega'}{f},$$

that is, the apparent magnitude of ω at F is equal to that of ω' at F′.

22. If ω at S gives ω' at S, then (Fig. 7) from the similar triangles SNS, SF′X, XFS we have

$$\frac{\omega}{\omega'}=\frac{\mathrm{NS}}{\mathrm{N'S}}=\frac{f'}{\mathrm{SF'}}=\frac{\mathrm{SF}}{f}.$$

In like manner if ω at S′ gives ω'' at S′ we have

$$\frac{\omega}{\omega''}=\frac{\mathrm{SF'}}{f}=\frac{f'}{\mathrm{SF}}.$$

Hence from the last two relations

$$\frac{\omega}{f'}=\frac{\omega'}{\mathrm{SF'}}=\frac{\omega''}{\mathrm{SF}}.$$

23. If ω at K gives ω' at F, and ω at F′ gives ω'' at K′, then (Fig. 7)

$$\frac{\omega}{\omega'}=\frac{\mathrm{NK}}{\mathrm{N'F}}=\frac{\mathrm{F'X}}{\mathrm{F'F}}=\frac{f'}{2h},$$

and

$$\frac{\omega}{\omega''}=\frac{\mathrm{NF'}}{\mathrm{N'K'}}=\frac{\mathrm{FF'}}{\mathrm{FX}}=\frac{2h}{f}.$$

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† *Vide* Helmholtz, *Optique physiologique*, p. 75.

II.

24. The geometrical method of the preceding sections may also be extended to the case of reflection at one or more spherical surfaces. A few examples will suffice to illustrate the method.

Thus for a convex mirror F and F′ are coincident; f is negative and f' positive, and formula (1) becomes

$$-\frac{f}{p}+\frac{f}{p'}=1.$$

Hence the line joining conjugate points on the two axes passes through X $(-f, f)$, as in Fig. 11.

For a concave mirror the formula is

$$\frac{f}{p}-\frac{f}{p'}=1,$$

and X is $(f, -f)$, as in Fig. 12.

25. In either case we have, from the similar triangles PFX, XF′P′ (Fig. 11 or 12),

$$\frac{\mathrm{PF}}{\mathrm{FX}}=\frac{\mathrm{F'X}}{\mathrm{P'F'}},$$

that is

$$dd'=f^2,$$

which is Newton's formula.

If d and d' be measured respectively from P and P′ in accordance with the rule of signs (§ 1), this formula should be written

$$dd'=-f^2,$$

as appears by deducing it from the relation $dd'=ff'$ of § 3.

26. The relation between the lengths of the object and image is most readily obtained by making the axes cross at O, the centre of the mirror.

Thus for a convex mirror we have (Fig. 13)

$$\frac{\omega'}{\omega}=\frac{\mathrm{OP'}}{\mathrm{OP}}=\frac{\mathrm{FX}}{\mathrm{PF}}=\frac{f}{d}.$$

In the case either of a convex or a concave mirror it may be remarked that, if account be taken of the signs of f, f', d, d', the relation

$$\frac{\omega'}{\omega}=\frac{f}{d}=\frac{d'}{f'},$$

determines whether the image is erect or inverted, the sign of $\dfrac{\omega'}{\omega}$ being positive in the former case, and negative in the latter.

27.* The method may also be applied to determine the spherical aberration of mirrors.

Thus in the case of a concave mirror if distances are measured from the centre O, and if the incident ray PI is reflected at I so as to cut the axis after reflection in P″ we know that

$$-\frac{f\sec a}{p}+\frac{f\sec a}{p''}=1,$$

where a is the angle AOI, OP $=p$, and OP″ $=p''$.

But, P′ being conjugate to P, we have

$$-\frac{f}{p}+\frac{f}{p'}=1,$$

where OP′ $=p'$.

Hence, if the separated axes cross at O, as in Fig. 15, whilst PP′ always passes through X $(-f, f)$, PP″ always passes through Y $(-f\sec a, f\sec a)$. P′P″ on the y axis will accordingly represent the longitudinal aberration, whose direction is seen from an inspection of the figure to be from O to A except when P lies between F and G.

The value of the aberration may be determined by comparing the similar triangles POP′, PFX, POP″, PGY. Thus

$$\frac{\mathrm{P'P''}}{p}=\frac{p''-p'}{p}=\frac{f\sec a}{p+f\sec a}-\frac{f}{p+f}.$$

whence we get $\mathrm{P'P''}=\dfrac{p^2f(1-\cos a)}{(p+f)\,(p\cos a+f)}$, the ordinary expression.

If PF $=d$, and PG $=\triangle$, we also have

$$\frac{p''-p'}{p}=\frac{\triangle-p}{\triangle}-\frac{d-p}{d}$$

$$=\frac{p}{d}-\frac{p}{\triangle}.$$

Therefore $p''-p'=p^2\left(\dfrac{1}{d}-\dfrac{1}{\triangle}\right)$.

It may be remarked that FG is the principal longitudinal aberra-

* This section was added December, 1884.

tion, and that the figure also gives the relation $\triangle\triangle' = f^2 \sec^2 \alpha$, where $\triangle' = P''G$.

In the case of a convex mirror X and Y will lie in the opposite quadrant and the longitudinal aberration will be found to be

$$p^2\left(\frac{1}{\triangle} - \frac{1}{d}\right).$$

III.

28. Since writing the above it has occurred to me that the relation $dd' = ff'$ leads to two other simple geometrical methods for exhibiting the relations between the conjugate points.

Thus if we separate the two axes FF′, FF′ so that F in the x axis coincides with F′ in the y axis, as in Fig. 14, then evidently the feet of the ordinates drawn from any point on the hyperbola $xy = ff'$ will be conjugate to one another. This construction gives us a readier means of finding many of the points whose positions have already been discussed.

Thus self-conjugate points are at once given by

$$x\,(2h - x) = ff';$$

and the points K, K′ (§ 15) by

$$2hx = ff'.$$

Again, H being the middle point of FF′, if H is the image of G, and J of H, we have

$$F'J = \frac{ff'}{h} = 2FK = FG.$$

29. From the construction of the preceding section it appears that the lines joining pairs of conjugate points on the two axes touch the hyperbola

$$4xy = ff'.$$

Fig. 14 shows that the conjugate points V, V′ are equidistant from H, the middle point of FF′, and that

$$FV = F'V' = FT = \sqrt{ff'}.$$

Prof. Galbraith, Mr. Wm. Houston, and Mr. A. Baker took part in the discussion which followed.

SECOND ORDINARY MEETING.

The Second Ordinary Meeting of the Session 1884-'85, was held on Saturday, November 8th, the President, Prof. W. H. Ellis, in the Chair.

The minutes of last meeting were read and confirmed.

The following gentlemen were elected members of the Institute :—

T. J. Mulvey, B.A., T. A. Haultain, B.A., H. R. Wood, B.A., J. H. Bowes, B.A., Charles Whetham, B.A., J. C. Smoke, M.A., Geo. G. S. Lindsey, B.A., F. C. Mensinga, Esq., W. Dale, M.A., W. A. Frost, B.A., Geo. Inglis, B.A., John Nairn, Esq., J. D. Barnett, Esq., D. H. Talbot, Esq., Prof. T. Nelson Dale, Rev. George Burnfield, M.A.

The following list of donations and exchanges received since last meeting was read :

1. The Canadian Practitioner for November, 1884.
2. Science, Vol. IV., No. 91, October 31st, 1884.
3. Science Record, Vol. II., No. 12, October 15th, 1884.
4. Journal of the Franklin Institute for November, 1884.
5. Proceedings of the Cambridge Philological Society, Vols. VII. and VIII., Lent and Easter Terms, 1884.
6. Bulletin de la Société d'Anthropologie de Paris, Tome Septième (IIIe Serie) 3e Fascicule, Mai à Juillet, 1884.

Prof. T. Nelson Dale then read the following paper :—

ON METAMORPHISM IN THE RHODE ISLAND COAL BASIN.

Sir Charles Lyell, in a paper read before the Geological Society of London in 1844, called the attention of British Geologists to the occurrence near Worcester, in Massachusetts, of a bed of Plumbago and Anthracite, which he was inclined to believe belonged to the Carboniferous Formation.* The Geological Survey of Rhode Island by Dr. Jackson, published in 1840, that of Massachusetts by President Edward Hitchcock in 1841, a short paper by the same on the Rhode Island coal field in 1853, as well as two papers by his son,

* Ch. Lyell, On the probable age and origin of a bed of Plumbago and Anthracite occurring in Mica-schist near Worcester, Mass.—Quarterly Journal of the Geological Society of London, Vol. I., 1845. See also on the Worcester beds the following paper, which has appeared since mine was read. Joseph H. Perry, Note on a Fossil Coal Plant found at the Graphite deposit in Mica-schist, at Worcester, Mass.—American Journal of Science, Vol. XXIX., p. 157, Feb., 1885.

Prof. Ch. H. Hitchcock, in 1860, have clearly established the fact that there extends from the vicinity of Worcester, Mass., to the southern extremity of Rhode Island, a more or less broken belt of rocks of Carboniferous age; and these writers all concur in describing these rocks as materially different from those of the best known coal fields. Instead of Bituminous coal or of Anthracite, we find there a plumbaginous Anthracite; instead of the accompanying clays and clay-slates, we find clay-slates and Mica-schists. The southern portion of the belt, at least, is traversed by numerous Quartz veins, and all the rocks and minerals of the region indicate varying degrees of metamorphism. During the last few years the writer has devoted considerable time to the construction of a geological map of the vicinity of Newport, R. I., and of a geological section across the entire basin, which at that point measures some fifteen miles in width. Since the publication of the results of this work, in extending during last summer the observations northwards, I came upon a locality where the metamorphism of the coal-measures had proceeded further than it is supposed to have done even in that region. The object of this paper is to give a brief statement of these observations.

[In order, however, to show their general bearing the following condensed summary of the writer's former papers on the stratigraphy of the vicinity of Newport is here given.* On either side of the basin we have areas of Protogine and Gneiss (A), and in the centre two isolated masses of stratified Protogine. Closely allied to this we have on the west side of the basin a long strip of Mica-schist (B), some of which contains rounded quartz pebbles, and is traversed both horizontally and vertically by veins of Granite. Not far from the juncture of the Gneiss and Mica-schist is a bed of granular Plumbago. A and B may be of Montalban or even of Huronian age. Then follow certain beds of Hornblende, Chlorite and Mica-schist (C), and of Epidote and Chlorite-schist (D), which may be synchronous. A series of strata similar to C, and probably of Silurian age, occurs in Connecticut.†

The next series (E) consists of Chloritic Argillytes with passages of Calcite, nodules of Jasper and some thick layers of Dolomite. Its age is doubtful.

* A contribution to the Geology of Rhode Island. Proceedings of the Boston Society of Natural History, Vol. XXII., Jan. 3rd., 1883. A contribution to the Geology of Rhode Island. American Journal of Science, Vol. XXVII., March and April, 1884. (In the Section on Pl. VI. of this paper the unconformity between the Coal-measures and the Protogine should probably have been represented rather as a thinning out of the Coal-measures in contact with Protogine beds of originally conformable stratification.) Remarks on some of the evidences of Geological disturbance in the vicinty of Newport. Proceedings of the Newport Natural History Society, 1883-4.

† See James D. Dana, On Rocks of Helderberg Era in the Valley of the Connecticut, etc. American Journal of Science, Vol. VI., p. 339, 1873.

Prof. T. S. Hunt, of Montreal, is disposed on chemical and lithological grounds to assign both this and the following to the Huronian. The next is a Siliceous Argillyte (F) passing into an impure Serpentine, with, however, some seams of Talc and Precious Serpentine. The relative age of this and the preceding series is difficult to make out. However, together with fragments of A, C. and E, it seems to have constituted an island some four miles in diameter in the midst of the Carboniferous marsh or estuary. All the rocks described above are presumably of Pre-Carboniferous age, and upon the different members of this series, for they do not seem to have been uniformly deposited, the Carboniferous rocks were laid down. The lowest bed of Carboniferous age is a conglomerate of fine Quartz pebbles with some argillaceous matter, metamorphosed into a dark, compact, siliceous rock, containing here and there a layer of black slate with *Annularia longifolia* (G). This probably belongs to the "Millstone Grit." The overlying bed is a Sideritic Argillyte (H)—a finely laminated slate generally with minute nodules of carbonate of iron with a crystalline structure. Then a thick bed of coarse conglomerate (I), the pebbles and boulders of which consist of a micaceous Quartzite, and contain in some localities Lingulæ. Minute crystals of Magnetite abound in the cement of this conglomerate. The pebbles are often coated with scales of Mica, and the shells of the Lingulæ are sometimes plumbaginous. Lastly, we have the Coal-measures proper consisting of alternating conglomerates, sandstones, clay slates and Mica-schists, together with several seams of plumbaginous Anthracite (J). About sixty species of coal plants occur in the slates of this series—mainly of the genera: Annularia, Calamites, Lepidodendron, Neuropteris, Odontopteris, Pecopteris and Sphenophyllum. The impressions are sometimes coated with Talc or Pyrite. The latest analysis of this coal * afforded the following extremes in nine analyses: Carbon 67—79 %, Ash 11—17 %, Volatile combustible 4½—7¼ %, Water 2¼—10¼ %. The Ash contains from 50—75 % of Silica. This coal, as stated by Dr. Emmons, possesses the property, after being dried at 115° Centigrade, of absorbing, when exposed to a N.W. wind, over 13 % its own weight of water, and, when placed over water, 22½ %. Veins of Quartz and of Asbestus traverse the coal seams.

The Pre-Carboniferous beds measure at least from 4,000 to 7,700 feet, the Carboniferous from 4,000 to 5,500, and in other parts of the basin perhaps 8,000 feet. All the beds have been folded parallel to the Appalachian chain, and the last flexure probably took place at the close of the Carboniferous Period. The beds were also flexed, though on a much smaller scale, in the opposite direction, indicating a pressure operating N.N.E.—S.S.W., as well as one W.N.W.—E.S.E.]

In the western part of the basin, along the West Passage of Narraganset Bay, the strata of the Coal-measures are much disturbed, being in places vertical or folded over upon themselves. In accord-

* Arthur B. Emmons, Notes on the Rhode Island and Massachusetts Coals. Transactions of the American Institute of Mining Engineers, Sept., 1884.

ance with the geological law that regions of the greatest disturbance are generally those of the greatest metamorphism, it is not strange that the rocks of the West Passage are more metamorphic than those of other portions of this section of the basin. On the west shore of the Island of Conanicut the Coal-measures dip E.S.E. true, away from the west side of the basin, the nearest rocks to the west being the Mica-schist (B), which forms there the shore of the mainland. In examining the outcrops on the west shore of the northern portion of Conanicut, which, with occasional interruptions, extend some three miles or more, I noted the following section, beginning with the more recent strata :

Mica-schist with Garnets, Staurolite, Ottrelite and Chlorite, 4 feet.

Plumbaginous Argillyte, with minute veins of Mica and coal ferns, 3 feet.

Mica-schist with Garnets, Staurolite, Ottrelite and Chlorite (including 2 feet of Plumbaginous-schist), 10 feet.

Several layers covered, but conformable.

Mica-schist with Garnets and Chlorite (including a few inches of Plumbaginous Argillyte), 3½ feet.

Quartzose Mica-schist (including 2 feet of Quartzyte with radiate Asbestus), 7 feet.

Plumbaginous Argillyte with Garnets and Chlorite, 2 feet.

Mica-schist with Garnets, Staurolite, Ottrelite and Chlorite, 8 feet.

The Staurolites occur as single crystals, twins of 60°, and drillings. The Garnets and Staurolites are generally partial pseudomorphs of Chlorite after Garnet or Staurolite.

If such highly crystalline Paleozoic rocks occur in one region they may elsewhere ; and it would not be surprising if some metamorphic rocks, now regarded as of Azoic or Eozoic age, should be ultimately found to belong to the Paleozoic.

The President, Messrs. Notman, Shaw and Livingston made some observations on the subject of the paper.

THIRD ORDINARY MEETING.

The Third Ordinary Meeting of the Session 1884-'85, was held on November 15th, the President, Prof. Ellis, in the Chair.

The minutes of last meeting were read and confirmed.

The following list of donations and exchanges received since last meeting was read :

1. Science, Vol. IV., No. 92, for November 7th, 1884.
2. Transactions of the Linnean Society of New York, Vols. I. and II., December, 1882, to August, 1884.

The President, Prof. W. H. Ellis, then read his Inaugural Address :—

THE PRESIDENT'S ADDRESS.

This year will be marked in the scientific annals of Canada with a red letter. It has been rendered memorable by the visit of the British Association. Although a sober estimate of the effects produced or likely to be produced by this visit will in all likelihood fall short of what has been claimed by some enthusiasts, there can not be two opinions as to its importance. It marks an era in our country's development. We have shaken hands with our brethren across the sea, and the leaders of British science have recognized that we too are alive to the great work of the advancement of human knowledge, and not only willing but able to bear our part in it.

We may smile when we read in an English newspaper that "*in consequence* of the visit of the British Association to Canada twenty thousand dollars has been subscribed in Toronto to found a public library;" but for all that we cannot fail to acknowledge that, setting aside exaggeration, the results of this visit must be of great importance—how great it is impossible to estimate.

The meeting will have a two-fold influence—an influence on our visitors and on ourselves. As to the effect upon the members of the British Association who made the voyage to Canada, and many of whom spent several weeks in travelling over the length and breadth of our land, we are scarcely in a position to speak, although we may feel confident that the intercourse that they have had under very favourable circumstances with a people of their own race—one with them in language, in religion, in allegiance, and in laws—

and yet exhibiting here and there those slight. often indeed indescribable. although readily appreciable, differences which inevitably follow the separation of a people from the parent stock cannot have been without interest. Interesting, too, must have been the spectacle of a race of Frenchmen. in whose past the Great Revolution has no place, to whom Voltaire is but a heretic, and to whom Napoleon is but a name of history—a people who unite with the shrewdness. the thrift and the lightheartedness of the Frenchman of to-day the simple faith of the Breton peasant of the middle ages.

As for the country itself. although the rawness unavoidable in a new country always produces an unpleasant effect upon those whose tastes have been formed in a land where the details have been wrought out by the labour of generations, and all unsightliness has been smoothed and toned away by the mellowing hand of time, yet there is such plain witness of wholesome strength, of plenty in the present and promise for the future, that the thoughtful visitor can well forgive faults which will be surely cured by time, and which time only can cure. But the exceeding loveliness of our woods and our waters may well atone for much that is crude and displeasing in our towns and settlements. Here one can praise without stint or qualification. if praise were not out of place among scenes where the fitting frame of mind is rather one of abandonment to the sweet influences of nature. and criticism. even in the form of the most appreciating commendation. seems to jar upon the ear.

It is always interesting to know how we seem to others. The American wants to see himself through English spectacles, and the Englishman is greatly interested in reading how he looks to a Frenchman. So we are naturally curious to find out how we appeared to our late guests. But, leaving this side of the question, the Montreal meeting ought to have, and will have, important influences upon ourselves. We have been brought into personal contact. or at least we have looked into the faces and listened to the voices of many of the foremost men of our race and time in every department of science. Names which to most of us were before but names have become living flesh and blood. Thinkers and investigators with whose minds, so far as they were set forth in their writings. we have long been familiar we have found to have not only minds but bodies. Henceforth they will be to us more than mere vague abstractions. They will have a living human personality, and our interest in their writings and in their work will be keener and more vivid.

To the student of science the value of this personal intercourse with those who have done and are doing great and lasting work is incalculable. It rouses his enthusiasm. It stimulates his ambition. It stirs his flagging energies, and wakes in his breast the aspiration to share with them, even if only in an humble way, the glorious work of searching out the truths of nature and thinking out the thoughts of God. It lifts him out of himself and the little circle of his own interests and cares and makes him feel himself a citizen of the great Commonwealth of Science—a soldier of the great army of workers whose aim is the discovery of truth.

The project of holding a meeting of the British Association in Canada was a bold one; and there were not wanting prophets of evil who, when it was first set on foot, were ready to throw cold water on it, and call it inadvisable if not impracticable. The length of time taken in going and returning, the discomforts of a long sea voyage, and the expense, would, it was said, prevent all but a few daring enthusiasts from taking part in it. It was feared also that the number of those in Canada who took enough interest in science to assist at the meetings would be small, and that only failure and disappointment would result from the attempt. Even if tempted by the inducement of a cheap excursion any considerable number of people could be induced to make the voyage, those whose presence would be most desirable on such an occasion would be absent, and if quantity was forthcoming quality would most certainly be inferior.

It is gratifying to know, as we do now, that these predictions were entirely groundless. In every respect the Montreal meeting of the British Association was a most successful one. The numbers attending the meeting were beyond all expectation; and these were not mere holiday seekers, but those really interested in the objects of the Association. The number of old annual and life members who attended the Montreal meetings was above the average.

The interest of the meetings of sections was also all that could be desired. The papers read, both as to number and character, were decidedly above the average, and the interest shown by the Canadian public was most satisfactory. In every respect those who planned and carried out the undertaking on both sides of the Atlantic have every reason to congratulate themselves upon the success that has crowned their endeavours. An experiment so successful will bear repetition; and in all probability some of us here to-night will have the pleasure of welcoming on some future occasion the members of the British Association to our own City of Toronto.

The British Association is now a little more than half a century old, having been established in 1831. The idea seems to have originated with Sir David Brewster, and to have been suggested to him by a German Science Congress, instituted eight years previously. The first meeting of the British Association was held at York, and the objects stated were :—

1. To give a stronger impulse and a more systematic direction to scientific enquiry.

2. To promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers.

3. To obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress.

It is the latter object which is, perhaps, the peculiar distinction of the British Association. While other learned societies are either select philosophical clubs or associations of those interested in some special branch of science, the British Association is catholic in constitution and appeals directly to the public. It demands in its members no literary acquirements, no special scientific attainments, no other qualifications, in fact, than such a degree of interest in science as is shewn by the payment of its fees and the attendance on its meetings. It is not like the Royal Society, for example, a body of men eminent in their respective pursuits, into which entrance is strictly guarded, and whose membership is looked upon as a coveted honour comparable with that conferred by an order of knighthood. It is rather an Association of all those interested in the progress of science willing to aid in its advancement or anxious to learn its condition.

But, though it thus addresses itself to the people and welcomes all who care to come to its meetings, it has always numbered among its members the very brightest names on the roll of British Science, and to this fact it owes alike its dignity and its usefulness. In this respect, as in others, the late meeting has been well up to the mark, as the names, which will at at once occur to all of us, abundantly shew.

The popular character of the objects and constitution of the British Association is highly typical of the modern philosophy as distinguished from the ancient, or at any rate, from the mediæval. The old philosophers were cloistered recluses, living apart from their fellows, and hiding their knowledge from the vulgar, or only displaying it to dazzle or to scare. Their works were not only written in a tongue unintelligible to the many, but were couched in language studiously obscure—a mystical jargon only understood by the initiated. Nowadays, each new discovery is at once communicated in clear and precise language, not only to those whose training has fitted them to understand the technicalities of science, but also so far as possible to the public. Indeed, many of the most gifted masters of experiment and research have in late years expended almost as much pains and labour in the popular exposition of the results of their investigations as they devoted to the investigations themselves. No sooner, too, has a new truth been discovered or a new law been established than a hundred acute minds are ready to seize upon it and turn it to practical utility—discovery and invention go hand in hand, and the door of the laboratory opens into the workshop.

It is in Italy that the germ of scientific associations first began to sprout, but England was not far behind, and there more than two centuries ago a little knot of earnest workers banded themselves together to form a Society the fame of which was destined to spread over the world, and on the model of which all subsequent scientific societies have been more or less constructed—the Royal Society of London, for the Promotion of Natural Knowledge.

The first President was Sir Robert Moray. The Society was soon incorporated under Royal Charter, and in 1663 a new charter was granted which is still the fundamental constitution of the Society. The first President under the new charter was Lord Browncker, the Chancellor to the Queen, and a mathematician of eminence, and among the members of the council appears the venerated name of Robert Boyle. Two years later appeared their first number of "Philosophical Transactions," as the papers published under the auspices of the Royal Society are still called, and the year 1671 was made memorable by the admission to the Fellowship of the Society of a young professor of mathematics, of Cambridge, who was destined to shed immortal lustre on the Society and on his country, under the name of Sir Isaac Newton. At a meeting held on the 28th of April, 1686, Newton presented his Principia, which, however, the Society had not funds to publish, its resources having been exhausted by the recent publication of a treatise on fishes.

But time would fail me to speak of Cavendish, of Davy, of Franklin, of Priestly, of Wollaston, of Brewster, of Buckland, of Faraday, of Herschel, and of a host of others who, from its foundation to the present day, have contributed to make famous the Royal Society of London.

So far as the object of its founders was concerned, the Promotion of Natural Knowledge—the encouragement of investigation and research—the Royal Society was nobly fulfilling the hopes that were entertained of it, and the expectations of its friends. But in order that a nation may advance in science it is not enough that it has philosophers, it is necessary that the results of the labours of its philosophers should be communicated to the nation at large, and that the public should be educated up to be able to understand and appreciate them. As yet there was no provision for this. But with the hour came the man. This man was Benjamin Thompson, better known by his title of Count Rumford, a name familiar to everybody, although of the man himself much less is generally remembered than his merits deserve. It may not be familiar to all of us that his title is derived from the New Hampshire village in which he was born in the middle of the last century, a village then called Rumford, but now known as Concord. His youth was that of a typical Yankee boy. He took a keen interest in chemical experiments, and although the Fourth of July had not yet been invented, he blew himself up with fireworks before he was sixteen. He served as clerk in a dry goods store in Boston, taught school, and, at the age of twenty, married a wealthy widow, and became a major of militia. At this juncture the Revolutionary War broke out and Thompson took the King's side. Sent with despatches to England he found favour in influential quarters, received a public appointment, and, returning to his youthful tastes, began a course of scientific investigations, and was elected a Fellow of the Royal Society. He made a friend of Hardy, and all through the campaign of 1799 he was on board the *Victory*, making experiments in gunpowder. We next find him Colonel of the King's American Dragoons, at the head of which he served with courage and distinction, and high in the friendship and confidence of Sir Guy Carlton. On the reduction of his regiment, subsequent to the close of the war, he went to Vienna to serve with the Austrians against the Turks. But the expected hostilities not taking place he entered the service of the Elector of Bavaria as Colonel of Cavalry and Aide-de-camp General. He devoted himself to physical researches and to the inauguration of reforms of all kinds, economical, political and military. Honours were showered upon him. He became Lieutenant-General of the Bavarian armies, a Count of the Holy Roman Empire, and was decorated with the order of the White Eagle. But, with all his manifold employments, he found time to pursue his scientific investigations, and was made a member of the Academy of Sciences of Berlin and of Bavaria. Returning for a while to England he read before the Royal Society in 1798 his remarkable paper "on the source of the heat which is generated during friction." While superintending the boring of cannon in the arsenal at Munich he was struck by the heat produced, and led to construct a special boring apparatus, by means of which he succeeded in making water boil. The paper is a description of these experiments, and contains the pregnant idea, expressly stated, that heat produced in this way could not possibly be a material substance—could not, indeed, be readily conceived as anything other than motion. Anxious to introduce into England those reforms with reference to the condition of the poor which he had endeavoured to inaugurate abroad, he set on foot, among other schemes, an institution "for the diffusion of scientific knowledge, and for the teaching of the application of science to the useful purposes of life." The outcome of this was the Royal Institution. Rumford was greatly interested in the economical applications of fuel. He had done a great deal in this direction in the kitchens of several public institutions in several parts of Europe; and one of his leading ideas with reference to the new institution was the exhibition of models of fire-places, stoves, boilers, as well as houses, bridges, spinning wheels, and such other machinery as the managers should deem worthy of public notice. In addition to this, a lecture-room was to be fitted for philosophical lectures and experiments, and a laboratory established and furnished with all the necessary apparatus for chemical and physical investigation. The instituion began its life with the present century, and the chair of Chemistry was soon filled by a young Cornish chemist, Humphry Davy, then only in his twenty-third year. The extent of his attainments, the originality of his ideas, and the fluency of his delivery, combined, perhaps, with his youth and good looks, took the London world by storm. The Royal Institution became the fashion. The gay world crowded to Davy's lectures, and Rumford's boilers and soup-kitchens were elbowed out of the way. The chair of Natural Philosophy was filled by Dr. Young—that extraordinary genius who added to his brilliant mathematical attainments, not only the command of nearly all ancient and modern languages, and a knowledge of botany of no mean order, but also remarkable proficiency in music, and, what is certainly not common among professors of Natural Philosophy—wonderful skill and daring as a circus rider. He was soon succeeded, however, by Dalton, who described his new colleague, Davy, as a "very agreeable and intelligent young man, whose principal defect as a philosopher was that he did not smoke!"

Men like these were sufficient to establish the renown of the Royal Institution; and the names of Faraday and Tyndal, who succeeded them, are enough to show that they found worthy successors.

As an exponent of science the Royal Institution addresses itself almost exclusively to the upper classes. Rumford's projects have been to a large extent carried out by another institution, in whose foundation he had no share—the Society of Arts.

Rumford himself soon returned to Bavaria, where he only remained a short time, and spent the closing years of his life in great retirement in Paris. He seems to have made few friends among the Parisians, partly because of his peremptory and unyielding disposition, and partly because of his eccentricities. Among the latter was his habit of wearing in winter a white coat and hat in order to reduce the radiation of heat from his body to a minimum.

At the time of the foundation of the Royal Society the scope of natural knowledge was so limited that one society was sufficient to include all those who pursued scientific research; and yet, as early as 1664—that is the year after the society received its amended charter—eight committees were struck for the purpose of furthering investigation in different directions. As, however, the number of known facts in each branch of science increased, and the field for further investigation opened out *pari passu,* while the number of special workers was also rapidly multiplied, one society was no longer able to include all the work, and various special societies one after the other began to spring into vigorous life.

The Society of Antiquaries was chartered in 1751.
The Society of Arts was founded in 1753.
The Linnæan Society was founded in 1788.
The Geological Society in 1807.
The Royal Astronomical Society in 1820.
The Zoological Society in 1826.
The Royal Geographical Society in 1830.
The Botannical Society in 1836.
The Microscopical Society in 1839.
The Chemical Society in 1841.
The Philological Society in 1842.
The Ethnological Society in 1843.

Besides these and other societies for the advancement of pure science, there are the various professional association: the Institution of Civil Engineers, the Medical and Law Societies, the Royal Institute of British Architects, and the Pharmaceutical Societies.

This, then, is a brief outline of the development of a few of the more important of the Learned Societies of England, which, together with hosts of others in other parts of the British Empire, in Europe, and in America, have done so much for the Promotion of Natural Knowledge. Let us now briefly consider what are or should be the aims of such associations, what are their proper functions, and how their objects may be best fulfilled.

I think all will agree that the first and most important function of Learned Societies is the publication of the results of investigation. It is before all things necessary to the growth of knowledge that the discoverer of a new truth should have the opportunity afforded him of making his discovery known as widely and as promptly as possible. It is most desirable that those engaged in research should have the fullest possible means of making themselves acquainted with what has been done by others, or, as the phrase goes, with the condition of our present knowledge of the subject. One truth leads to another; and each new fact observed, each new law established, suggests fresh fields for investigation, and furnishes new weapons to the armoury of science. *Vixere fortes ante Agamemnona.* There were philosophers before Newton, but, unless they had sufficient private means to publish their own works, or enough influence to induce some wealthy man to do so for them, oblivion awaited them with far more certainty than any pre-homeric hero. For conquests remain if the conqueror's name is forgotten; but a discovery unpublished is lost to the world. But, all-important as they are, it unfortunately happens that even in times of the greatest intellectual activity, and among the most highly cultivated people, the records of original research, even of the most brilliant character and upon the most momentous subjects, can never command a remunerative market. They must be published at a pecuniary loss. The number of those whose training enables them to follow intelligently the technicalities of such a paper is necessarily limited, and the number of those whose interest in the special subject under consideration is sufficient to induce them to master the tedious details of experiment and induction by which the conclusion is reached is usually still more limited. Moreover, such publications are often very expensive. Carefully executed drawings of apparatus or natural objects, machinery or anatomical details, diagrams and mathematical formulæ, combine to render them in many cases exceedingly costly. And, since the author can seldom hope for any pecuniary advantage from them, while he has usually already expended much valuable time, and often also money in the research itself, without any expectation of profit or reward, it is not only most desirable, but it is an act of bare justice, that the expense of publication should be shared among those interested in the subject of the investigation; and indeed frequently but for channels so offered most valuable investigations would either never see light or would be published in such an inadequate way as to lose half their value.

Herein lies the immense public benefit of the published Transactions of Learned Societies. By means of them any one who does work worth recording has an opportunity of publishing his investigations free of cost; and knows that when he does so his work will be immediately placed in the hands of all those likely to take an interest in it, and capable of appreciating it at its proper value. So, too, the student who wishes to keep abreast with the march of knowledge has only to read the Transactions of the Learned Societies to learn all that is being done in his special line of study.

Another object of scientific associations is to promote intercourse among those pursuing similar lines of research, and indeed among those engaged in the cultivation of science in any of its departments.

This also is a highly important function. The stimulus derived from the impact of mind upon mind, whereby ideas are often generated like sparks from flint, is proverbial. Personal contact, too, with men distinguished in any branch of science has a wonderfully stimulating effect upon the younger students of the same branch; and experience abundantly shows that in science as elsewhere it is not good for man to be alone. The reading of a paper in such a society is usually followed by a discussion in which those whose special studies have rendered them familiar with the subject of which the paper treats join, and, with an audience understanding the subject and capable of fairly criticizing the paper, this discussion is often as valuable as the paper itself.

Again, science is now so vast that it is wholly out of the power of any man to master it all. Hence the division of labour. Hence the separation of Human Knowledge into separate sciences. But after all these divisions are not hard and fast lines. Each science so called is dependent more or less upon its fellows; and each contributes its share to the others. Chemistry cannot do without Physics, and Biology cannot do without Chemistry, while Geology is an application of all three to the study of the earth's crust. There are, therefore, advantages of no mean order in the facilities afforded by learned societies for the intercourse of students of different branches of science with one another.

The social element then, as we may call it, is an important factor in the influence of Learned Societies upon the advancement of science. But science does not exist only for the scientific. It is a most essential condition to its exercising its due influence upon the world that its discoveries should be disseminated among mankind at large. And this propagation of knowledge is another most important function of Learned Societies. We hear much now-a-days of popular science, and the phrase as sometimes understood has a rather questionable signification. Too often those who have undertaken to enlighten the people in scientific matters have been sadly unfitted for their self imposed task. The spectacle of a man with only the merest smattering of a subject endeavouring to teach those whose ignorance is only less than his own is not an edifying one. Unfortunately it is not a rare one. The shallow pretender who seems to think that any knowledge that goes beneath the skin of the subject would only be an incumbrance likely to hinder his glib and self satisfied deliverances has done much to bring science into disrepute. It cannot be too strongly urged that no man can teach what he does not know. Self evident as the proposition seems, experience constantly shews that it is in danger of being ignored.

With some again popular science is another name for scientific fooling. They seem to think that the popular stomach is unable to digest anything but froth. "Strong meat is for men and milk for babes," but these people feed their scientific infants not on good wholesome milk, but on sugar plums and curry powder. Their children cry for bread and they give them a Pharoah's Serpent!

None the less, however, is it a matter of the highest moment that sound scientific instruction should be given to the public, that the truths laid hold of by the few should be made known to the many, that science should be no esoteric possession of the favoured few, but should become the heritage of the world.

The vastness of the practical benefits which the application of scientific discoveries and scientific principles to practical life has brought in the past, and is likely to bring in the future, is one most cogent reason for the more general dissemination of these discoveries and principles.

If we try to picture to ourselves the condition of society at the end of the 17th century, when Savery exhibited before the Royal Society a model of his engine for Raising Water by Fire, and compare it with that with which we are now familiar, when the great agents of Heat, Light and Electricity have been brought by the aid of science into such wonderful subjection to the wants of mankind; and if we try to pierce with prophetic vision into the mists of the future, and speculate upon the gigantic possibilities which the light of science, brightening every hour, seems to render visible before us, we may well be impressed with the necessity of disseminating a knowledge of science as a means of benefiting the human race.

But besides the practical advantage to be derived from the spread of scientific information, it has a highly important reflex action upon the scientific investigator.

Man will not work without a motive, and the applause of a discriminating public is one very strong incentive to exertion in science as in every other field of labour. It is true that some men love knowledge for its own sake, and that the most successful workers are likely to be those who are enamoured of their labour. But for all that, there can be no doubt that a sympathetic appreciation of his work is a most grateful and effectual stimulus to the scientific investigator, and in most cases beyond the pleasure that his labour itself brings, it is the only reward he can have or hope for.

Now the amount of sympathy and appreciation that a scientific investigator gets is in direct proportion to the number of his fellow men who are capable of understanding his work, and whose tastes are cultivated sufficiently to awaken in them an intelligent interest in it. Here, then, we have another cogent argument in favour of the importance of the diffusion of scientific knowledge among the people.

Then scientific investigation costs money. It demands, in the first place, leisure on the part of the investigator. Then the apparatus required in exact researches is frequently most expensive, and is every day becoming more so. The time has gone by when discoveries which revolutionize science can be made with a few glass bottles and a pair of apothecary's scales. To do good work instruments of the greatest refinement and delicacy are absolutely necessary, and such instruments are not to be had for nothing. In many cases the apparatus used for a particular research is of no further use when that research is completed, and becomes of merely historic value. Then there is publication, the cost of which we have already considered. Again, a philosopher is not born but made. True, nature must do her part, but what would avail the genius of a Newton or of a Lavoisier if—

> "—— Knowledge to their eyes her ample page,
> Rich with the spoils of time, did ne'er unrol,
> Chill penury repressed their noble rage,
> And froze the genial current of their soul."

The man who is to accomplish anything in science must have a scientific training, and a scientific training means laboratories, lecture rooms, apparatus, books and instructors, and here again the question of cost stares us in the face.

Now, science is never self-supporting. The application of science to the arts is often extremely profitable. The cultivation of pure science is never so; *yet upon this cultivation of pure science* all the applications of science directly depend. It is then adsolutely necessary to the advancement of science that scientific institutions of various kinds should be supported by generous donations either from the public funds or from private munificence. Without liberality in this respect there can be no scientific progress.

Now it is obvious that private contributions to scientific objects can only be looked for in a community among which a knowledge of the importance of science and of the needs of science is prevalent. So, also, no considerable grants of public money for scientific purposes can be expected unless those who control the public purse are impressed with the importance of science from a national point of view. In a free country the public purse is controlled by the people themselves, and it is self-evident that the most likely way to impress them with the importance of science is to disseminate among them a knowledge of its facts and principles. A sound and liberal popular scientific education is indeed the only way to ensure an enlightened public support of scientific institutions and a proper public recognition of the claims of scientific investigators.

A great scientific discoverer is an expensive product. As thousands of eggs are laid for every trout that arrives at maturity, so it takes a thousand embryo philosophers to produce one Newton. It is well, then, that public attention should be directed to science in order to incite promising youths to acquire a scientific training, and thus qualify themselves to follow scientific pursuits.

These then, I take it, are the objects and functions of a scientific association :—

1. To publish transactions ;
2. To afford opportunity for intercourse among scientific men, and
3. To assist in the diffusion of scientific knowledge among the people at large.

How may they best be accomplished?

With regard to the first I have nothing to say. The form of the transactions must be left to the exigencies of each individual case.

As for the third head, viz., the diffusion of scientific knowledge, there are two ways in which it seems to me that a scientific society can promote this object : —

First, the very existence of an active society of this kind in a community is a kind of scientific mission continually winning converts to the cause of scientific study, and inciting them by precept and example to keep themselves abreast with advancement of knowledge. By reading papers and by discussion scientific culture is promoted among the members, and by a library and reading room an opportunity is given them to acquaint themselves with what has been done and what is doing in all departments of science.

Secondly, an important method of attaining this object is by means of public lectures upon scientific subjects delivered by competent persons.

These lectures should be suited to a popular audience, in so far that they should assume no profound knowledge of the subject on the part of the audience, and hence should avoid unexplained technicalities. But they should not be "popular" in the sense alluded to previously of conforming to the (generally erroneously) supposed popular taste for the sensational and the trifling to the exclusion of the useful and the solid.

A popular scientific lecture, which is really popular and really scientific, is an excellent thing, and well deserving the encouragement of a Learned Society.

Intercourse among the members is promoted formally by papers and discussions, and informally by affording a common meeting place and common interest for those engaged in scientific pursuits.

Much of the value of a society from this point of view will depend upon the interest shewn at its meetings and the character of the papers read. And here a society of general scope, such as our own, is placed at a marked disadvantage as compared with one which addresses itself to the cultivation of a special branch of science.

The reader of a paper before a mixed audience, such as the members of such a society, is placed between the horns of a dilemma. He must either adapt his discourse to the audience generally, and thereby make himself tedious to those whom he particularly wishes to interest, while he will be compelled to omit much of what would be of special value to those who understand the subject of his paper. Or he must address himself to those who have made his department of science their peculiar study, and thereby render himself unintelligible to nine-tenths of his audience.

There are a hundred little points of detail which are of the keenest interest to those actually working in any branch of science but which are not the slightest consequence to anyone else. The discussion of such points as these gives life and interest to a meeting of specialists, which can not be attained elsewhere. From these and similar considerations, as well as from the mere demands of time and space, the various special societies have in England come to monopolize the greater part of the work which the Royal Society originally undertook, while that body reserves to itself the consideration of questions involving the general principles of science and leaves matters of detail to the special societies for the cultivation of the different branches of science. Yet, in the Royal Society itself, the principle of division of labour is by no means neglected. As early as 1664 eight committees were formed for the purpose of promoting the propagation of natural knowledge in different directions. With some few modifications these committees still exist and form part of the machinery of the Society. These committees comprise :—

Mathematics, Astronomy, Physics and Meteorology, Chemistry, Mineralogy and Geology, Botany and Zoology.

Each of these committees has its own chairman and secretary. The Royal Society of Canada, a body fashioned to some extent on the lines of the Royal Society of London, although in other respects it rather follows the model of the French Academy, is divided into sections with special officers, each charged with the care of certain allied subjects. The British Association is similarly divided into sections as follows :—

A.—Mathematical and Physical Science.
B.—Chemical Science.
C.—Geology.
D.—Biology.
E.—Geography.
F.—Economic Science.
G.—Mechanical Science.

The American Association has a similar division as follows :—

A.—Mathematics and Astronomy.
B.—Physics.
C.—Chemistry.
D.—Mechanical Science.
E.—Geology and Geography.
F.—Biology.
G.—Histology and Microscopy.
H.—Anthropology.
I.—Economic Science and Statistics.

Now, it seems to me that some such divisions might with great advantage be introduced into the Canadian Institute, and I would venture to suggest for your consideration the outlines of such a scheme. If the idea should be favourably received details can be considered at leisure, and the plan modified as seems best.

Briefly, then, I would suggest the establishment of say four sections as follows :—

A.—Mathematics, Physics and Mechanics.

B.—Chemistry, Mineralogy and Geology.

C.—Biology.

E.—Ethnology, Philology, History and Economy.

Each of these sections should have its own chairman and secretary, who, with the officers of the Institute, might constitute the general council.

Each section might meet once a month, and whenever there was a paper of sufficiently general interest to merit its being read before the whole body of members, a general meeting of the Institute might be held.

I am fully aware that the division that I have suggested is far from a philosophical one, and I am in no way wedded to any of the details of the scheme. All I ask is that the members of the Institute will give the matter their consideration, and if it seems to them that the change will be likely to have the effect of arousing more interest in the meetings of the Canadian Institute and of furthering the objects that we all have at heart, then I shall be happy to adopt any modification that the Institute think best, and I will gladly co-operate in giving such a scheme a fair trial.

FOURTH ORDINARY MEETING.

The Fourth Ordinary Meeting of the Session 1884-'85, was held on Saturday, November 22nd, the President in the Chair.

The minutes of last meeting were read and confirmed.

Donations and Exchanges received since last meeting:

1. The Canadian Entomologist, Vol. XVI., No. 8, August, 1884.
2. Monthly Weather Review, October, 1884.
3. Monthly Health Bulletin of Ontario, September, 1884.
4. Science, Vol. IV., No. 93, November 14th. 1884.
5. Transactions of the American Society of Civil Engineers for September, 1884.
6. Memoirs of the Boston Society of Natural History, Vol. III., No. 10 May, 1884.

7. Monthly Notices of the Royal Astronomical Society, Vol. XLIV., No. 9.
8. Proceedings of the Royal Geographical Society, N.S., Vol. VI., No. 11, November, 1884.

The following gentlemen were elected members of the Institute:

W. S. Milner, B.A., Dr. T. Walker Simpson, William McCabe, Esq., Geo. H. Jarvis, Esq., Robert Winton, Esq.

Mr. W. A. Douglas then read a paper on

WAGES.

The current doctrines respecting the distribution of wealth are very contradictory, and still require much investigation. Mill's doctrine of wages has three assumptions:

1. Wages are drawn from capital, that part thus devoted being called the wage-fund.

2. Average wages may be ascertained by dividing the wage-fund by the number of labourers.

3. Wages can be increased only by increasing the numerator or diminishing the denominator.

Therefore, if wage-fund be 10, labourers 5, wages will be $\frac{10}{5} = 2$, and if labourers be increased to 6, wages will full to $\frac{10}{6} = 1\frac{2}{3}$.

The following are a few of the objections of this doctrine:

1. An additional labourer will receive employment only on condition that he produce 2 + something, that something being enough to cover profit and rent. The additional labourer will increase not merely the denominator but also the numerator.

2. It is illogical, Mill teaches that capital is one of the component forces, wealth the resultant; wages, rent and profits, the division of the resultant. He is, therefore, illogical in calling capital a component force and also a resultant.

3. This doctrine teaches a wrong perspective of society. It represents the capitalist as the initial party in production, supporting the labourer, and the latter as the dependent party; whereas, in fact, the capitalist and labourer are co-workers, mutually dependent, working concurrently to obtain wealth, and when the wealth is produced, then dividing the product.

The study of political economy presents two distinct questions:

1. Given a number of labourers and a certain quantum of natural forces; what will be the product?

2. Given a certain product, what quantity will go to the landowner, the capitalist, and the labourer? This is the question to be solved that we may determine wages.

Ultimate analysis will show that the division of the product is either for land or for labour.

To determine the distribution of the product we must have regard to the following considerations:

1. Competition of labourers amongst themselves. Labourers are moveable, hence within areas in which competition is effective, wages are equal among labourers of the same class.

2. Competition of landowners amongst themselves. Land is inmovable, hence the values differ enormously, all the way from nothing in rural districts to fifty or one hundred thousand dollars per acre per annum in cities.

3. Competition of labourers against landowners. Labourers increase, land does not. Increase of labourers increases their competition, rents rise at the expense of wages.

4. Relative power of landower and labourer in determining a bargain. Labourers must have access to land or die; this dependence is absolute. The dependence of the landowner is determined only by the necessity of maintaining the labourer alive. Hence unskilled labour has ever had to be content to accept a bare subsistence. The fulcrum is placed so that the advantage is altogether with the landowner. Strikes, as at present conducted, do nothing to remove that fulcrum in favour of the labourer.

Mr. Murray criticized the principles advanced by Mr. Douglas, contending that rent had not increased but diminished; that wages had not diminished this century, and that the rich are not becoming richer and the poor poorer. He declared that wages must be a matter of free agreement between employer and employé.

Dr. Bryce questioned the statement that the amount of wages earned, when land produces no rent, is the measure of the wage-fund.

Mr. Browning controverted the position that wages diminish as wealth and population increase, and that the statistics show the contrary.

Mr. Livingston said labour and capital regulated themselves.

Mr. Douglas made a general reply.

FIFTH ORDINARY MEETING.

The Fifth Ordinary Meeting of the Session 1884-'85, was held on Saturday, November 29th, the President in the Chair.

The minutes of last meeting were read and confirmed.

Donations and Exchanges received since last meeting:

1. List of Publications of the Geological and Natural History Survey of Canada, 1884.
2. Science, Vol. IV., Nos. 94 and 95.
3. Transactions of the American Society of Civil Engineers for October, 1884.
4. The Journal of Speculative Philosophy, Vol. XVIII., No. 1, January, 1884.
5. Bulletin of the Museum of Comparative Zoölogy at Harvard College, Cambridge, Geological Series, Vol. I., Nos. 2, 3, 4, 5, 6, 7, 8 and 11, with Title page and Index to the Vol.
6. Bulletin of the Essex Institute:

   Vol. 15, Nos. 7, 8, 9, July to September, 1883.

   Vol. 16, Nos. 4, 5, 6, April to June, 1884.
7. Report of the Proceedings of the Sixteenth Annual Convention of the American Railway Master Mechanics' Association, held at Chicago, June 19th, 20th and 21st, 1883.
8. Transactions of the Manchester Geological Society, Vol. XVIII., Part I., Session 1883-'84.
9. Journal of the Quekett Microscopical Club, Series II., Vol. II., No. 10' November, 1884.
10. Journal of the Anthropological Institute of Great Britain and Ireland, Vol. XIV., No. 2, November, 1884.
11. Trübner's American, European and Oriental Literary Record, N.S., Vol. V., Nos. 9 and 10.
12. Minutes of Proceedings of the Institution of Civil Engineers, Vol. LXXVIII., Session 1883-1884. Part IV. Brief Subject-Index to Minutes of Institutions of Civil Engineers, Vols. LIX. to LXXVIII.
13. Correspondenz-Blatt der Deutschen Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte, XV. Jahrgang, No. 9, September 1st, 1884.
14. Canadian Practitioner, December, 1884.

Mr. Thomas Robertson was elected a member of the Institute.

Captain Gamble Geddes, A.D.C., read a paper on

THE AFFECTION OF INSECTS FOR THEIR YOUNG.

The writer of this paper took the ground "that insects are capable of feeling quite as much attachment to their offspring as the largest quadrupeds. They undergo severe privations in nourishing them; they expose themselves to great risks in defending them, and even at the time of death much anxiety is exhibited for their preservation." This was not claimed for all insects, but in proof of the writer's contention the instances adduced were those of the common house-fly, the common white butterfly, the musquito, the gadfly, ichneumon flies, the ephemeridæ, the clothes-moth, the wild bee and the beetle.

Reference was made to the various expedients and artifices employed by these in suitable places upon which to deposit their eggs, with a view not only to the safety of the eggs themselves, but to the sufficiency of a food supply when the young reaches its perfect state.

In concluding his paper, the writer said:—"I have myself, upon many occasions, experimented with the dead bodies of frogs, and even with fish—all these are excellent baits to attract the species of our own Canadian burying insects—and I have enriched my collection with fine specimens many a time, after observing their habits sufficiently to be convinced that it is for the object of a future supply of food for the larva that the beetles undergo this severe labour," *i. e.*, the dragging and burying of the bodies of small animals.

Remarks were made by the President, Drs. Workman and O'Reilly, and Messrs. Macdougall, Murray, Notman, Livingston, VanderSmissen and Mowat.

SIXTH ORDINARY MEETING.

The Sixth Ordinary Meeting of the Session 1884-'85, was held on December 6th, 1884, the President in the Chair.

The minutes of last meeting were read and confirmed.

Donations and Exchanges received since last meeting:

1. The Canadian Entomologist, Vol. XVI., No. 9, for September, 1884.
2. Journal of the Franklin Institute for December, 1884.

3. Proceedings of the Asiatic Society of Bengal, Nos. 6 and 7, June and July, 1884.

   Journal of the Asiatic Society of Bengal, Vol. LIII., Part II., No. 2, 1884.
4. Mittheilungen der Anthropologische Gesellschaft in Wien, XIV. Band, 2 und 3 Heft.
5. Archivio per l'Antropologia e la Etnologia, Vol. XIV., Fascicolo Secondo Firenze, 1884.
6. Société des Ingénieur Civils. Séance du 7th November, 1884.

Mr. F. J. Garden and Mr. Herbert L. Bowman were elected members of the Institute.

Dr. Daniel Wilson read a paper on "The Bohemian Skull," which will appear in a subsequent fasciculus.

Messrs. Buchan and Bain made brief remarks.

A paper by Dr. Neil MacNish on "The Gaelic Topography of Damnonia," was read for the author by Mr. VanderSmissen.

THE GAELIC TOPOGRAPHY OF DAMNONIA.

I propose in this paper to examine the Topography of that portion of England which was at one time known as Dumnonia or Damnonia. For the sake of convenience it may be maintained that Damnonia embraced Devonshire, Cornwall, and the Scilly Isles. A writer in the *Encyclopædia Britannica* remarks that "Dumnonia or Damnonia, the Latinized name of a kingdom which long remained independent after the arrival and early conquests of the West Saxons, seems to be identical with the Cymric Dyfnaint, which survives in the present Devon. The Saxon settlers, as they advanced into the country, called themselves *Defenas, i. e.*, men of Devon or *Dyfnaint*, thus adopting the British name." Into *Dyfnaint*, *Devon*, the Welsh word *dwfn*, Gaelic *domhain*, seems to enter as a component part. Professor Rhys states, that the remains of the language of the Dumnonii in Devon and Cornwall leave no kind of doubt that they were of the earlier Celts or Goidels, and not Brythons. I am of opinion that satisfactory evidence can still be extracted from the names of rivers and bays and headlands in the ancient kingdom of Damnonia, to show that Celts, whose language was Gaelic, gave in the distant past many of those topographical appellations which, with various degrees of correctness, have come down to our own time. It may be safely affirmed that the names which were given in an early age to the streams and lochs and hills and headlands of a country were intended to express some physical peculiarity. In his introduction to the "Vindication of Irish History" (p. 6), Vallancey thus writes: "It is unreasonable to suppose that the proper names of men, places, rivers, &c., were originally imposed in an arbitrary manner, without regard to properties, circumstances, or particular occurrences. We should rather think that in the earliest period, and especially when the use of letters was unknown. a name usually conveyed a brief history of the thing signified; and thus recorded as it were by a method of artificial memory." Dr. Bannister, the author of a Glossary of Cornish names, says "that Cornwall is a peculiar country. From its geographical position it may be called the first and last in England; and *one and all* good Cornishmen will maintain that it is also the best. Time was when Devonshire was part of Cornwall, with Exeter, it is thought, for its capital; which city was till the tenth century inhabited conjointly by Cornish and Saxons. The Cornish were driven across the Tamar by Athelstane; and it was declared death for one to be found east of its banks." It was about 930 that Athelstane thus violently compelled the Cornish to retire to the west of the Tamar. Devonshire, therefore, was much more strongly subjected to Saxon influences than Cornwall; and hence it may be expected, that the traces of Gaelic will be less distinctly and commonly marked in the Topography of the former than of the latter county.

The names of the rivers of Devonshire readily disclose their Gaelic origin, *e. g.*:

Teign, *teth*, hot, and *an*, *amhainn*, river. The *Tyne* of Haddington and Northumberland.

Dart, *doirt*, to rush, or pour out.

Plym, *plum*, to plunge.

The *Mew* and *Cad* unite to form the *Plym*.

Mew or *Meavy*: *magh*, a plain; or *meadhon*, middle.

Cad, *cath*, battle; or *cas*, rapid.

Tavy, *Taw*, *tamh*, quiet, *a* river. The Thames, Tay in Scotland, and Taff, Tave, Taw in Wales, come from the same root. *Tabh* in Irish and Scottish Gaelic signifies *water* or *ocean*.

Torridge, *Tor*, *Tory*: Into those names *torr*, a heap or round hill, clearly enters. *Torr* is a purely Gaelic word. It forms one of the expressive monosyllables which frequently occur in the poems of

Ossian. It is present in such words as Tormore, Torness, Torryburn, Torryline, Tory Island.

Avon, *amhainn*, a river.

Erme, *ear*, east; *amhainn*, a river.

Yealm, *ealamh*, quick.

Exe, *uisge*, water.

Culme, *cul*, back; *magh*, a plain. *Cul* occurs often in the Topography of Scotland, *e. g.*, Cullen, Culross, Culloden.

Creedy, *criadh*, clay.

Otter, *oitir*, a ridge near the sea, *Dunottar*.

Axe, *uisge*, water.

East Lyn, *West Lyn*, *linne*, a pool. *Linne* is present in such words as Dublin, Roslin, &c.

Barle, *barr*, a top; *liath*, grey.

Oare, *odhar*, dark-grey, sallow.

Mole, *moyle*, *maol*, bare.

Oke, *oiche*, *uisge*, water.

Yeo, Welsh *aw*, flowing, Gaelic, *a* water, resembles very strongly *Awe* in Argyllshire.

Bray, *Braighe*: height or upper part.

The names which have now been adduced are Gaelic, and occur frequently in the Topography of Ireland and Scotland, thereby enabling us to conclude that the same people who employed such words as *Teign*, *Avon*, *Tay*, *Awe*, &c., in connection with the streams and rivers of Ireland and Scotland, made use of the same words in connection with the streams and rivers of Devonshire.

Cum, valley or dingle; Cornish, *cwn*; Welsh, *coom*, *Coome*, *Coombe*; Irish, *cumar* or *Comar*, a confluence of waters, occurs repeatedly in the Topography of Devonshire, *e. g.*:

Lannacombe, *lan*, full.

Colcombe: *caol*, narrow.

Branscombe, *bran*, a mountain stream.

Dunscombe, *dun*, hillock.

Wiscombe, *wis*, *usk*, *ouse*, water.

Salcombe, *sal*, the sea or salt water.

Orcombe, *oir*, border.

Purely Gaelic words are thus found in combination with *cum*, a term which is found with little variety in Irish and Scottish Gaelic, and Welsh and Cornish.

So unmistakable is the Gaelic complexion of *Torr*, and so commonly is it to be found in the Topography of Ireland and Scotland, that were other evidences altogether wanting, the constant occurrence of it in the names of places in and around *Dartmoor* and elsewhere in Devonshire, might furnish a strong argument in favour of the contention, that Celts who spoke Gaelic must have occupied that part of England for some time at least during the early settlement of Britain. Were it to be maintained that *Dart* in *Dartmoor* is the Gaelic word *tart, thirst* or *drought*, a striking correspondence would be found between the very name and the sterile character of that region. *Moor*, the latter syllable of *Dartmoor*, bears a close resemblance to *mòr*, the Gaelic adjective for *great* or *extensive*. Thus interpreted, *Dartmoor* would signify *the extensive drought*. Nor can there be any difficulty in seeing how Dart, the principal river which issues from Dartmoor, and to which I have already assigned the derivation *doirt*, would bear the name of the region in which it rises, in spite of the incongruity that may attach to applying to any river of considerable magnitude a name that is indicative of drought or scantiness of water.

Crockern Torr is the name of a hill in the centre of Dartmoor, where the legislative business of the tin mines of Devonshire used to be transacted. *Crockern Torr*, *cnoc air an Torr*, the hill on the heap. The name is purely Gaelic, and the well-known word *cnoc* occurs in it.

In *Torquay*, *Torcross*, the word *torr* is present. Other names of places in Devonshire are of Gaelic origin, *e.g.*:

Carnmere, *carn*, a heap or pile of stones. *Kenton*, *ceann*, head; *dun*, a hillock. *Hamoaze*, *camus*, *chamus*, a harbour; *Culbone*, *cul*, back; *beinn*, a hill.

Beer, *bior*, water.

Ness, *an eas*, cascade.

Exbourne: *uisge*, water: *burn*, water. In such words as *Cudleigh*, *Leigh*, *Chumleigh*—, *liath*, grey or hoary appears.

The Topography of Devon, in spite of all the political changes that have passed over that county, and in spite of the different races that have inhabited it, preserves unmistakable reminiscences of Gaelic-speaking Celts, who must have been its earliest inhabitants of any permanence.

Isaac Taylor, in his "Words and Places," affirms that the word *Cornwall* or *Cornwales* signifies *the country of the Welsh, or strangers of the horn. Cornwall* may be regarded as a compound of *corn*, a Cornish word signifying *horn*, and *waller* a *stranger*. The origin of the term *corn* or *horn* may be discovered in the peculiar form of Cornwall, running as it does like a horn into the sea. *Cernow* is the Cornish word for Cornwall, and *Cernewec* and *Kernnak* for Cornish, *e.g.*, *Metten da dha why: elo why clapier Kernnak*: good morning to you, can you speak Cornish? Max Müller, who has evidently bestowed great attention on the language and antiquities of Cornwall, thus writes in his "Chips from a German Workshop" (Vol. 3, pp. 242, 247): "The Cornish language is no doubt extinct, if by extinct we mean that it is no longer spoken by the people. I . in the names of towns, castles, rivers, mountains, fields, manors and families, Cornish lives on and probably will live on for many years to come. More than four hundred years of Roman occupation, more than six hundred years of Saxon and Danish sway, a Norman conquest, a Saxon reformation, and civil wars, have all passed over the land, but like a tree that may bend before a storm but is not to be rooted up; the language of the Celts of Cornwall has lived on in an unbroken continuity for at least two thousand years." Norris, the editor of the ancient *Cornish Drama*, is of opinion that the Cymric was separated from the Gaelic before the division into Cornish and Welsh was effected, and that Cornish is the representative of a language once current all over South Britain at least. The author of the article on "Celtic Literature" in the *Encyclopædia Britannica* writes that "among the British dialects, the most archaic, *i. e.*, the one which best represents the British branch, is Cornish, which is the descendant of the speech of the unromanized Britons of England."

So very numerous are the Celtic words in the Topography of Cornwall, that, in his Glossary of Cornish names, Dr. Bannister asserts that there are 20,000 Celtic and other names. Owing to the difficulty as well as the uncertainty which must of necessity obtain in arriving at the true derivation of so many words, Bannister has with commendable modesty adopted as his motto the expressive language of Horace:—

> "Si quid rectius istis
> Candidus imperti: si non his utere mecum."

The names of the streams and rivers of Cornwall are to a large extent Gaelic, *e.g.* :—

Tamar, *tabh*, water; *mor*, large.

Camel, *cam*, crooked; *heyl*, *tuil*, flood.

Alan, *geal*, white; *an*, river, *Gealan*. There is a river of the same name, *Allan*, in three counties in Scotland.

Lynher, *linne*, pool; *hir sior*, long.

Looe, *loch*, or *luath*, swift.

Fal, *foil*, gentle; *fal*, a circle.

Bude, *buidhe* (?), yellow.

Inny, *innis*, an island; or *inne*, a bowel.

Cober, *cobhar*, froth.

Kensey, *ceannsa*, mild, gentle.

Hayle, *sàl*, *shail*, salt water.

Hone, *amhainn*, rivers.

It is quite evident that into the names which have been now adduced purely Gaelic roots enter—roots which appear very often in the Topography of Ireland and Scotland. The slight examination that I have made of the names of the rivers of Damnonia will tend to exemplify the correctness of the remarks which Lhuyd makes in the Welsh preface to his *Archæologia Britannica*: "There is no name anciently more common on rivers than *Uysk*, which the Romans wrote *Isca* and *Osca*, and yet, as I have elsewhere observed, retained in English in the several names of *Ask*, *Esk*, *Usk*, and *Ex*, *Axe*, *Ox*, &c. Now, although there be a considerable river of that name in Wales and another in Devon, yet the signification of the word is not understood either in our language or in Cornish; neither is it less vain to look for it in the British of Wales, Cornwall, or Armoric Britain than it would be to search for *Avon*, which is a name of some of the rivers of England, in English. The signification of the word in *Guydeleg* (*i. e.*, Gaelic) is water. * * * So do the words *uisge*, *Loch*, *Ban*, *Drum*, &c., make it manifest that the *Guydhelod* (*i. e.*, the Gaels) formerly fixed their abode in those places."

Carn, which is eminently a Gaelic word, occurs often in the Topography of Cornwall. *Carn* is one of the most expressive monosyllables that are to be found in the poems of Ossian. As *Cairn* it is commonly used in the English language. *Co nach cuireadh clach 'n a charn*, is a Gaelic proverb of very ancient date.

In Cornwall such words exist as :

Carn brea, *briadha*, beautiful.

Carn beak, *beag*, small.

Carn-clog, *clach*, *cloiche*, a stone.

Carn Pendower, *pen ceann* head, *dobhar*, water.

Carn voel, *mhaol*, *maol*, bare.

Carn leskez, *leus*, *loisgidh*, burning.

Carnglos, *glas*, grey.

Carn meal, *mil*, *meala*, honey.

Carn Tork, *torc*, a boar.

Carn Enys, *Innis*, an island.

Cnoc is found in such words as :

Crocadon, *cnoc*, *dun*, a hillock.

Crockard, *cnoc ard*, high.

Carraig, which, along with *carn* and *cnoc* and *dun*, may fairly claim to be regarded as a representative Gaelic word, and which constantly occurs in the Topography of Scotland and Ireland, is present in such names as these :

Carrick gloose, *carraig glas*, grey.

Carradon, *dun*, a hillock.

Caregroyne, *ron*, a seal.

Cardew, *dubh*, black.

Careg Tol, *toll*, a hole.

Cardrew, *doire*, a thicket ; *Druidh*, a *Druid*.

Dun, a hillock or fortress ; Cornish, *Din*, occur in such words as :

Dunbar, *barr*, a top.

Dunsley, *sliabh*, a mountain.

Dunster, *tir*, land.

Dunmear, *mear*, joyful ; *mor*, large.

Tintagel, *Tin*, *dun*, castle ; *diogel* (Cornish), secure. The first syllable is very similar to *dun* or *din*.

Tiadhan is a Gaelic word that signifies a *little hill* ; *dioghailt* in Gaelic signifies revenge. Gaelic roots are thus discernible in *Tintagel*, which is supposed to have been the birth-place and principal residence of the famous Arthur. Borlase says regarding it "that it was a product of the rudest times before the Cornish Britons had learned from the Romans anything of the art of war." So doleful are the changes which time has effected in the palace of Arthur, that is is no longer like the residence of

"that Arthur who
Shot through the lists at Camlet, and charged
Before the eyes of ladies and of Kings.
The old order changeth, yielding place to new."

It appears that there is an old couplet in Carew's Survey

"By *Tre*, *Pol* and *Pen*,
You shall know the Cornish men."

The well-known Cornish rhyme is merely an expansion of that couplet:

"And shall Trelawney die?
Here's twenty thousand Cornish boys
Will know the reason why?
And shall they scorn *Tre*, *Pol* and *Pen*,
And shall Trelawney die?
Here's twenty thousand Cornish men
Will know the reason why."

Camden has the couplet:

"By *Tre, Ros, Pol, Lan, Caer, and Pen,*
You may know the most Cornishmen."

According to him those words mean respectively a *town*, a *heath*, a *pool*, a *church*, a *castle*, or *city*, and a *foreland* or *promontory*.

Tre, *trev*, a home or dwelling place; Irish *treabh*, Gaelic *treubh*, a tribe or family. The word in question does not enter to any extent at least into the Topography of Scotland and Ireland; though it enters very largely into the Topography of Cornwall, *e. g.*:

Trebean, *beagan*, a small number.

Tredhu, *dubh*, black.

Tredryne, *droigheann*, thorn.

Treglome, *lom*, bare.

Trekavwr, *gobhar*, a goat.

Trelase, *glas*, grey.

Tremeal, *mil*, *meala*, honey.

Ros (Cornish, a *heath*, *mountain*, Gaelic, a *promontory*), occurs in Scotland in such names as *Rosdu*, *Roseneath*, *Roslin*, *Ross*, *Kinross*; and in Ireland in such names as *Ross*, *Rosscor*, *Rossmore*. It enters into such Cornish words as

Roscarnon, *carn*, a heap or mound.

Roskear, *ciar*, dusky.

Roskearn, fearna, fhearna, an alder tree.

Roster, tir, land.

Rosevean, bhan, ban, white; *beagan,* a little.

Pol, a pool, mud, occurs in *Poolvash* in the Isle of Man; and such Irish names as *Poolboy, Ballinfoyle, Pollrany*; and in such Scottish names as *Polmont, Polldhu, Poltarff.*

The presence of *Pol* can readily be observed in such Cornish words as these:

Polbrock, broc, a badger.

Polcairn, carn, a heap.

Poldew, dubh, black.

Poldower, dobhair, water.

Poldrissick, dreasach, thorny.

Polhern, iarunn, iron.

Polkillick, coilleach, a rooster.

Pollick, leac, a flat-stone.

Pollyne, linne, a pool.

Polmellin, muileann, a mill.

Lan. In his Cornish Dictionary, Williams remarks regarding *Lan* "that its primary meaning was a piece of ground enclosed for any purpose—an area to deposit anything in—a house, a yard, a churchyard." In dealing with the Topography of Wales in a previous paper, I endeavoured to prove on the authority of Dr. Joyce, that *lan* or *lann* is a Gaelic word, and that it does not belong exclusively to the Cymry. Lan is often met in the topographical names of Cornwall, *e. g.*:

Lanarth, ard, high.

Lanaton, dun, a hillock.

Lancarf, garbh, rough.

Landare, darach, oak; or *doire,* a thicket.

Landenner, dun, a hillock; *hir sior,* long.

Landew, dubh, black.

Caer, Gaelic *Cathair,* a city or fortified place, which is of frequent occurrence in the Topography of Ireland and Scotland, and to which a very remote origin must be assigned, appears in such Cornish names as:—

Caer Laddon, leathan, broad.

Carbean, ban, white; or *beagan,* a little.

Carcarick, carraig, a rock.

Cardew, *dubh*, black.

Carhallack, *shalach*, *salach*, filthy.

Carhart, *ard*, high.

Pen, *ceann*, a head, than which no root is more largely present in the Topography of Ireland and Scotland, enters into very many Cornish names, *e. g.* :—

Pelynt, *linne*, a pool.

Penavarra, *bharr*, *barr*, top; or *muir*, *mara*, the sea.

Pencair, *caer*, *cathair*, a city.

Pencarra, *carraig*, a rock.

Pendennis, *dinas* (C.), *dun*.

Pendew, *dubh*, black.

Pendour, *dobhar*, water.

Pendrathen, *traigh*, a shore.

Pendrean, *droighionn*, thorn.

Pendalow, *da*, two, *loch*.

Penellick, *seileach*, willow.

Peninnis, *innis*, an island.

Pennard, *ard*, high.

Penrose, *ròs*, a headland.

Penryn, *rhyn*, *roinn*, a point.

Pentire, *tir*, land; the *Kintyre* of Argyllshire.

Pentell, *toll*, a hole.

It is evident that those distinctive roots or words by which, according to Camden, Cornishmen are to be recognized, are, with the exception of *Tre*, of frequent occurrence in the Topography of Ireland and Scotland, and cannot on that account be restricted to the Cymry, but must be regarded as Gaelic in themselves, and therefore as entering into the Topography of these countries and islands where the Gaels had permanent homes. The citations which have been made from the Topography of Cornwall, in connection with the words or roots in question, show that purely Gaelic nouns and adjectives combine with those roots to form Cornish names.

The Gaelic word *tigh*, a house, enters in the form *chy* into the Topography of Cornwall, *e. g.* :—

Chytane, *tigh an teine*, the house of fire.

Chelean, *tigh an leana*, the house of the meadow.

Chenton, *tigh an duin*, the house of the hillock.

Chycarne, *tigh a' chuirn*, the house of the cairn.

Chryose, tigh an rois, the house of the foreland.

Coille, the Gaelic term for *wood*, which enters into such Scottish names as *Killiecrankie, Killiemore*, is discernible in such Cornish words as :—

Killiard, coille ard, high.

Killignock, coille cnoc, a hill.

Killigrew, coille garbh, rough.

Killivor, coille, mhor, mor, large.

Lios, a garden or entrenchment, which forms the first syllable of *Lismore* in Scotland and *Lisdoo, Lismoyle, Lismullin*, in Ireland, appear in the Cornish names :

Liskeard, lios gu h-ard.

Lizard, the Cornish Chersonesus, *lios, ard*, high.

Toll, a hole, belongs to the category of expressive Gaelic monosyllables, and is found in such Cornish words as :

Tolcairn, toll cairn.

Toldower, dobhar, water.

Tolver, mor, large.

Tolverne, bhuirn, burn, water.

Porth, port, a harbour, is a Gaelic word of indisputable antiquity, and is present in numerous Cornish names, *e. g.:*

Porth ennis, innis, an island.

Porth glas, glas, grey.

Porth lea, liath, hoary.

Porth loe, loch, a loch.

Portugal, port nan Gaidheal, the harbour of the Gaels, continues to declare that the Gaels could not have been strangers in the far-off ages in the south-west of Europe.

Port na curaich, in the island of Iona, enables the traveller to determine the exact locality where St. Columba first landed from the coracle or wicker-boat covered with hides, that conveyed him from Ireland.

The citations which have been adduced from the Topography of Cornwall furnish satisfactory evidence, that the substratum of that Topography is Gaelic ; and that the conclusion may in all fairness be drawn that Celts, whose language was Gaelic, had their home in that portion of England before the Cymry had a distinctive existence in Britain, and long before the days of Arthur and the Knights of the Round Table.

In his Lectures on *The Science of Language* (1st Series, Lecture II.), Max Müller remarks "that it is not in the power of man either to produce or prevent a continuous change in language. * * * Language cannot be changed or moulded by the taste, the fancy or the genius of man. * * * Language exists in man, and it lives in being spoken. * * * A language as long as it is spoken by anybody lives and has its substantive existence." Cornish is no longer spoken. In 1860 Prince Louis Lucien Bonaparte, in company with the Vicar of the Parish of St. Paul, Cornwall, erected a monument to the memory of Dorothy Pentreath, who died in 1778, and who is said to have been the last person that could converse in Cornish. In the preface to his Glossary of Cornish names, Dr. Bannister remarks, on the authority of Polwhele, that Williard Bodenner, who died about the year 1794 at a very advanced age, could "converse with old Dolly," and "talked with her for hours together in Cornish." Whether Dolly Pentreath was the last person who spoke Cornish or not, it is admitted that about the close of the last century, Cornish ceased to be a spoken language.

It is beside the purpose of this paper to examine the question, as to what place or places may have been included under the designation, *Cassiterides*. The author of an article on Cornwall in the *Encyclopædia Britannica* affirms "that there can be no doubt that Cornwall and Devonshire are referred to under the general name of the *Cassiterides* or the Tin Islands." In adverting to the *Scilly Isles* in his Celtic Britain (p. 44–47), Rhys states that "they have been sometimes erroneously identified with the Cassiterides of ancient authors. * * * There is not a scrap of evidence, linguistic or other, of the presence of Phœnicians in Britain at any time." Warner, in his *Tour Through Cornwall*, which was published in 1809, contends (p. 199) "that it is a fact irrefragably established that the Phœnician colonists of Gades trafficked to the south-western coast of Cornwall from high antiquity." Betham, in his *Gael and Cymbri* (p. 64), asserts "that the Phœnicians were called so, because they were a nation of sailors or mariners, as the word *Phenice* intimates—*felne*, a ploughman, and *oice*, water—a *plougher of the sea.*" A wide divergence of opinion thus prevails as to the relation of the Phœnicians to the south-west of England in the far off centuries. Betham contends that the word *Scillies* or *Sceleys* is derived from *scal*, noisy, and *uag*, rocks; and that, accordingly, the signification is *sacred sea cliffs.* He further states that "*Scylla* or *Scylleum*, the names of promontories in Greece and Italy, and the British and Irish seas; the *Scilliés* off Cape Belerium in Cornwall, and the *Sceligs* off Cape Bolus in Kerry, stand in the same track of Phœnician navigation with Cape Belerium near Corunna in Spain." *Scylla* is derived by Greek writers from σχύλλω, to *skin*, to *mangle*. *Scilly* in Cornish means to *cut off*. Hence it has been ' eld that the Scilly Isles received that appellation because they "are cut off from the insular Continent." Joyce, in his *Irish Names of Places* (vol. 1, p. 420), states that *Sceilig* (skellig), according to O'Reilly, means a rock. The form *Scillic* occurs in Cormac's Glossary in the sense of splinter of stone, and O'Donovan, in the Four Masters, translates *Sceillic* sea-rock." I am disposed to believe that the Gaelic word *sgaoil*, to spread or scatter, enters into *Scilly*, and that the Scilly Isles were so designated in consequence of their scattered appearance. It is true that Scilly is likewise regarded as equivalent to *Sulley*, and that thus construed the term means *flat rocks of the sun* (lehau sul).

Gaelic roots appear in the Topography of the Scilly Isles, e. g. :—

Bryher, *bre braigh*, brae ; *hir shior*, long.

Tean, *tiadhan*, a little hill.

Pool, *poll*, a *hole*, mud.

Carn Morval, CARN, a *heap* ; *mor*, large ; *baile*, town.

Peninnis Head, *ceann*, head ; *innis*, island.

Carraigstarne, *carraig*, a rock ; *stairn*, noise.

Carnlea, *carn*, heap ; *liath*, hoary.

Tolmen Point, *toll*, a hole.

Porth Minick, *port*, a harbour ; *manach*, monk.

Port Hellick (the bay in which the body of Sir Cloudesley Shovel was washed ashore) is derived from *port*, a harbour, and *sheilich*, *seileach*, a willow tree.

Drumrock, *druim*, a ridge.

Sufficient evidence has, I trust, been adduced to prove, that the Topography of Damnonia is fundamentally Gaelic; and that before the arrival or the distinctive existence of the Cymry, Celts who spoke Gaelic inhabited the south-west of England in such numbers and for such a length of time, as to give to the streams and hills and headlands those names which have come down to our own day, and which still reveal their own Gaelic lineage.

Many attempts have been made to explain the Etymology of the word *Britain*. Betham is of the opinion that the Phœnicians gave the name *Briteen* (*brith*, painted, and *daoine*, men) to the people whom they found in Britain; and that the word *Britain* is compounded of *brit*, painted, and *tana*, country, the meaning thus being *the country of the painted people.* It has also been maintained that *Britain* derives its name from *Prydain*, the first legendary King of Britain, after whom the island was called *Ynys Prydain*, *The Island of Prydain.* Before the Christian era *Albin*, or *Albion*, was an appellation by which the countries now known as England and Scotland were designated. *Albin*, or *Albion*, is now restricted to Scotland, and is the term which the Scottish Gaels apply to that country. *Albin* is in all likelihood compounded of *alb*, *alp*, a mountain, and of *fhonn*, *fonn*, a country, the import of the word thus being *the country of hills or mountains.* The conjecture has been advanced that the name *Britain* is composed of *braigh*, a top, and *tonn*, a wave, *braitoin;* and that that appellation was given to Britain in consequence of its lofty coast line as seen from the opposite shores of Gaul. *Breac*, variegated, and *innis*. an island, *Breacinnis*, is another derivation which has been assigned for the word in question. It is almost needless to remark, that although such interpretations may be ingenious, very much that is fanciful enters into them. An interpretation of a more plausible and accurate kind has recently been given by Prof. Rhys, who maintains that "the Greeks of Marseilles obtained the word *Britanni* from the natives of the south-west of England, who brought their tin to market, and in whose country the only Celtic speech in use was as yet Goidelic." He discovers in the word *Britain*, *Bretnais*, *brat*, *brattan*, the Gaelic term for a covering or a *cloak*,—an argument in support of the theory, that the Celts assumed the name which the Romans afterward wrote *Britanni*, to distinguish themselves as a *clothed* or *cloth-clad* people (*breid*, a piece of cloth) from the naked races who preceded them in the occupation of the British Isles. Though, amid so many explanations of the origin and Etymology of the word *Britain*, it appears to be impossible to arrive at a solution that can be regarded as in all respects satisfactory, it may at least be conceded that the term in question is rather Cymric than Gaelic. *Breathnach* is the name which is applied in Irish Gaelic to a Welshman. *Dumbarton*, which was once the capital of a Kingdom of Britons in the valley of the Clyde, is compounded of *Dun*, a fort or hillock, and *Breatunn*, *i.e.*, *the fort of Britain*, and, as we may fairly argue, *of the Britons*—if those to whose capital the Scottish Gaels gave the name *Dun-Breatuinn*—, the name by which Dumbarton is known to the Scottish Gaels of our own day. Such words as *Frangach*, a Frenchman; *Sasunnach*, an Englishman, a Saxon; and *Breatunnach*, a Briton, are merely adaptations to the Gaelic language of *France*, *Saxon*, *Briton*. The Scot tish Gael is wont to characterize the inhabitants of Scotland as *Albannaich*. *Is Albannach mise*, I am a Scotchman. The word in Scottish Gaelic for a *British subject* or for *the British* is *Breatunnach*, *na Breatunnaich*. The name *Galbraith* is in Gaelic *Mac a' Bhreatunnaich*, *the son of the Briton*, and, as we may infer, the son of one who belonged to a different people from the Gaels among whom he may have resided, and whose name is perpetuated in the common surname *Galbraith*.

Whether the exact Etymology of *Britain* can ever be ascertained or not, or whether it may have more than one derivation, the usages of the Gaelic language go to show that it is *Cymric* and not Gaelic; and that, although it passes as current coin in the words *Breatunn* and *Breatunnach*, such words found their way into Gaelic from another source; and even when they are commonly employed, they carry with them reminiscences of an origin that is not purely Gaelic, but is to be construed as indicating that the Gaels of a far-off time adopted such words to describe the members of a race with whom they came frequently in contact, and who, as at Dumbarton, had their home for a time in the immediate neighbourhood, if not in the midst, of the Scottish Gaels.

Dr. Scadding, and Messrs. Buchan and Rouse made remarks on the subject of the paper.

SEVENTH ORDINARY MEETING.

The Seventh Ordinary Meeting of the Session 1884-'85, was held on Saturday, December 13th, 1884, the President in the Chair.

Donations and Exchanges received since last meeting:

1. Appleton's Literary Bulletin, Nos. 11 and 12, Vol. III.

2. Annual Report of the Curator of the Museum of Comparative Zoölogy at Harvard College for 1883-'84.
3. Science, Vol. IV., No. 96, for December 5th, 1884.
4. Transactions of the Manchester Geological Society, Vol. XVIII., Part II., Session 1884-'85.

The minutes of last meeting were read and confirmed.

Mr. J. F. Brown, B.A., and Mr. Martin Luther Rouse were elected members of the Institute.

Mr. Martin L. Rouse read a paper "On the Number, Nature and Musical Character of Vowel Sounds."

Premising that no complete classification of the simple vowel sounds in existence had ever been made, he drew especial notice to the omissions and the anomalies of Walker, Webster, Pitman and Nuttall. Then, by drawing analogies between the pronunciation of English words and comparisons between their utterance and that of French, German and Italian ones, he constructed a table of sixteen true vowels, eight long and eight correlatively short (indicating by examples which of them occurred in the four chief tongues of western Europe)—the vowels heard in the English and French words, *boom* (long), *bush* (short); *mote, morality* (or *maux, mot*); *dawn, don; path* (or *pâte*), *patte; bur, but; age, edge; su, suspendre; keen, kin.* He further resolved six diphthongs used in the four languages into components enumerated in his table; and, departing from all previous traditions, he gave a place among the diphthongs to the *a* of *care* or *ai* of *air*, while he found this diphthong to be unique in possessing a short correlative—the *a* of *carry* or *at.* Being now enabled to test the comparative richness of the languages in vowel sounds, whether simple or compound, he did so not only by counting up the examples in the table itself but by marking from the table every first occurrence of a sound in choice passages of English, French and German poetry (Italian being completely shut out of the competition by the table). The result was greatly in favour of the German; but that language, on the other hand, was shown to be disfigured by oft-recurring gutturals, as was not the case with English, the least monotonous of the remaining three.

The speaker then announced that he had completed a discovery of which only isolated fragments had hitherto been made—of music in the vowels—the eight long simple sounds that he had discriminated making up two perfect musical scales: the one when whispered, the other when spoken. In each the music ascended from the *oo* in *boom*, regularly through the list to the *ee* in *keen;* and in each the *oo* sound fell upon the same note, which in the speaker's voice was *e* below the bass stave on a high-pitched piano. But the vowels of the whispered scale mounted in the intervals *e*, *a*, *b*, *c* sharp twice repeated, and the latter half of them at least emitted also a fainter resonance descending in the opposite order; whereas the spoken scale was throughout single and chromatic.

Lastly, Mr. Rouse adverted to the use of vowel interjections in common by nations widely severed in habitation and kinship—a permitted relic, as he thought, of the time before the confusion of tongues; and he showed the remarkable fact that each one of the long simple sounds he had distinguished was used in English to express a different emotion—*oo* or *oogh* for anger, *oh* for surprise, *aw* for wonder, *ah* for sorrow, *urgh* for disgust, *eh* for inquiry, *üch* for contempt, and *eegh* for pain.

Remarks were made by Dr. Workman, and Messrs. VanderSmissen, Boyle, Keys, Mowat, Galbraith and Macdougall.

After the reading of Mr. Rouse's paper, Mr. John Phillips introduced the subject of the "Centrifugal Forces of the Planets."

EIGHTH ORDINARY MEETING.

The Eighth Ordinary Meeting of the Session 1884-'85, was held on Saturday, December 20th, 1884, the President in the Chair.

The minutes of last meeting were read and confirmed.

Donations and Exchanges received since last meeting:

1. Monthly Weather Review, November, 1884.
2. Journal and Proceedings of the Hamilton Association for 1882-'83, Vol. I., Part I.
3. Canadian Entomologist, Vol. XVI., No. 10, October, 1884.
4. Science, Vol. IV., No. 97, December 12th, 1884.
5. Second Annual Report of the Bureau of Ethnology, Smithsonian Institution, 1880-'81.
6. Boletin de la Academia Nacional de Ciencias in Cordoba (Republica Argentina), Tomo VI., Entregas *2a* & *3a*.

Mr. Aubrey White was elected a member of the Institute.

Mr. Sandford Fleming, C.M.G., read the following paper on

UNIVERSAL OR COSMIC TIME.

On the first day of the month, the President of the United States, in his message at the opening of Congress, referred to the International Meridian Conference lately convened in Washington, in the following words :—" The conference concluded its labours on the first of November, having with substantial unanimity agreed upon the meridian of Greenwich as the starting point whence longitude is to be computed through one hundred and eighty degrees eastward and westward, and upon the adoption for all purposes for which it may be found convenient of a universal day, which shall begin at midnight on the initial meridian, and whose hours shall be counted from zero up to twenty-four."

The Canadian Institute is peculiarly interested in this announcement. No society, literary or scientific, has taken a more important part in the initiation of the movement to reform our Time System, of which the success is, to some extent, indicated in the President's words. It therefore appears to me fit and proper that I should recall to your attention the various steps which, from time to time have been taken so that we may possess a record of the events which have led to the now almost general recognition of the necessity for a new notation.

Six years ago on several occasions the meetings of the Institute were engaged in discussing the subject of Time-reckoning and the selection of a Prime Meridian common to all nations. Papers were read and arguments were advanced, with the view of showing the necessity of establishing a cosmopolitan or universal time, by which the events of history might be more accurately recorded, and which would respond to the more precise demands of science, and generally satisfy the requirements of modern civilization. The proceedings of the Institute for January and February, 1879, give at considerable length the views submitted and the suggestions offered to meet the new conditions of life. While on one hand it was argued that the introduction of a comprehensive scheme by which time could be universally reckoned was highly desirable, it was equally maintained that the determination of a common Prime Meridian for the world was the key to its success, and that the establishment of such a meridian, as a zero, recognized by all nations, was the first important step demanded.

These proceedings were brought under the notice of His Excellency the Marquis of Lorne, then Governor-General of Canada. In the name of the Institute, they were submitted, in the form of a memorial, with the hope that His Excellency would see fit to lay them before the Imperial Government. That they would by these means obtain the attention of the several scientific bodies throughout Europe, and that some general systematic effort would be made in the right direction to secure the important objects sought to be attained.

Through the good offices of His Excellency, copies of the Canadian Institute proceedings found their way to the British Admiralty, the Astronomer Royal, Greenwich, The Astronomer Royal for Scotland, Edinburg, The Royal Society, The Royal Geographical Society, The Royal Astromomical Society, The Royal United Service Institute, and other societies of eminence and weight in the United Kingdom. Copies of the papers were likewise sent through the Imperial Government to the governments of the following countries, viz. :

FRANCE,	GERMANY,
ITALY,	NORWAY AND SWEDEN,
THE UNITED STATES,	RUSSIA,
AUSTRIA,	BELGIUM,
BRAZIL,	DENMARK,
JAPAN,	THE NETHERLANDS,
SPAIN,	PORTUGAL,
SWITZERLAND,	TURKEY,
GREECE,	CHINA.

In the year following, the American Metrological Society issued a Report of the Committee on Standard Time. It bears the name of Mr. Cleveland Abbe, the Chairman of the Committee, and the date of May, 1879. It draws attention to many of the causes calling for the establishment of accurate time, and the attempts made since the establishment of the electro-magnetic telegraph to make the notation of time synchronous. While pointing out that this result had been obtained in Great Britain through the efforts of Professor Airy, Mr. Cleveland Abbe gave a list of the various observatories on this continent which are in possession of the necessary apparatus and force proper to furnish astronomically accurate time by telegraph. Writing in February, 1880, while giving the resolution adopted by the society, recommending the adoption of accurate time by telegraph from an established astronomical observatory, Mr. Cleveland Abbe points out that the subject of accurate time had been taken up by the Horological Bureau of the Winchester Observatory of Yale College, and that the most perfect apparatus had been received for the purpose of distributing New York time to the highest degree of uniformity and accuracy.

Mr. Cleveland Abbe's own remarks on the subject are of high value. He forcibly points out the difficulties and inconvencies under which railway operations in America labour from the want of a proper system of time. To show this fact in greater force, he gives the seventy-four standards then followed. These several standards he proposed to set aside and replace by standards each differing one hour or 15° of longitude.

While recommending this course, the report sets forth that the change could only be regarded as a step towards the absolute uniformity of all time-pieces, and the Society passed resolutions, that absolute uniformity of time is desirable; *that the meridian six hours* west of Greenwich should be adopted as the national standard to be used in common on all railways and telegraphs, to be known as "Railroad and Telegraph Time;" that after July 4th, 1880, such uniform standard time should be the legal standard for the whole country, and that the State and National Legislatures should be memorialized on the subject.

Mr. Cleveland Abbe in this report alluded to the previous proceedings of the Canadian Institute.

The active sympathy of the Marquis of Lorne greatly aided the movement of Time-reform in its early stages. In 1879, in his official position as Governor-General he had been the recipient of the papers published by the Canadian Institute, and had transmitted them to Great Britain, and through the Imperial Government to the several European centres. In 1880, it was learned that the report to the American Metrological Society above alluded to, would shortly be issued. Accordingly, advance copies were obtained from New York, and, together with additional papers issued by this Institute, they were transmitted by His Excellency to the following

European Societies, and the special attention of their members was directed to the documents themselves :

1.	The Institut de France	Paris.
2.	Societè de Geographie	Paris.
3.	Societè Belge de Geographie	Brussels.
4.	Königlich Preussische Akademie der Wissenschaften	Berlin.
5.	Gesellschaft für Erdkunde	Berlin.
6.	Kaiserliche Akademie der Wissenschaften	Vienna.
7.	K. K. Geographische Gesellschaft	Vienna.
8.	Nicolaevskaia Glavnaia Observatoria	Pulkova.
9.	Imper. Rousskae Geograficheskoe Obschestov	St. Petersburg.
10.	Imp. Akademia Nauk	St. Petersburg.
11.	Societè de Geographie	Geneva.

By this means attention was obtained for the subject in Europe, and when I submit evidence of the fact, I think you will agree with me, that no little of the success which has attended the movement is owing to our late Governor-General. We must all acknowledge how much we are indebted to him for the great personal interest he has always shown on the subject. We are certainly warranted in forming the opinion, that the dissemination of these papers, under such distinguished auspices, awakened attention to the arguments they contain, and prepared the way for the subsequent action taken at the International Geographical Congress at Venice, at the Geodedic Congress at Rome, and more recently at the Conference at Washington.

Mr. Wilhelm Förster, director of the Berlin Observatory, enters into the subject at length in a paper "Zur Beurtheilung Einiger Zeitfragen, insbefondene gegen die Einfuhrung einer deutschen Normalzeit." [A Review of some considerations on Time, especially against the introduction of German National Uniform Time].

Mr. Förster proceeds to say: The British Government is now transmitting, through its representatives, although at the same time it declares itself neutral, a proposition which has been published by a society of scientific men in Canada, which aims at the establishment of a cosmopolitan normal datum (Prime Meridian) and of Universal Time, and also the establishment of 24 meridians of an hour apart, by which local time will be absorbed. The first proposal, Mr. Förster describes as an important sign of the times and evidently favours it.

He strongly protests against the establishment of a national German time; but for railway business, and for such matters of communication which require precision, also for the form of expression of all scientific relations to time, Mr. Förster points out that a universal time common to the whole world is to be recommended.

Dr. G. Von Boguslauski, in the *Verhandlungen der Gesellschaft für Erdkunde,* (transactions of the Geographical Society of Berlin), commends the new scheme as it has been put forth in the Canadian Institute papers, and foretells that it will be a matter of fact in a short time.

Col. Aden, Director of the Military School, Belgium, has two papers in the *Bulletin de la Societé Belge de Geographie.* He supports the proposal to establish universal time, and expresses the opinion that longitude throughout the world should have a common notation, dating from one universally accepted Prime Meridian.

Col. Wauverman, President of the Geographical Society of Antwerp, in the Bulletin of that society, 1882, advocates the change, and with ability meets the arguments raised against it, showing them to be groundless and arising from a want of thoroughly understanding the question.

In Spain, the proposals have met with full support. All the papers issued by the Canadian Institute have been translated and published in a pamphlet of 80 pages by the Revista General de Marina. The translator, Don Juan Pastorin, an officer of the Spanish navy. is warm in his commendation of the scheme, and takes a wise and comprehensive view of the whole question. The Spanish Government secured the advantage of this gentleman's services as a delegate to the Washington Conference.

M. Otto Struve, the well-known Astronomer and Director of the Imperial Observatory, Pulkova, reports on the papers transmitted by Lord Lorne to the Imperial Academy of Sciences, St. Petersburg. He gives his adherence to the establishment of Universal Time, based, as suggested, on a Prime Meridian common to the whole globe, and strongly advocates counting the hours in one series up to twenty-four.

In England, the Royal Society considered favourably both the establishment of a Universal Time and the determination of a common Prime Meridian, while the psesent Astronomer Royal, Mr. Christie, takes a favourable view of the question, his predecessor, Sir G. B. Airy, reported in a qualified manner. The report of the Astronomer Royal for Scotland, Prof. Piazzi Smith, is unfavourable. The latter documents have already been submitted to the Institute.

In Italy, the Italian Geographical Society has given its countenance to a work by Mr. Fernando Bosari, who, in a pamphlet of 68 pages, reviews the whole question at length, and lays down three principles ; 1. The determination of a zero meridian ; 2. The establishment of cosmopolitan time based upon it ; 3. The notation of the hours from 1 to 24 in a continuous series.

The question of Universal Time and the selection of a Prime Meridian is discussed with ability in a paper published by M. Thury, professor at the University of Geneva.

At the meeting of the Association for the Reform and Codification of the Laws of Nations at Cologne, Prussia, in 1881, the question of regulating time on the new system was considered and resolutions moved.

In the same year (1881), the subject occupied the attention of the International Geographical Congress at Venice, at which a delegate from the Canadian Institute attended. The general question was warmly discussed, and resolutions adopted. The appointment of an international conference to meet at Washington, specially to consider the question, was then suggested by the Canadian delegate. The president of the Congress communicated the resolutions to the Italian Government, and Prince Teano, on behalf of the Italian Government, undertook to conduct the official correspondence. Out of this appears to have sprung the important discussion at the meeting of the International Geodetic Association at Rome, in October, 1883, when the utility of Universal Time was recognized, and a special international conference for the establishment of a zero meridian for longitude and time recommended.

Turning to this side of the Atlantic, the question of regulating time for railway, telegraph, and civil purposes generally, was considered at the Convention of the American Society of Civil Engineers, held at Montreal, June 15, 1881, and a committee of men engaged in the management and familiar with the economy of railways, appointed to examine the question. The committee has reported from time to time. They recognized that a proposition to reform the general time system of the country was a problem beset with difficulties, but it did not appear to them insolvable. It was felt, however, that the question affected so many interests that any change could only be effected by general concurrence.

To attain the end proposed by this society, the papers bearing on the question were printed, and a scheme modified on the proceedings of the Canadian Institute was drawn up, under the title of "Cosmopolitan scheme for regulating time."

I may briefly recall the features of the scheme.

There should be one standard of absolute time, a Universal Day, based on the mean solar passage, at one particular meridian, the Prime or initial meridian for computing longitude. This Prime Meridian, together with the universal day, to be observed by all civilized nations.

There should be 24 secondary or hour meridians established, 15 degrees of longitude apart, beginning with the Prime Meridian as zero.

To distinguish the universal day from local time, it should bear the title of "Cosmic Day."

[NOTE.—I may remark, that the designation "Cosmic" was first suggested, independently, by two Canadian gentlemen widely separated, by Mr. R. G. Halliburton, then in Algiers, and by Mr. Thomas Hector, of Ottawa. The etymology commends the use of the word. It has been accepted by a number of societies and by many individuals as appropriate and applicable.]

Cosmic time is intended to be used to promote exactness in chronology, and to be employed in astronomy, navigation, metrology and in synchronous observations throughout the world. To be employed in ocean telegraphy and generally in all operations non-local in character.

The several twenty-four meridian to be used as standards local time around the globe. Applying the system to North America, the effect would be to reduce the standards to four or five, as suggested by the metrological society.

A circular, dated March 15th, 1882, signed by Mr. John Bogart, the Secretary of the American Society of Civil Engineers, was forwarded to the leading men in railway direction, either as general managers, superintendents or engineers, and to men of scientific attainments throughout the United States and Canada. The papers thus circulated contained eleven questions, and catagorical replies were invited to them.

Replies were received and reported on at a convention of the society, held in Washington on the 17th May, 1882. The scheme submitted was generally and cordially approved.

An emphatic and unanimous opinion was expressed, that there should be established as early as possible a comprehensive system of Standard Time for North America.

Of those who replied to the queries, ninety-five per cent. favoured the idea that there should be a common agreement between the standards of time in all countries. That while we must primarily look to our own convenience on this continent, it is proper to aim at eventually attaining general uniformity among all nations.

Seventy-six per cent. were in favour of reducing the standards in North America so that they would differ only by intervals of one hour, and ninety-two per cent. were in favour of a notation of the hours of the day in a single series from 1 to 24, instead of in two divisions each of twelve hours.

The character of the replies received indicated that a remarkable unanimity of opinion prevailed in every section of the continent heard from. The Convention accordingly resolved that an attempt should be made to obtain European concurrence to the selection of a Prime Meridian on which a time system could be definitely based. But, failing to obtain this recognition, the people of the Western Continent should determine a zero meridian for their own use and guidance.

It was thereupon resolved to petition the Congress of the United States to take the matter into consideration. The American Metrological Society about the same time adopted a similar proceeding. The consequences were that a Joint-Resolution of the House of Representatives and the Senate was passed authorizing the President of the United States to call an International Conference to fix on and recommend for universal adoption a common Prime Meridian to be used in the reckoning of longitude and in the regulation of time throughout the world.

On the meeting of the American Association for the Advancement of Science in Montreal, in July, 1882, the subject was brought forward, and all the documents were submitted and discussed. It was agreed that the Association should co-operate with other bodies in furtherance of the movement.

On two occasions the Royal Society of Canada has had its attention directed to the matter, and this body has assisted in furthering the determination of the problem by its co-operation and by correspondence with the Government.

Some delay took place in summoning the International Conference by the President, in consequence of lengthy correspondence on the subject between the United States Government and the Governments of other countries. In the meantime a decision with respect to the regulation of local time had been anticipated by the railway authorities in North America, who adopted the system of hour standards which had been prominently brought forward as described.

On November 18th of last year (1883) the new system of regulating railway time on this continent came into operation. There had been several preliminary meetings of railway managers; the last meeting was a Convention held in Chicago the previous October, and it was then determined immediately to carry out the change.

Mr. W. F. Allen, the secretary of this Convention, who also took a prominent part in effecting the adoption of the change, has given a history of the events leading to it. Upon this gentleman mainly fell the labour of arranging details, and he executed the difficult duties assigned to him with consummate ability. In the words of the historian, the transition from the old to the new system "was put into effect without any appreciable jar, and without a single accident occurring." According to this authority the first newspaper to advocate some change was the *Railroad Gazette* for April 2, 1870, and it is claimed that as early as 1869 Prof. Charles F. Dowd, Principal of Temple Grove Ladies' Seminary, Saratoga Springs, proposed a system of meridians based on the meridian of Washington at intervals of one hour, by which railways should be operated, and that an expression of his views was placed in the hands of the President of the New York and Canada Railroad. The proposition appears to have attracted attention in the *Travellers' Official Guide* of 1872. In 1873 it was brought before the Railway Association of America, not now in existence. A committee was appointed to examine into its merits; they failed to recognize its necessity, and recommended that the question of national standard time for use on railways be deferred until it more clearly appeared that the public interests called for it.

Mr. Dowd's efforts to introduce a national standard time to meet the difficulties which were being developed were at the time imperfectly appreciated. He, however, has had the satisfaction of seeing a scheme unanimously accepted, and put in operation, which in essential features does not materially differ from that which he advocated; and he himself attended at the meeting of the American Metrological Society, and took part in the proceedings when the details of the new time arrangements were officially narrated.

Prominent among those who have earnestly laboured to advance the movement of time-reform is the distinguished president of Columbia College, New York. Dr. Barnard has from the first taken the deepest interest in the question, and few men have done so much to bring it to a practical issue. In the proceedings of the American Metrological Society for 1881 will be found a paper prepared by Dr. Barnard in 1872, and presented to an association which has since assumed an international character, and known as the association for the Reform and Codification of the Laws of Nations. In this paper Dr. Barnard recommends the selection of Greenwich as the Prime Meridian for the world, and he submits the views he held at that early date, which at this hour are of peculiar interest. He points out that "it is becoming a matter of greater importance every day that there should be established some universal rule for defining the calendar day for all the world."

I have alluded to the valuable report of Professor Cleveland Abbe, of the United States Signal Service, to the Metrological Society, and I cannot deny myself the pleasure of acknowledging the services of the gentlemen with whom I have been associated on the special committee on Standard Time of the American Society of Civil Engineers, Mr. Paine, of New York; Mr. Theodore N. Ely, of Altoona, Pennsylvania; Mr. J. M. Toucey, of the Hudson River Railway; Professor Hilgard, Coast Survey, Washington; Professor Egleston, of Columbia College; General T. G. Ellis, of Hartford, now unfortunately deceased, and Mr. John Bogart, Secretary of the Society,

The American Society of Civil Engineers, since meeting in Montreal, in 1881, has made persistent and continuous efforts in the common interest to advance the movement of Time-reform, having greatly aided in bringing about the important change carried into effect a year ago. This society is now directing attention to a reform of scarcely less importance, the notation of the hours of the day. At the Buffalo convention in June last, this particular question received prominent consideration in the address of the President, as well as in the report of the special committee. Since that date a correspondence has taken place between the Secretary and the Railway Managers in the United States and Canada. Already replies have been received from the representatives of some sixty thousand miles of railway, ninety-eight (98) per cent. of whom have given expression to their sympathy with the movement, to abandon the old practice of halving the day, designating the two sets of twelve hours by the abbreviations A.M. and P.M., and are prepared to adopt a simple notation of 1 to 24 in a single series, The great telegraph interests of the country are likewise in full sympathy with it. The President of the Western Union Telegraph Company, Dr. Norwin Green, states that their telegraphic traffic is equal to the transmission of forty-four million messages a year, and the general adoption of the 24 o'clock system, as it has been designated, would be cordially welcomed by telegraphers. It would reduce materially the risk of errors, and to the company over which he presides, he says it would save the transmission of at least 150,000,000 letters annually.

The branch literature bearing on the two questions of Universal Time and the establishment of a Prime Meridian, has been enriched by a series of papers which have appeared during the past year in the *International Standard*, a magazine published in Cleveland, Ohio. These papers are by the following gentlemen connected with the International Institute :—Rev. H. G. Wood, of Sharon, Pennsylvania ; Professor C. Piazzi Smyth, Astronomer Royal for Scotland ; Professor John N. Stockwell, Astronomer, Cleveland ; Mr. Jacob M. Clark, C.E., New York ; Mr. William H. Searle, Pennsylvania ; L'Abbé F. Moigno, Canon of St. Denis, Paris ; Commodore Wm. B. Whiting, U. S. Navy ; Mr. Charles Latimer, C.E., Cleveland ; and others.

It will be seen from what I have submitted, that the proceedings have neither been few nor without success. That since this Institute published the first issue of papers on Time and Time-reckoning, the subject has received much attention on both sides of the Atlantic. Societies with kindred pursuits, men of recognized merit in the scientific world, have turned to its examination and aided in its development. Some few men have acted in concert. The labour of others have been independent. Some of these names I have been able to record, but I fear that I neglect to include many of eminence because they are not known to me. It is this varied and widely diffused effort which has rendered possible the realization of the practical results which I have the gratification to record, and all must equally join in the common satisfaction in the measure of success which has been achieved.

Six years back, when the subject was discussed in this hall, there were probably not a few who viewed the propositions then submitted as merely fanciful theories. Others who did not refuse to recognize their bearing, entertained the feeling that many grave difficulties presented themselves to interfere with any successful attempt to reform or modify usages so ancient as the computation of time. But the Institute, as a body, was hopeful. The action taken by the Council to extend the field of discussion and awaken the attention of foreign communities, evinced confidence, and we may now ask, was this confidence justified? What are the facts to-day? Twelve months have passed since an important change in the notation of Railway Time was made with general approval throughout the length and breadth of North America, a revolution in the usages of sixty millions of people has been silently effected and with scarcely a trace that it has happened. A proceeding which has been followed by events of equal importance. On the 1st of October last a body of accredited delegates from the different nations, on the invitation of the President of the United States, met in conference to consider the problem first submitted to the world by this Institute. The delegates were the representatives of twenty-five (25) civilized nations. The conference continued during the whole month of October, and, as a body, they came to conclusions affecting all peoples living under our theories of civilization.

It was early understood that a determination with respect to Universal Time was not possible without the general recognition of an initial meridian. Hence the importance attached to its choice, that it should be universally accepted.

For many years attempts have been made to effect the establishment of an initial meridian recognized in common by all nations, but every attempt hitherto had proved completely unsuccessful. It is therefore the greater cause for congratulation, that the efforts of the Washington conference have succeeded in its determination.

The discussions of the conference were long, and being carried on in different languages, could not have been of equal interest to all present. Translations became necessary, so that all the delegates might equally understand the propositions which were daily submitted. This necessary course prolonged the sessions and multiplied the adjournments. At last, however, the choice of a Prime Meridian was obtained. The following resolution was passed, the delegates voting by nations:

"*Resolved*, That the Conference proposes to the Governments here represented the adoption of the meridian passing through the centre of the transit instrument at the Observatory of Greenwich as the initial meridian for longitude.

The above resolution was adopted by the following vote:

In the affirmative:

AUSTRIA,	MEXICO,
CHILI,	NETHERLANDS,
COLOMBIA,	PARAGUAY,
COSTA RICA,	RUSSIA,
GERMANY,	SALVADOR,
GREAT BRITAIN,	SPAIN,
GUATEMALA,	SWEDEN,
HAWAII,	SWITZERLAND,
ITALY,	TURKEY,
JAPAN,	UNITED STATES,
LIBERIA,	VENEZUELA.

In the negative:

SAN DOMINGO.

Abstained from voting:

FRANCE AND BRAZIL.

AYES 22. NOES 1.

There was less difficulty and even greater unanimity displayed when the consideration of Universal Time was submitted. The Conference adopted the principle of a Universal Day without a single negative vote. The resolutions carried are substantially in accord with the essential principles, if not with the precise features of the proposals set forth in the proceedings of the Institute, published in 1879.

The resolution defining the Universal Day reads as follows: "*Resolved*, That this Universal Day is to be a mean solar day; is to begin for all the world at the moment of mean midnight of the initial meridian, coinciding with the beginning of the civil day and date of that meridian, and is to be counted from zero up to twenty-four hours."

This definition, taken in conjunction with the other resolutions of the Conference, is fraught with important consequences.

When it is mean midnight at Greenwich, that moment it is mean noon at the meridian 180° from Greenwich, as indicated by the solar passage. Hence the anti-Prime Meridian practically becomes the time-zero for the world.

The initial instant of the twenty-four hours of each successive Universal or Cosmic Day is the moment of mean sôlar passage on the Anti-Prime Meridian. The first hour of the Cosmic Day is at the solar passage on the meridian 15° westward This then becomes the 1st hour meridian. The second hour of the Cosmic Day is at the solar passage on the meridian 15° still further westward. This becomes the 2nd hour meridian. And so on in turn, each meridian which is an exact multiple of 15° from zero becomes an hour meridian corresponding in number with the numbers of the successive hours of the Cosmic Day.

The twenty-four hour meridians so determined come in the following order, viz.:

LONGITUDE EAST AND WEST.	HOUR MERIDIAN.	COSMIC TIME AT SOLAR PASSAGE.
ANTI-PRIME MERIDIAN	ZERO.	THE DAY BEGINS.
165° East	1st Hour Meridian	1 o'clock.
190° East	2nd " "	2 "
135° East	3rd " "	3 "
120° East	4th " "	4 "
105° East	5th " "	5 "
90° East	6th " "	6 "
75° East	7th " "	7 "
60° East	8th " "	8 "
45° East	9th " "	9 "
30° East	10th " "	10 "
15° East	11th " "	11 "
Prime Meridian	12th " "	12 "
15° West	13th " "	13 "
30° West	14th " "	14 "
45° West	15th " "	15 "
60° West	16th " "	16 "
75° West	17th " "	17 "
90° West	18th " "	18 "
105° West	19th " "	19 "
120° West	20th " "	20 "
135° West	21st " "	21 "
150° West	22nd " "	22 "
165° West	23rd " "	23 "
160° West	24th " " ..	24 "

Thus the exact position of the twenty-four secondary or hour meridians is practically determined, and provision is thereby made for extending around the globe so as to secure complete uniformity, the hour system of regulating time which has been adopted with so much advantage in America.

These hour meridians, so designated, completely establish the relation between Cosmic time and longitude and likewise between Cosmic time and local time. Once every day the relationship will be prominently brought under the notice of every individual. Any one, for example, living on the 6th hour meridian, will know at noon that it is at that instant six o'clock Cosmic time; or, take a citizen of Toronto, the local time of which would be governed by the 17th hour meridian. At the instant of noon he will know that it is 17 o'clock Cosmic Time. Invariable time will thus agree with longitude, conversely longitude with time. The earth itself becomes the great chronometer, and in its daily relations the passage of the sun will everywhere be the index of Cosmic time.

The resolutions of the International Conference establish a means of reckoning time which promises, in the years to come, to be of the highest advantage to the human family. Cosmic time, or whatever name may be given to Universal time applied to civil purposes is an entirely new feature. It has now obtained recognition by a properly constituted authority, although until recently, I believe, it has remained unconsidered. Astronomers have long had equinoctial time, which is absolute time, dating from an epoch determined by the sun's motion among the stars; beyond this I cannot find any nearer approach to the mention of Universal Time as now understood.

The conclusions of the Conference mark a new era. The civil time of England is adopted as Universal Time. It may be said that Greenwich time is already known on every sea, that it has been carried by British ships wherever British explorers and colonists and merchants have penetrated, but Greenwich time is the local time of Greenwich, and, heretofore, it has always been held as such. Universal time, based on the Prime Meridian of the globe, and recognized by the several civilized nations is an entirely different conception. As the time of the world common to every nation, it is held that the term Cosmic will better express that meaning than Greenwich. Cosmic and Greenwich time are identical, by accident, but the expressions imply two totally different ideas, and known national sensitiveness suggests the good taste and expediency of distinguishing the two ideas by different terms.

I am induced to add a few words in explanation of the principles of Cosmic time.

Time has been the subject of profound thought by many philosophic minds of the past. They have attempted to define it, and their definitions have been manifold. If we view the earth as a whole, and the conditions of the age in which we live, oblige us so to view it. I am unable to see that any one of the recorded definitions gives support to the ancient system of keeping count of time which we follow. Our ordinary usages imply that there is an infinite number of times, and they are based on the principle that time is dependent on local situation. Nothing can be more erroneous and misleading. It is this false principle entering into every detail of daily life which has led each insignificent locality on the circumference of the globe to claim the right to have its own time. It is self-evident that time is in no way dependent on locality. I will quote on this point but one authority, the great Sir Isaac Newton. "Absolute true and mathematical time of itself, and from its own nature, flows equally without regard to anything external."

Our finite minds are incapable of understanding fully what time is, but this much is perfectly clear to our reason. Time is a measureable quantity, it may be termed a flowing magnitude, and only as one such magnitude is it conceivable. A distinct and separate flow of time in each of the myriad localities throughout the universe is perfectly inconceivable. If time be anything it is a *unity* and not a *plurality*. The cardinal principle of Cosmic time is *unity*, and with unity as a fundamental idea of time it must be held that the Cosmic system is the only sound principle of reckoning, and that as the area of civilization broadens, it must in the end be recognized as applicable everywhere and for all purposes.

The conclusions of the International Conference are fruitful of results of high importance. They may be said to point to the opening of a new chapter in the world's annals. They make provision for a complete cessation of ambiguity in hours and dates. By Cosmic Time all events whatsoever will be systematically arranged according to their proper chronological order. The calendar days the world over consequently will begin at the one initial instant, and clocks will strike the same hour at the same moment in all longitudes.

But the new system can only be gradually introduced. The majority of mankind have firmly fixed ideas with regard to the passage of the day and the numbers of the hours by which their social habits are regulated. A proposal suddenly to change the old familiar succession of the hours will be misunderstood. The influence of custom is always powerful under any aspect. It is anticipated that this influence will be the one serious obstacle to be overcome. The belief, however, may be permitted that the change will be rendered easy when men understand that the numbers of such hours have been arbitrarily chosen; that there is no necessary connection between them and the position of the sun in relation to the earth in its daily rotation, and that whatever numbers may distinguish the twenty-four divisions of the day, the recurring phenomena of light and darkness will always regulate sleeping, waking, eating, and working, and all the routine of life in every locality. Noon has heretofore been associated in our minds with the hour of 12, but among the Jews noon was the 6th hour, and astronomers have almost invariably recognized it as the 24th hour. For a year back throughout the United States and Canada the agreement between 12 o'clock and precise noon has been at an end. It may be said that, except on four or five meridians, 12 o'clock is nowhere coincident with mean solar noon. This departure from an old usage must tend to unloosen the traditional idea that the mere numbers of the hours have any necessary connection with the position of the sun in the heavens. If this innovation has any effect it must help to pave the way for still further and more important changes than have yet been introduced. The meridians by which time is regulated in North America are 5, 6, 7 and 8 hours of longitude west from the Prime Meridian. It will only be necessary to move forward our clocks 5, 6, 7, and 8 hours respectively to bring them all into agreement with the time of the Prime Meridian which is Cosmic Time, and thus obtain complete uniformity. It cannot, however, be looked for that Cosmic Time will at once be adopted in ordinary affairs. A generation probably will pass away before it will obtain general acceptance. The difficulties to be overcome cannot be ignored, and we may assume that it will only be step by step that the change will be made, the more advanced nations taking the lead. On this continent positive progress has been made, to be succeeded before long, I do not doubt, by another advance in public opinion, and a general acceptance of the principles recently recognized. In the course of years the prejudices engendered by inherited customs will be greatly modified, and the masses will gradually have their minds familiarized with new ideas. It is a significant fact that the principles of the new system should be unanimously recommended by delegates from all civilized nations. I do not doubt that the several peoples they represent will sooner or later understand that one uniform reckoning of time for every purpose throughout the globe is the only rational system, and the one notation which in coming years will properly meet the necessities and requirements of mankind.

In these remarks I have narrated the events which have taken place on both sides of the Atlantic to influence and determine the conclusions which, a few weeks back, the President submitted to the Congress of the United States.

On this occasion I cannot think that I am entirely wrong when I venture to congratulate the Canadian Institute on the part which it has taken in the solution of this problem. It stands among the Societies who first considered this comparatively new question. Indeed, it may be claimed that the Institute is to some extent the pioneer Society in awakening the world to the advantages to be derived from the establishment of Cosmic Time..

In conclusion, I will avail myself of the words of an early President of the of the Institute, whose portrait for more than thirty years has adorned the hall in which we are now assembled. Referring to the results already effected in Time-reform and the prospects for the future, General Sir Henry Lefroy, in his address at the late meeting of the British Association in Montreal, remarked: "Whether we conceive its educational tendency or its influence on future intercourse of unborn millions, it is a somewhat remarkable evidence that agreement upon questions of general concern is not that unattainable thing which we are apt to consider it."

Questions as to the effect of the proposed change were put by Mr. Notman, Mr. Murray and Mr. Macdougall, and answered by Mr. Fleming. Mr. Carpmael referred to the Spanish translation of Mr. Fleming's previous papers. Dr. Meredith congratulated the Institute on its having taken the initial proceedings. The President also made some remarks on the subject.

The following Resolution was moved by Dr. E. A. Meredith, seconded by Mr. W. H. VanderSmissen, and passed :

"That the meeting, considering this as an exceptional case, desire to tender a cordial vote of thanks to Mr. Sandford Fleming, C.M.G., for his interesting communication on the subject of 'Cosmic Time,' and they wish, at the same time, to record their satisfaction that to one of the original members of the Institute is due the honour of being the first to bring prominently before the scientific world, through the medium of the Journal of the Institute, the important subject of Time Reform, and the adoption of uniform or Cosmic Time."